Viking HVDC Link

Submarine Cable Route Development

Final Report

CONTROLLED DOCUMENT

Revision	Date	Prepared by	Authorised
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1.0	21st April 2015	D Percy, F Stewart	J Hodder

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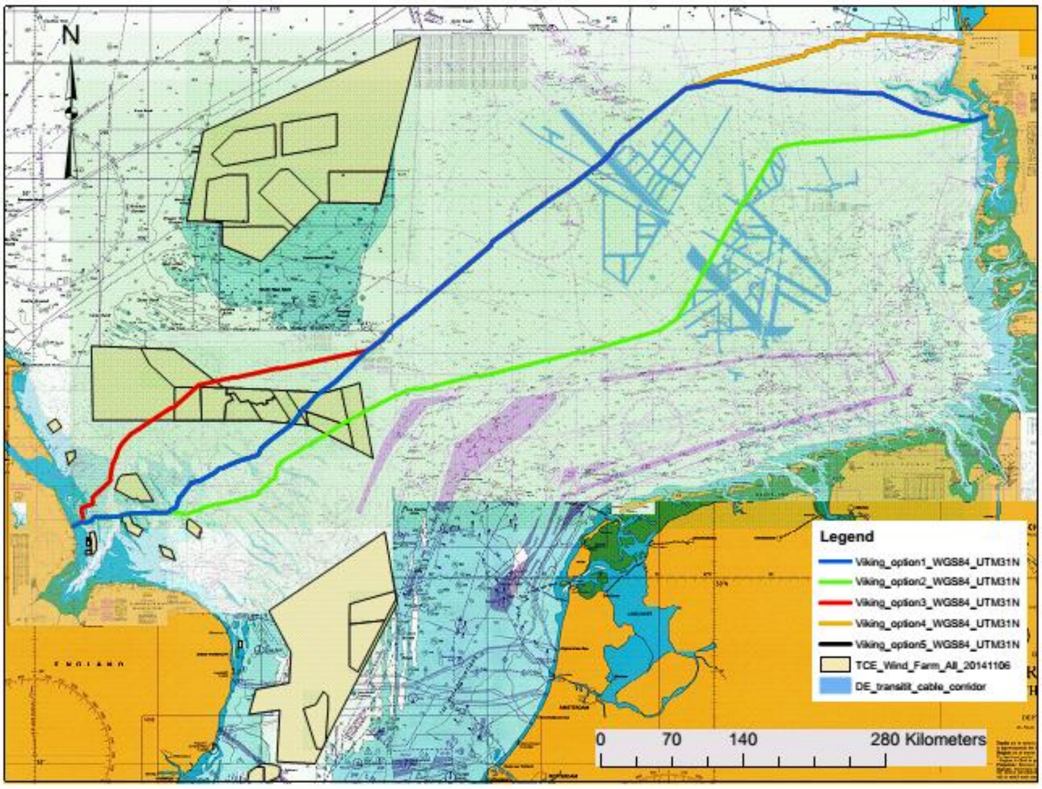
EXECUTIVE SUMMARY

Red Penguin Associates (RPA) has been appointed by NGIL & Energinet.dk to undertake the development of the Viking HVDC link submarine cable route between Denmark and the UK. The scope of work was to take the results of the Ramboll Viking Link Offshore desktop route study which identified a number of high level route options and using additional data such a UKHO charts and other relevant data sets, develop further route options taking into account cable engineering and environmental constraints.

The Ramboll report and the Technical Working Group identified two principal route options: a Southern option which utilises the designated German cable corridors; and a Northern route, which aims to minimise the route distance in the German waters by crossing the narrow Northern Western arm of the German EEZ.

During the preparation of this report, it has become apparent from meetings with the German and Dutch authorities that, in principle, they favour the Northern option.

RPA has taken the initial Ramboll routes and developed five Route Options: 1, 3,4, and 5, based on the Northern route; and Route Option 2 is based on the Southern route.



Note: Route Option 5 is not displayed on the overview due to being common with sections of routes 1 and 4, for details of route 5 see Figure 7

In terms of overall route length there is a relatively little difference between the three options that land in Fanø (1, 2 & 3), the longest being 627km and the shortest being 620 km. The two options that land in Blabjerg (4 & 5) are respectively 615km and 610km in length. In our opinion, and in the overall scale of the project, the difference in route lengths of the Fanø route options does not significantly favour one option against another. The Blabjerg routes are marginally shorter and may offer some advantage.

The route development exercise has identified numerous physical features that need to be taken into consideration, particularly in the UK EEZ where there is significant oil and gas and windfarm infrastructure, both existing and planned.

While the routing exercise has minimised crossings with other subsea infrastructure, all the route options have a significant number of crossings with existing infrastructure which are unavoidable. The route with the least number of crossings is Route Option 1 with 24 in total. Route Option 5 has 25, Route Option 2 has 27 and Route Options 3 and 4 each have 31.

Following liaison with the developers, planned windfarm export cables have been identified as a significant constraint. Route Options 3 and 4 have a crossing with the Hornsea export cable corridor and Route Options 1, 2 and 5 have a crossing with the Triton Knoll export cable corridor. Of these two, Hornsea is considered the most significant constraint as it is planned to utilise the corridor for both Projects 1 and 2, which could have a total of 12 cables, if both projects adopt an HVAC transmission system.

When analysing the overall density of constraints on the routes, Route Options 3 and 4 are subject to significant congestion in the first 50km from the UK landfall, due to mineral extraction dredging areas, pipeline crossings, bathymetric features and windfarm corridors.

Taking the issues highlighted above and the other issues discussed in report in to consideration, Route Options 1 and 5 appear to be the preferred options at this time. Route Option 1 and 5 avoid the worst constraints close to the UK landfall and takes the Northern route preferred by both the Dutch and German permitting authorities.

While this report has focussed primarily on the physical constraints present in the southern North Sea, it is acknowledged that the final route selection will also be determined by high level permitting and environmental issues and compromises may be needed to reconcile these two elements, which may require further route development.

RPA recommend that further studies are undertaken in relation to selection of the UK landfall and other issues are investigated further where data gaps have been identified in this report.

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List of Abbreviations

BGS	British Geological Society
BSH	Bundesamt für Seeschifffahrt und Hydrographie
CPA	Closest Point of Approach
DE	Germany
DK	Denmark
EEZ	Exclusive Economic Zone
FO	Fibre Optic
FPO	Fish Producers Organisation
GIS	Geographic Information System
hp	Horse Power
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IMO	International Maritime Organisation
km	Kilometre
LAT	Lowest Astronomical Tide
NFFO	National Federation of Fishermen's Organisations
NL	Netherlands
m	Metre
NGIL	National Grid Interconnectors Ltd
RPA	RedPenguin Associates
RWS	Rijkswaterstaat
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TCE	The Crown Estate
TSS	Traffic Separation Scheme
TWG	Technical Working Group
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKHO	United Kingdom Hydrographic Office
UNCLOS	United Nations Convention on Law of the Sea
UNESCO	United Nations Education Scientific & Cultural Organisation
WD	Water Depth

1.0 INTRODUCTION

Red Penguin Associates (RPA) has been appointed by NGIL & Energinet.dk to undertake the development of the Viking HVDC link submarine cable route between Denmark and the UK.

The scope of work is to take the results of the Ramboll Viking Link Offshore desktop route study, which identified a number of high level route options and using additional data such a UKHO charts and Crown Estate Seabed Licensing areas, and develop further route options taking into account cable engineering and environmental constraints.

The Project Technical Working Group (TWG) reviewed the high level route options, presented by Ramboll, and concluded that two route options were preferred from the proposed route segments (TWG 2014), as indicated in Figure 1.

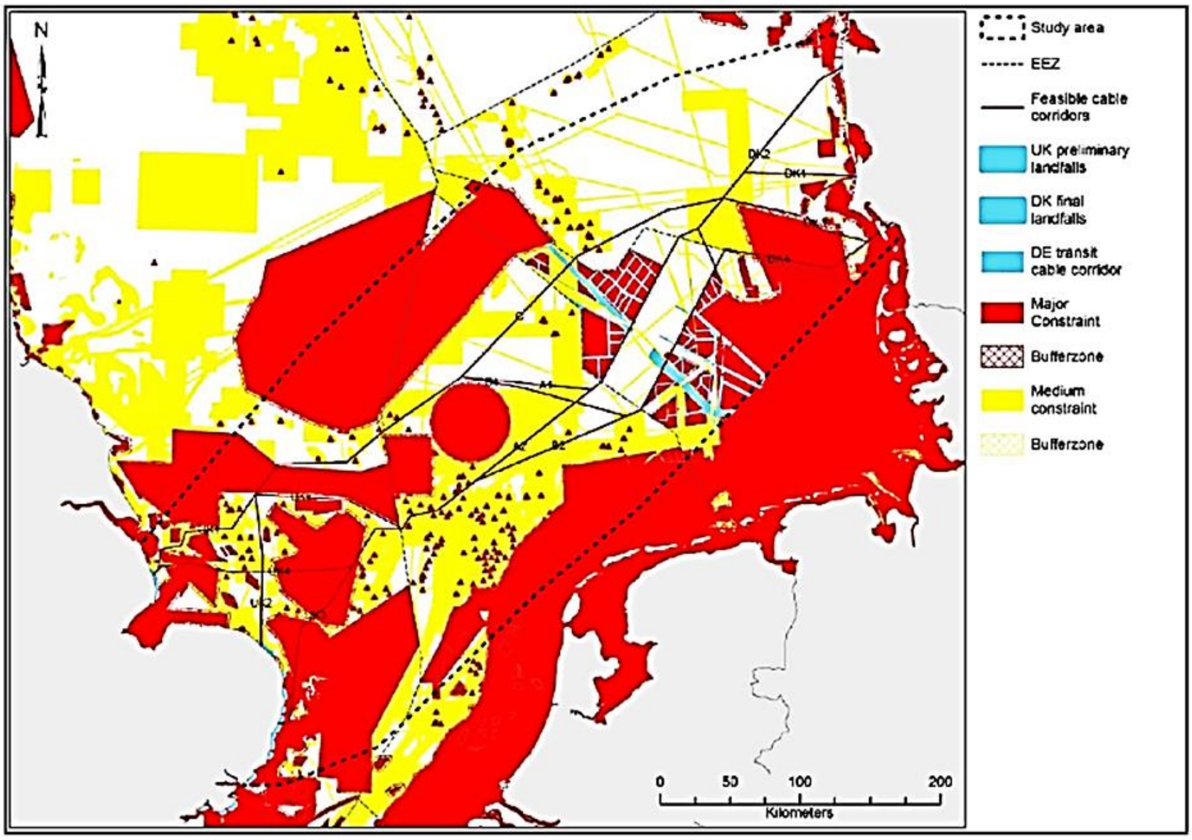

Figure 1. Route Segment Options

Route Option	Segments	Comments
South	UK-B2-DK4	The shortest route compliant with designated cable corridors in the German EEZ
North	UK1-C-DK1	The shortest overall route, which requires a permitted deviation from the German EEZ cable corridors

Table 1. Route Segment Options

The two route options were examined and engineered in more detail by the routing engineers of the RPA team. This exercise was based on a set of routing objectives and criteria, which are set out in section 2, and comprised a review of the available data provided within the geodatabase (Ramboll GIS).

2.0 ROUTING OBJECTIVES AND CRITERIA

The main objective of the route development was to engineer the shortest possible route between the landfalls, in order to minimise cable length. However, there are several criteria that may result in deviations from the shortest route. These criteria related to environmental conditions; obstruction avoidance; protected areas and third party installations, activities and exclusion zones; as well as safe cable installation and operational criteria. Costing and risk mitigation are also of high importance.

The route engineering is primarily based on the geomorphological, geological and sedimentological (geotechnical) criteria related to the seabed and shallow geology, with due consideration to protection, installation and operational aspects of the marine cable. However, conditions onshore, which determine the location of the converter / terminal stations, will greatly influence the choice of landing points.

The most important criteria for evaluation of the detailed route are to:

- minimise total cable length, as far as possible;
- reduce environmental impact;
- reduce/avoid impact and conflict with other human activities;
- reduce / avoid impact from environmental hazards; and
- minimise cost.

These criteria will lead to routing which will:

- minimise areas with unstable seafloor and steep seabed slopes, where possible;
- avoid critical combinations of strong current and free spans;
- minimise length of cable laid across rock outcrops;
- minimise areas with cemented or hard/highly over-consolidated seabed soils;
- avoid / reduce to a minimum routing through areas of fishing, high density shipping and anchorages;
- avoid pockmarks;
- avoid fault lines;
- minimise areas hazardous for laying and protection operations as well as maintenance and repair;
- seek cable protection provided by the seabed relief or seabed conditions;
- seek areas beneficial for intervention protection of the cable; and
- secure space for possible cable repair / field joints.

Table 2 presents the routing criteria which were applied to develop five route options (see Section 5 for more detail).

Criterion	Factors to be considered
Development of the shortest route possible to minimise cable length and hence cable manufacturing and installation costs	Achieving optimal balance between a straight line from A to B and a route avoiding existing infrastructure, topographic features and geological features. I.e. subject to tolerable risks.
Where possible avoidance of areas that would present insurmountable technical difficulties for installation and/or maintenance of cable burial depths	Route length in intertidal areas minimised. Route length in water depths of less than 10m minimised. Crossing of sand banks and sand waves minimised. Avoidance of hard grounds, indurated layers, continuous intervals of rock exposure, pockmarks, boulder fields and severe gradients. Avoidance of peat-rich sediments, and/or minimise length of crossing over this sediment. Avoidance of areas of high current, sediment movement (scour / erosion and spanning potential).
Avoidance of areas with a prior use, where there is increased risk of damage to cable	Anchorage areas, dredging areas, disposal areas*, munitions areas to be avoided. Fishing areas, where possible, shipping channels (shortest possible crossing distance, if cannot be avoided),
Avoidance of areas of existing and proposed seabed development	Oil and gas infrastructure, port developments, dredged channels and existing windfarms to be avoided. Consideration given as to whether to avoid proposed windfarms or having the route proximate to existing assets.
Avoidance of wrecks	Wrecks avoided by 100m
Avoidance of areas of archaeological significance	Archaeological sites to be avoided by appropriate national CPAs or 100m buffer zone
Bundle with existing infrastructure	250m separation from existing cables and 500m separation from existing pipelines where possible .Highlight proximity issues Pipelines and cables to be crossed at right angles.
Avoidance of areas with pre-existing environmental designations	Avoid or minimise crossing of protected sites e.g., SACs, SPAs, Ramsar Sites, Sites of Special Scientific Interest (SSSI), National Nature Reserves.
Avoidance of areas of National Restrictions	Avoidance of areas with restrictions from States / Government exclusion zones, or minimise exposure to such restrictions

Table 2. Routing Criteria

3.0 ROUTING METHODOLOGY

The routing was carried out by the RPA route engineers, applying the route criteria indicated in Table 2, and working within the GIS.

The work flow included, but was not limited to:

- Evaluate high level route for physical obstructions (physical features and environmental conditions) – revise route as appropriate to avoid obstructions;
- Evaluate high level route for licensing and legislature obstructions / exclusion zones – revise route as appropriate to avoid, or minimise length of route across the area;
- Evaluate high level route for man-made infrastructure obstructions – revise route to avoid and/or cross at 90° or acceptable crossing angle;
- Review route to ensure the cable length is minimised, as far as possible, after considering major constraints;
- Evaluate if any of the proposed route is at risk from installation and protection concerns which cannot be avoided by optimal routing alone, and flag these areas for further analysis;
- Review process by independent routing engineer;
- Update route as required;
- Summarise the route and generate an issue list of areas where there are critical gaps in the available database, which must be closed in order to deliver a more robust route, and/or reduce risks to the cable installation and protection; and
- Issue Report to Client for review.

The route development has been an iterative process, some of the items being re-addressed as the routing focussed on areas where there are high constraints and/or difficult topography and installation conditions.

4.0 DATA SOURCES

The primary source of data for the route development exercise was the Ramboll GIS data set provided by the Client. This was provided as an ARCs GIS dataset and loaded on to the RPA GIS system. Additional data sets were added to the GIS during the process and others were sourced as hard copies.

The following table lists the data referred to during the exercise.

Source	Format	Data set
Ramboll	GIS	VikingLinkSkabelon20140825_rev1_10_0-ArcMap
SeaZone	GIS	UKHO Raster Charts,3766,1423,1187,1503,1190
BGS	Hard Copy	Regional Report No.7 Southern North Sea
BGS	Hard Copy	1/2500 Seabed Sediment and Quaternary Charts for Spurn, Indefatigable, East Anglia, Flemish Bight.
RWE	GIS	Triton Knoll Windfarm Export Cable corridor
The Crown Estate	GIS	UK Wind Farms
The Crown Estate	GIS	UK Extraction Areas
Triton Knoll	GIS	Export cable corridor
KISORCA	GIS	Subsea Cables and Renewables
UK Oil & Gas	Online GIS	UK Pipelines
DECC	GIS	UK Oil and Gas infrastructure
Energinet	GIS	Seabed sediment map of the Danish Waters. GEUS 2015
Primo Marine	GIS	NL Oyster Grounds & Frisian Fronts
Primo Marine	Hard Copy	IMO Proposed NL Traffic Separation scheme changes
National Grid	GIS	BSH Research Areas , NL designated environmental areas

Table 3. Data Sources

5.0 PRELIMINARY CABLE ROUTING (RAMBOLL REPORT & GIS)

The TWG recommended the route UK4-B2-DK4 as the primary option within the southern sector of the development envelope, with an alternative UK1-C-DK1 within the northern sector of the envelope. The northern route avoids the majority of the constraints, with the exception of the Hornsea windfarm development. Conversely, the preferred southern route crosses some important constraints with both; environmentally sensitive areas, marine aggregate extraction licence areas and windfarm development areas, both on the UK and Danish sectors of the route.

Micro-routing has looked in greater detail at the constraints along the TWG-recommended routes and has resulted in the following proposed routes, shown in Figure 2, which have addressed the geomorphological and anthropogenic constraints in more detail. As such, the routes are more complex. Negotiations with other seabed users may result in simplified routing, and reduction in cable length, and crossings.

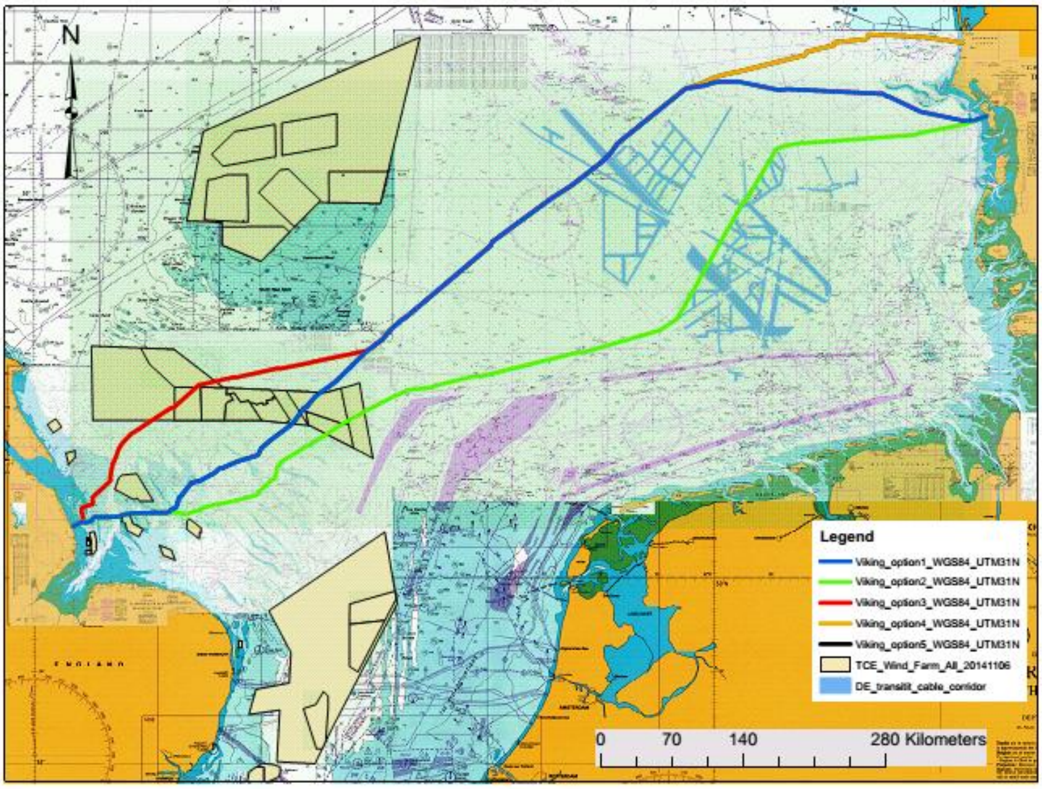

Figure 2. Viking route option overview

Note: Route Option 5 is not displayed on the overview due to being common with sections of routes 1 and 4, for details of route 5 see Figure 7

5.1 ROUTE SUMMARY DESCRIPTIONS

5.1.1 Introduction

Five routes have been developed during the exercise and are identified as route options 1 to 5

For the purposes of the exercise one UK landfall point has been used, located at Huttoft, on the East Lincolnshire coast. Following further investigation of the UK landfall and land route options, it is likely that this location will be modified and a second landing option may be added.

Two landfalls have been included in Denmark, one located in Fanø and the second Blabjerg.

The table below identifies the route options, whilst the comments refer to two of the constraints which potentially have a major influence the routing. These are the Hornsea Round 3 windfarm zone and the designated German cable corridors.

Route ID	UK Landfall	DK Landfall	Route Length km	Comments
1	Huttoft	Fanø	620.993	North German territorial waters, East of Hornsea
2	Huttoft	Fanø	619.502	Southern German cable corridors, East of Hornsea
3	Huttoft	Fanø	627.238	North German territorial waters , West of Hornsea
4	Huttoft	Blabjerg	615.267	North German territorial waters, West of Hornsea
5	Huttoft	Blabjerg	610.024	North German territorial waters, East of Hornsea

Table 4. Route Options

Note: Routes 3 and 4 are common over the majority of their length, route 4 diverging towards the Blabjerg landfall in Danish waters. Routes 1 and 5 are also common over the majority of their length, route 5 diverging towards the Blabjerg landfall in Danish waters. It is not possible to illustrated Route 5 on the overview as it is overlaid by routes 1 & 4. Refer to figures 6 and 7 for an overview of routes 4 and 5.

5.1.2 Route Option 1 Description

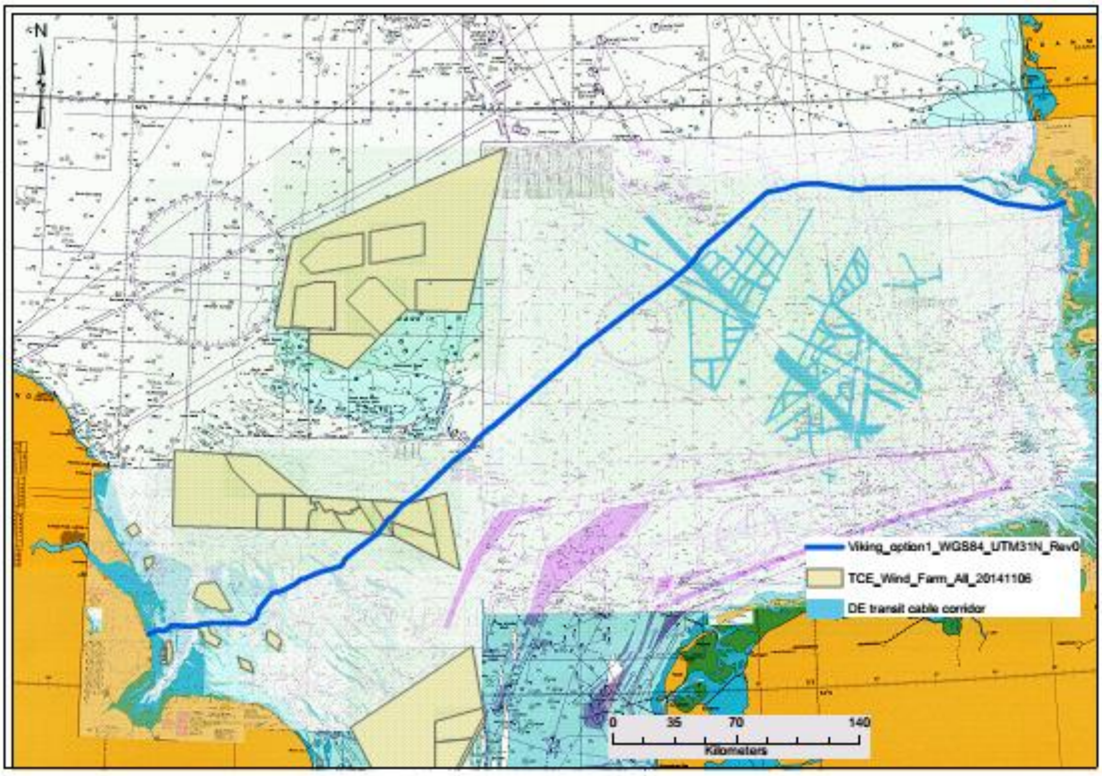

Figure 3. Route Option 1 Overview

From the Huttoft UK landfall, the 5m depth contour is 1.5km distant and the 10m contour is 5km distant. The route crosses the proposed Triton Knoll export cable corridor before passing north of the Inner Dowsing Bank. The route continues in an easterly direction, passing to the North of the Race Bank wind farm development and north of the East Dudgeon Shoals.

The route then heads in a North Easterly direction to pass west of the Guinevere, Lancelot, and Excalibur Gas fields. The Sole Pit is passed to the North of the route, before passing to the North of the Ensign Platform. The route then crosses the north part of the North Swarte Bank and subsequently passes South of the Well Hole.

The route then transits across the Hornsea round three wind farm zone in an easterly direction, crossing the designated no development shipping zone and Project 3 area SPC 7.

The route continues North East, passing South of the Ketch Gas field to the UK/NL territorial waters EEZ and heads towards the narrow section of German territorial waters, North of the designated wind farm areas.

There are few features of note in the 27km of Dutch waters prior to crossing the NL/DE EEZ, however the route then passes South of a designated research area, before transiting into Danish waters.

In Danish waters, the route passes South of the Dan oil field then turns East adjacent to the North East apex of the German Territorial waters. The route then passes North of the Horns Rev Danger area and South of the Vyl Bank and the Losseplads Spoil Grounds.

The route then turns North East towards the Danish landfall at Fanø, crossing the 10m contour 6.5 km from the landfall and the 5m contour 3.8km from the landfall.

5.1.3 Route Option 2 Description

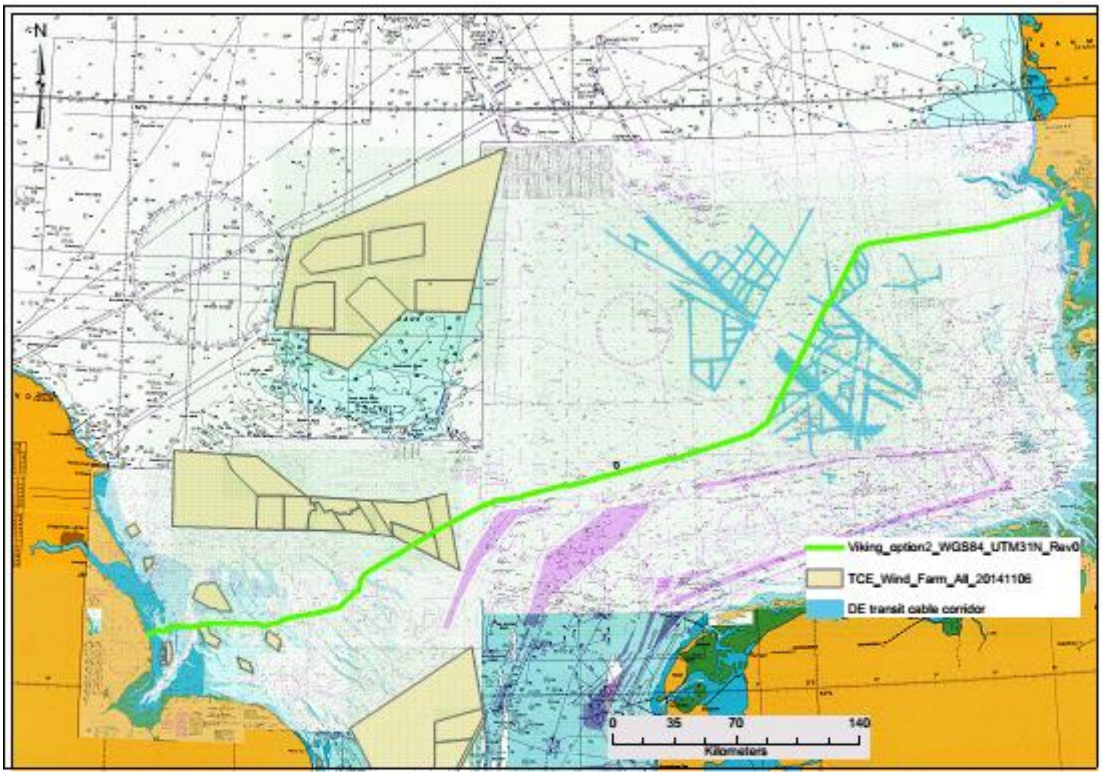

Figure 4. Route Option 2 Overview

From the Huttoft UK landfall, the 5m contour is 1.5km distant and the 10m contour is 5km distant. The route crosses the proposed Triton Knoll export cable corridor before passing North of the Inner Dowsing Bank. The route continues in an Easterly direction, passing to the North of the Race Bank wind farm development and North of the East Dudgeon Shoals.

The route continues in an Easterly direction, passing to the South of the Waveney Gas field then North of the Cromer Knoll Shoals. The route then heads East-North-East, crossing the Haddock Bank and passing to the North of the North Anglia and Galleon Gas fields.

The route then heads North-North-East to pass to the North of the Indefatigable Bank; then heads North-East towards the Hornsea round three wind farm zone and transiting the zone through development areas 7 & 8.

The route then crosses the UK/NL EEZ, passing close to the North of the "Off Botney Ground" deep water shipping lane and heads through Dutch waters towards the South Eastern end of the designated German Cable corridor.

Immediately prior to entering the designated cable corridor the route crosses the NL/DE EEZ. The route remains in the designated corridor before exiting German territorial waters and turning Eastwards towards the Danish landfall.

The route passes North of the "Recording Station" prohibited area, crosses the 10m contour 6.5km and the 5m contour 3.7km distant from the Danish landfall at Fanø.

5.1.4 Route Option 3 Description

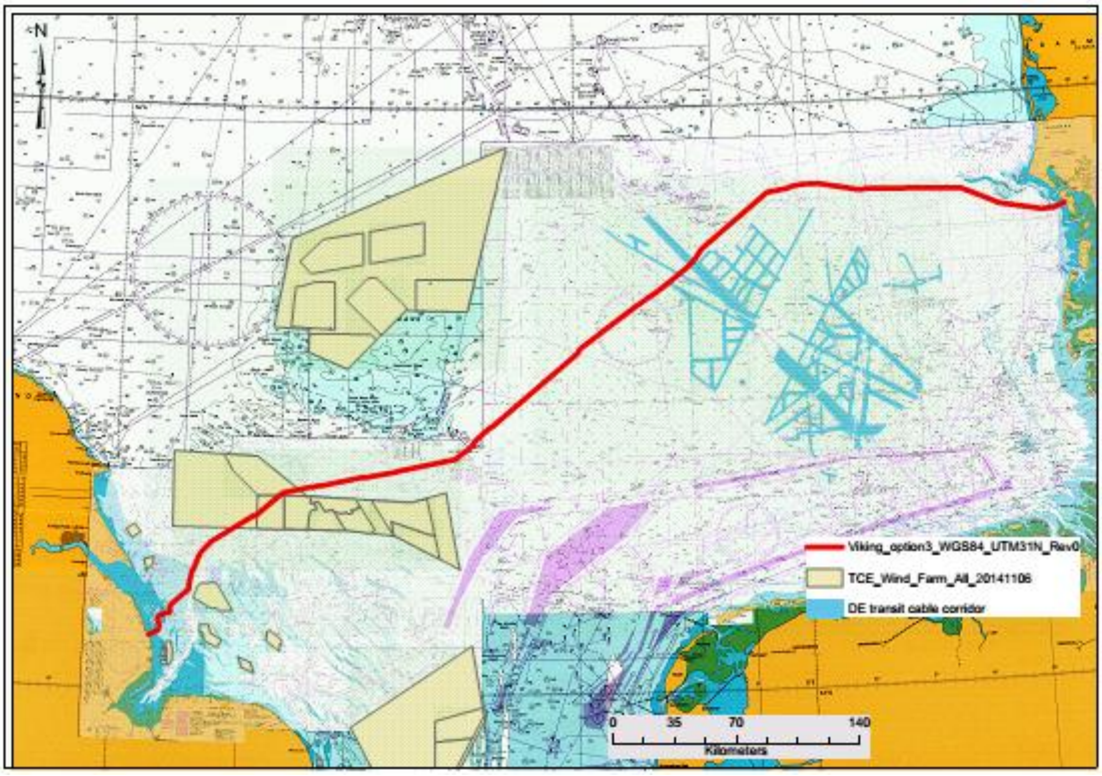

Figure 5. Route Option 3 Overview

Route option 3 originates at the Huttoft UK landfall, crossing the 5m depth contour at 1.5km and the 10m contour at 4.7km. It then crosses a group of 4 pipelines, which land close by at Theddlethorpe.

A dog's leg is then necessary to negotiate the marine aggregate extraction areas 179 and 106/3, after which, the route heads North East remaining to the West of Silver Pit. There is a crossing with the proposed Hornsea Export cable corridor, before the route passes to the West of the Amethyst Gas Field.

The route rounds the Northern end of the Silver Pit, before turning to head North East and passing to the North of the Hyde and Hoton gas fields. The route then transits the Hornsea round three wind farm zone, remaining clear of the project 1 & 2 areas and passing through SPC 5 & 6.

Once clear of the zone, the route turns to the East, passing through the Outer Silver Pit. The route then passes to the North of the Ketch gas field prior to crossing the UK/NL EEZ and heading towards the narrow section of German territorial waters, North of the designated wind farm areas.

In Dutch waters the route heads North East, passing North of the Hanze Oil field before crossing the NL/DE EEZ. The route then passes South of a designated research area, before transiting into Danish waters.

In Danish waters the route passes South of the Dan oil field then turns East close to the North East apex of the German Territorial waters. The route then passes North of the Horns Rev Danger area and to the South of the Vyl bank and the Losseplads spoil grounds.

The route then turns North East towards the Danish landfall at Fanø, passing the 10m contour 6.5 km from the landfall and the 5m contour 3.8km from the landfall.

5.1.5 Route Option 4 Description

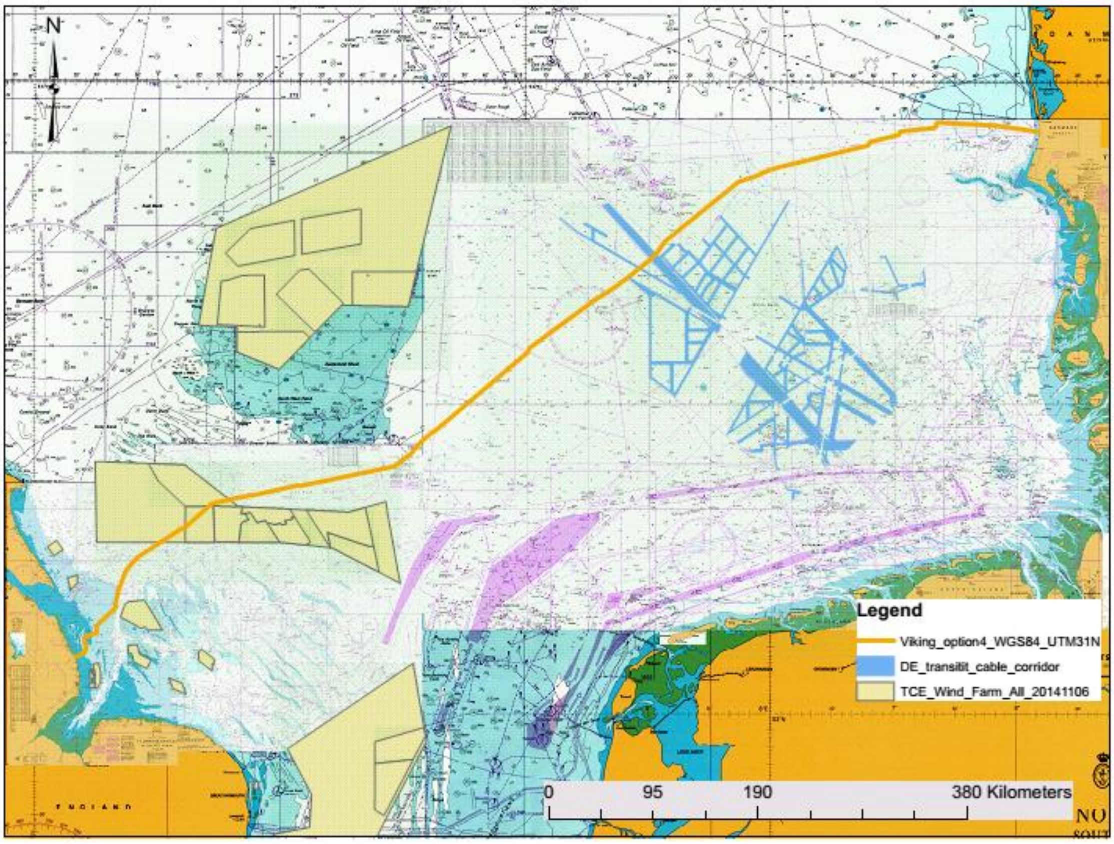

Figure 6. Route Option 4 Overview

Route option 4 also originates at the Huttoft UK landfall, crossing the 5m contour at 1.5km and the 10m contour at 4.7km. It then crosses a group of 4 pipelines which land close by at Theddlethorpe.

A dog's leg is then necessary to negotiate the marine aggregate extraction areas 179 and 106/3. The route then heads North East remaining to the West of Silver Pit, after which there is a crossing with the proposed Hornsea export cable corridor, before the route passes to the West of the Amethyst Gas Field.

The route rounds the Northern end of the Silver Pit, before turning to head North East and passing to the North of the Hyde and Hoton gas fields. The route then transits the Hornsea round three wind farm zone, remaining clear of the project 1 & 2 areas and passing through SPC 5 & 6.

Once clear of the zone, the route turns to the East, passing through the Outer Silver Pit region, the route then passes to the North of the Ketch gas field prior to crossing the UK/NL EEZ and heads towards the narrow section of German territorial waters, North of the designated wind farm areas.

In Dutch waters the route heads North East, passing North of the Hanze Oil field before crossing the NL/DE EEZ.The route then passes South of a designated research area, before transiting into Danish waters.

In Danish waters the route passes South of the Dan oil field then continues heading East North East towards the Blabjerg landfall.

On the approached to the land fall the route passes north of both the Hornsrev 3 wind farm development area and the North Horns Rev Danger Area and crosses the 10m contour 2.5km from the Blabjerg landfall.

5.1.6 Route Option 5 Description

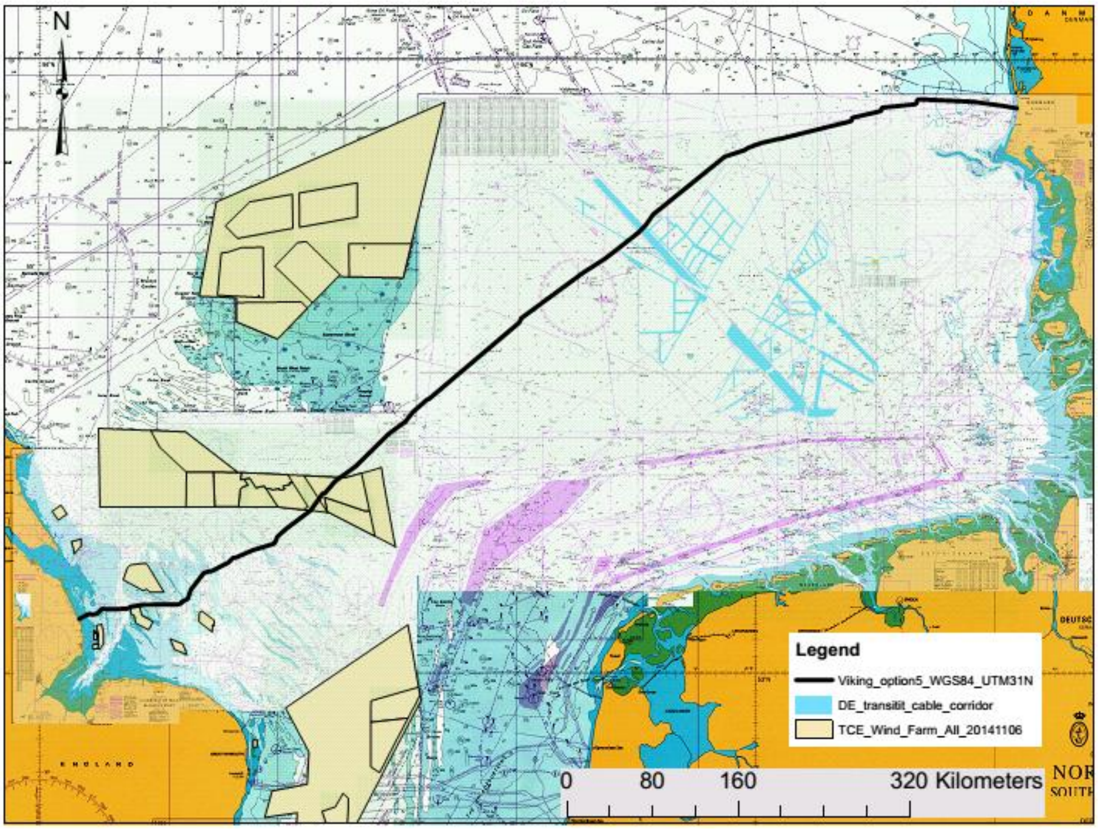

Figure 7. Route Option 5 Overview

From the Huttoft UK landfall, the 5m depth contour is 1.5km distant and the 10m contour is 5km distant. The route crosses the proposed Triton Knoll export cable corridor before passing north of the Inner Dowsing Bank. The route continues in an easterly direction, passing to the North of the Race Bank wind farm development and north of the East Dudgeon Shoals.

The route then heads in a North Easterly direction to pass west of the Guinevere, Lancelot, and Excalibur Gas fields. The Sole Pit is passed to the North of the route, before passing to the North of the Ensign Platform. The route then crosses the north part of the North Swarte Bank and subsequently passes south of the Well Hole.

The route then transits across the Hornsea round three wind farm zone in an easterly direction, crossing the designated no development shipping zone and Project 3 area SPC 7.

The route continues North East, passing South of the Ketch Gas field to the UK/NL territorial waters EEZ and heads towards the narrow section of German territorial waters, north of the designated wind farm areas.

There are few features of note in the 27km of Dutch waters prior to crossing the NL/DE EEZ, however the route then passes South of a designated research area, before transiting into Danish waters.

In Danish waters, the route passes south of the Dan oil field then continues heading East North East towards the Blabjerg landfall.

On the approached to the land fall the route passes north of both the Hornsrev 3 wind farm development area and the North Horns Rev Danger Area; and crosses the 10m contour 2.5km from the Blabjerg landfall.

6.0 BATHYMETRY AND GEOLOGY

6.1 OVERVIEW

The Southern North Sea forms a shallow embayment of the North Sea, with connection via the Dover Straits to the English Channel and the Atlantic Ocean. Within the corridors for the proposed cable the waters are shallow, mainly <50m with occasional deep water within incised linear features on the UK continental shelf (UKCS) such as the Silver Pit and the Sole Pit. Sand ridges that are orientated parallel to the East coast of England are the other dominant feature on the UKCS. Moving Eastwards, the seabed has less extreme features, and exhibits an undulating seafloor, rising gently to the shallow sea and extensive near shore sandbanks off the coast of Denmark. The Dogger Bank encroaches on the Northern limit of the route development envelope, and comprises of a shallow area of extensively reworked sands of predominantly glacigenic origin.

Within the route development envelope, there are designated areas of gas-release seabed structures in the Danish sector (pockmarks and seeps). The known areas are found outwith the proposed optional routes; however the presence of uncharted pockmarks and seabed seeps cannot be discounted along the Danish portions of the route options.

The North Sea Basin is a Palaeozoic to Holocene multistage rift zone within the North-West European Craton (BGS, 1990). Rapid subsidence has taken place during the Pliocene and Pleistocene with a trough of maximum subsistence lying parallel to the East coast of England from the Wash to the Firth of Forth. This is similar to a trough in the Dutch sector, which developed in the Tertiary. Uplift of the western flank of the trough in East Anglia has produced local regressive events, and local unconformities preserved within the stratigraphical record. The subsidence has been calculated to be in the region of 0.4m per thousand years, with a maximum of 255m subsidence in 750 000 years.

The geological factors that are of relevance for the cable route engineering are dominated by the thickness of Pleistocene sediments deposited in the Southern North Sea.

Halokinetic structures within the Pleistocene sediments to the South of the Dogger Fault Zone are thought to be active, and as subsidence continues, there is no reason to consider that faulting is not active within the Pleistocene sediments.

The Pleistocene sediments have been subdivided into a lower regressive phase, and an upper fragmented transgressive / regressive, non-deltaic phase.

The lower, regressive, phase is comprised of mainly deltaic sediments, indicating Northward progradation. It is suggested by Cameron et al. (1987) that there were two deltas: a smaller westerly delta supplied from England, (East Anglia), and an easterly delta, supplied from the European mainland (Low Countries). This phase of development is not considered further.

The upper fragmented transgressive / regressive, non-deltaic division has developed under varying glacial and interglacial conditions, and sediments from this phase are the main areas of interest for the geological description of the route options.

The oldest of the non-deltaic Pleistocene sediments are interpreted as Elsterian (Anglian) subglacial glacilacustrine to glacimarine sediments, the Swarte Bank Formation. The Swarte Bank formation comprises three members which consist of Chalky Jurassic Till (basal member), overlain by glacilacustrine muds, especially in the Dutch sector, which in turn is overlain by a transition from glacilacustrine sediments to marine interglacial sediments. The formation infills deep channel features incising into the underlying deltaic sediments, which have been interpreted as subglacial meltwater channels associated with the maximum advance of the Elsterian (Anglian) ice sheet. The modelled extent of the ice sheet is illustrated in Figure 8. From this it is apparent that the southern North Sea was at the southerly margin of the ice sheet.

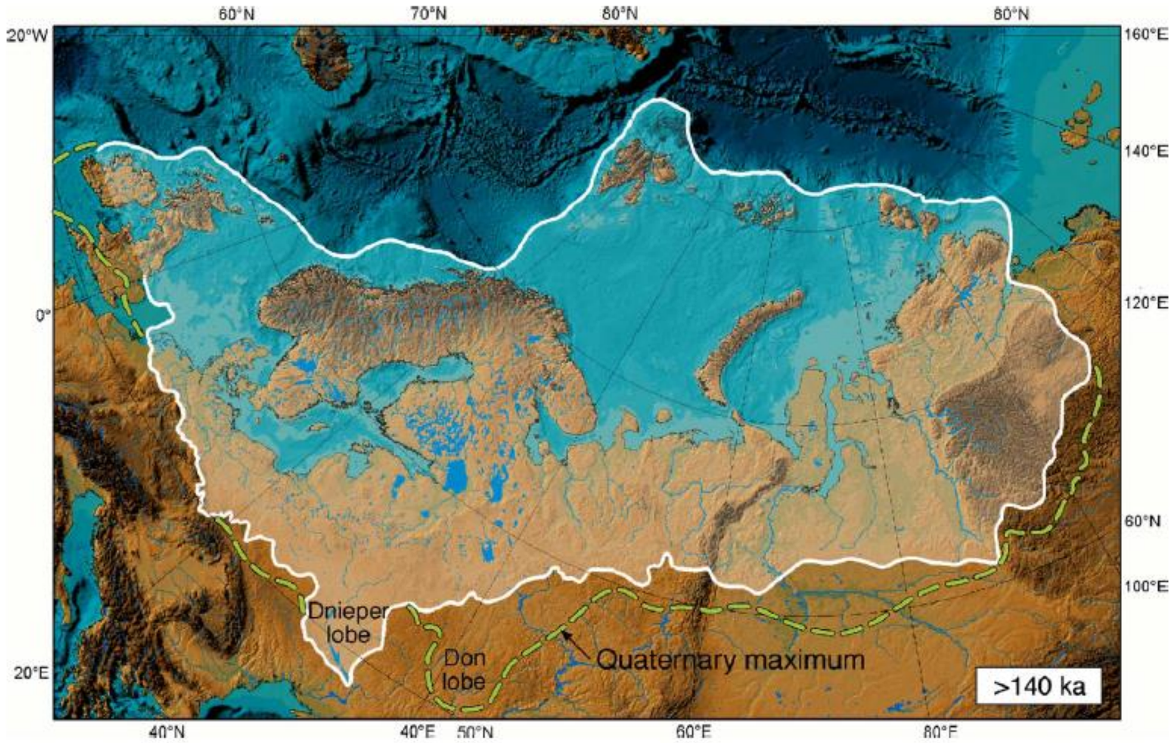

Figure 8. Modelled Limit of Elsterian (Anglian) Glaciation in Eurasia

(Fig. 13 in J. I. Svendsen et al., 2004 /6/)

Overlying the Elsterian (Anglian) sediments are Holsteinian stage formations associated with non-glacial shallow marine conditions. The units are the Sand Hole Formation and the Egmond Ground Formation. The Sand Hole Formation is found locally around the Silver Pit, infilling a bowl-like depression, with seismic expression and borehole samples indicating laminated clays. The Egmond Ground Formation is more extensive and younger than the Sand Hole Formation; it is interpreted as a marine deposit of locally gravelly sands interbedded with silt and clay (Cameron et. al. 1989). It also sits non-conformably on the Swarte Bank Formation infilling the incised channels. The Egmond Ground Formation is c. 8m thick in the west of the area increasing up to is up to 20 m thick within the UK sector, in the centre of deposition within the subsiding basin, and within the incised valleys.

The Saalian stage followed the Holsteinian Stage and was dominated by sedimentation in restricted, shallow marine environments. The Saalian was a glacial period, but there is no evidence that the Southern North Sea was covered by an ice sheet, although the area is interpreted as a partially flooded, periglacial area proximal to the margin of the Saalian icesheet (Balson and Jeffrey, 1991).

Two formations are associated with the Saalian: the Tea Kettle Formation, a thin aeolian deposit which increases in thickness into the Dutch sector, and the Cleaver Bank Formation. The Cleaver Bank Formation is defined as a tabular body of stiff, laminated, dark grey clays with scattered angular granules of chert or chalk, with some intercalated micaceous sands (Cameron et al. 1992). The unit thickens to the east of the UK sector, and to the east of 4°E transitions to the Borkumriff Formation, a subglacial unit (Joon et al. 1990).

The Eemian stage marked a reversal from glacial to interglacial conditions and the North Sea became deeper. The formations representative of this stage are the Eem and Brown Bank formations. The Eem formation is found to the east of 2° 30'E, and is more localised than originally interpreted. Where it is possible to isolate it from the underlying Egmond Ground Formation, it consists of shelly sands, up to 20m thick, passing into finer silt and clay sediments at the west of the extent of the formation.

The Brown Bank formation is located east of 2°E, and comprises of silty clays, deposited in brackish waters at the transition from the Eemian to early Weichselian. This is limited in northern extent to c. 53° 30'N.

The Weichselian stage is the last glacial event which has affected the area. Figure 9 shows the modelled extent of the Eurasian ice sheet, with the main difference between the Saalian and Weichselian extents being a reduction of the ice extent between northern Holland and western Denmark.

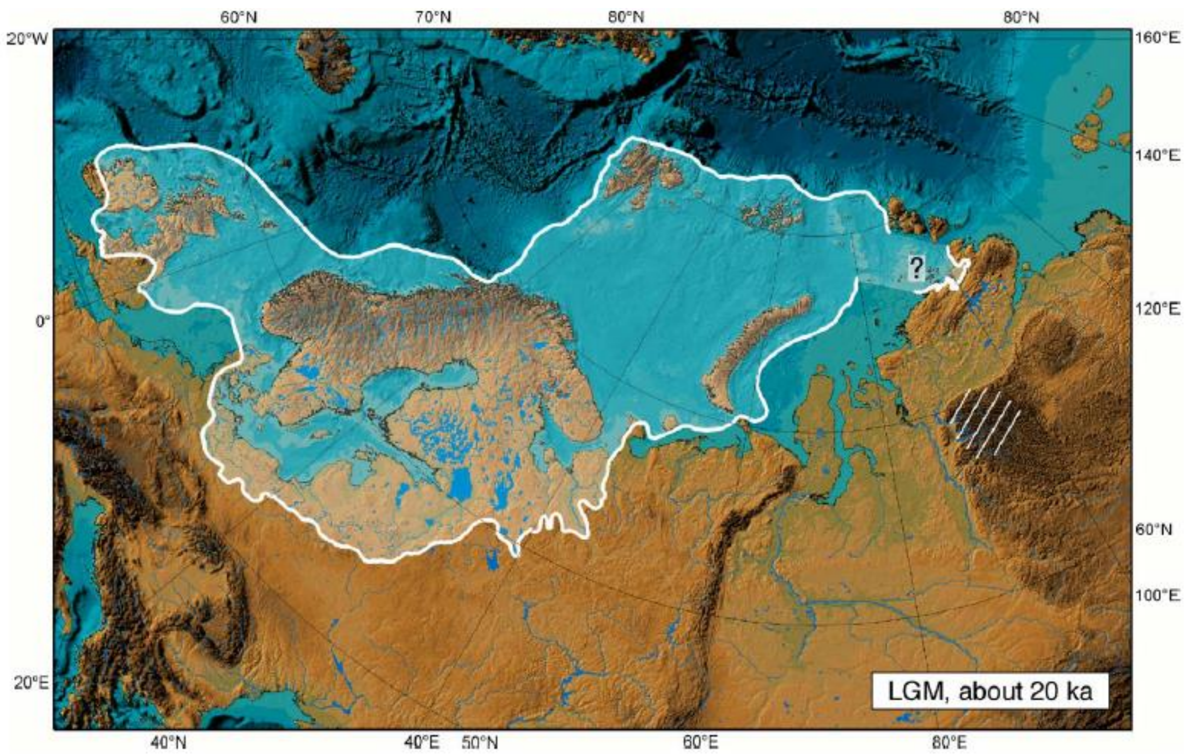

Figure 9. Modelled limit of the Last Glacial Maximum during the Late Weichselian (Devensian) in Eurasia

(Fig. 16 in J. I. Svendsen et al., 2004/6/)

The late Weichselian formations, which are most relevant to the route corridor, are the Bolders Bank and Dogger Bank formations. These are laterally equivalent, and are characterised by diamictons (Bolders Bank) and proglacial, ice proximal glacimarine sediments. The Bolders Bank Formation includes pebbles of chalk and other sedimentary rocks from the east coast of England, as well as exhibiting expressions of deformational structures in the seismic expression of the formations (glacitectonic structures). The Dogger Bank Formation thickens to the north east where the sediments can be up to 42m thick (in the UK sector). There are also localised deposits of aeolian material of the Twente Formation, to the south of the Bolders Bank Formation, and a fluvioglacial system that underlies the Bolders Bank Formation. The latter is localised, but can be several metres thick.

A second phase of subglacial meltwater channels which are thought to have formed by the same process as the Elsterian channels are found incising into the late Weichselian, and older sediments. The upper channels are partially infilled with the Botney Cut Formation, which comprises a lower unit of stiff diamicton, and an upper unit of fluvioglacial to glacimarine origin, which is softer.

The transition from the glacial period to the present interglacial (Holocene), was marked by rising sea level and the deposition of intertidal material, including peats, silts and muds (Elbow Formation), which extends into the Dutch sector and is important for the routes described in detail in the following sections. Other Holocene units have been identified including the Well Hole Formation, which often forms infill within the late Weichselian incised channels, and can be up to 25m thick within the channels. Other Dutch and German equivalent formations are the Nieuw Zeeland Gronden Formation, which is found in the northern part of the area, close to the Dogger Bank and comprises marine silty or sandy reworked material, or muddy fine grained sands. This varies between 1m and 10m thickness. The Western Mud Hole member is found to the east of the median line and varies in thickness from 1m to 7m. The Indefatigable Grounds Formation covers Pleistocene diamictons, and consists of gravelly sand and sandy gravel veneers.

Finally, the Bligh Bank Formation which is equivalent to the Dutch 'Young Sea-sands' comprises marine sands which are in active transportation across the seabed, and includes the tidal sandbank landforms, so can be up to 35m thick, locally.

Holocene sediments are normally thin and overly the late Weichselian sediments, but there has been a degree of reworking, of the late Weichselian sediments, and thin sands are also found in the deeper water. Tidal currents have been responsible for significant sediment transport, although there is some storm wave transport too. Sediment is also provided by coastal erosion of the east coast of England. Close to shore there are large deposits of gravels, especially in the offshore vicinity of the Humber, where aggregate extraction occurs.

6.2 BATHYMETRY

Figure 10 presents the bathymetry of the southern North Sea, as presented in the Ramboll Report.

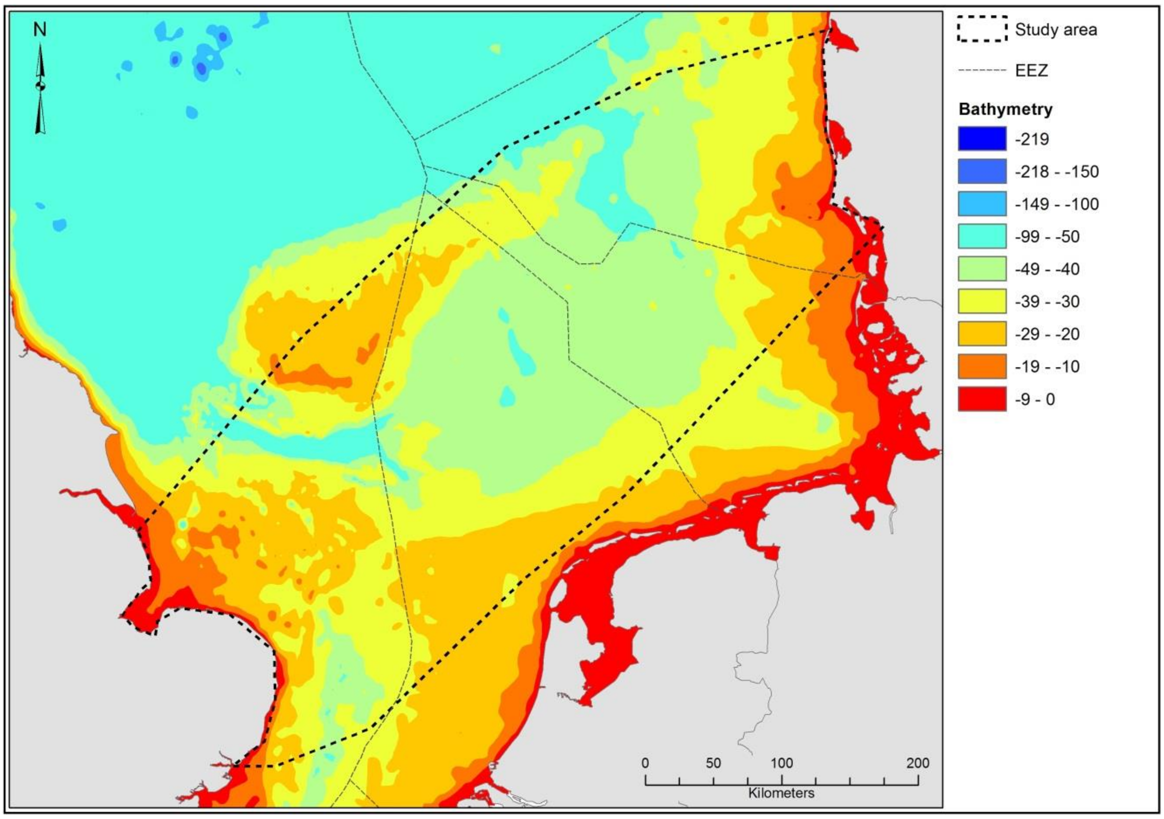

Figure 10. Bathymetry over the corridor area

The bathymetry of the development corridor is complex, with the majority of the water depths being less than 50 m LAT, except across the enclosed deeps such as Sole Pit and the Outer Silver Pit area where depths are close to 100 m LAT. Figure 10 does not illustrate the curvilinear sand ridges which dominate the area to the east of the East Anglian coast, and north east of the Wash, including the Norfolk Banks. Sandwaves and sandbanks are also present in most of the UK sector of the southern North Sea, as well as along the west European coastline, and reflect tidal current activities, and significant sediment transportation.

6.3 SURFICIAL SEDIMENTS

The surficial sediments are composed primarily of gravel, sands, and silts and clays (muds). The distribution of the surficial sediments mirrors the bathymetry. The gravels are mainly located close to the Humber estuary on the UK east coast, and are best delineated by The Crown Estate (TCE) licence areas shown on the constraints map. The sands dominate the areas where sediment transport features occur (both moribund and active), with the size of the sand determined by the strength of the currents and therefore the particle entrainment factors. The finer materials, silts, clay and 'muds' occur in areas where the water is deeper, and less energetic, or where the main sediment environment is inter-tidal with mud flats.

A transect from southwest (Sutton-on-Sea) to northeast (Fanø) would pass over sands associated with the shallow coastal waters, passing into an area of sandy gravel and gravelly sand, extending for c. 50 – 60km before passing into an area of gravelly sand and sand, in the vicinity of the linear sand ridges of the Norfolk Banks. Gravelly sand, sand and localised areas of sandy gravel occur along the route until the route moves into the localised deep of the Outer Silver Pit, where finer sediments will become more common. Moving into the Dutch and German sectors the seabed sediments are expected to be dominated by fine to medium sands, except in localised deeps where finer material is also present. Moving closer to the Danish coastline, the water shallows and large sandbanks are encountered along with coarser material, and gravel banks, which are located on the periphery of the approaches to Fanø. However there are also extensive areas of finer material such as the area of silty sands to the north of the route corridor (GEUS lithology map).

The Danish coastal zone is highly dynamic, due to the shallow waters, interaction of the local currents, plentiful sediment supply and transportation by wave and storm action. In addition the coastal geomorphology is highly vulnerable to erosion by wind and sea, resulting in a highly mobile seabed and unstable coastline. This is very well documented by the work associated with the Horns Rev offshore windfarm development, and ongoing environmental monitoring.

6.4 SHALLOW GEOLOGY

The shallow geology differs between the northern and southern route options, as the southerly route does not cross late Weichselian sediments until it approaches the German and Danish sectors. The southern route crosses older sediments from the Eemian stage and onset of the Weichselian, which represented marine sands with clay-laminae, and are typical of a regressive marine environment. This area also has significant thicknesses of Holocene sand overlying the older sediments. Section 6.1 introduced the geological stratigraphy and Formation descriptions in some detail. Section 6.6 includes a general soils description which highlights this difference, for each of the route options.

6.5 HAZARDS

The geological hazards include:

- Large scale sediment bedforms such as sand ridges, sand banks, and active sandwaves, especially in the UK and DK sectors. Where these cannot be avoided by routing, due to other constraints, there will need to be careful design of protection in order to ensure burial is maintained. As an alternative, consideration should be given to mitigating dynamic seabed conditions by post construction activities.
- Mobile sediment is widespread across the southern North Sea, and an understanding of the areas where sediment transport occurs will need to be presented for the routes, to ensure that the cable protection is sufficient to counteract de-burial, or deposition of sand. In particular, the Danish landfalls are located within a very dynamic coastal environment, and the cable protection required to mitigate the processes will need appropriate design.
- Enclosed deeps, where the steep side walls will present hazards to the cable installation and difficulties in protection. These are avoided by the micro-routing.
- Gas escape features (pockmarks) are noted in the east of the route area and present a hazard for the cable. Although the routes avoid the known area of gas escape features, the

survey background briefing pack should address the possibility of encountering this geo-hazard, either as seabed features, or areas of shallow gas and gas chimneys within the shallow geology. Gas escape features should be avoided by micro-routing.

- Peat layers, including buried layers, have been noted in the Elbow Formation, and have been found in the Leman Bank, as well as the Danish and Dutch nearshore approaches. Peat can present an installation hazard, and should be avoided. Survey data interpretation should consider the presence of peat.

- Gravel rich sediments can be hazardous to cable protection, and avoided where micro-routing permits, however if large areas of gravel cannot be avoided, the most efficient method of cable burial will need to be considered.
- Glacial diamictons, (non sorted or poorly sorted sediments) can be problematic for cable burial operations. Large areas of the route are underlain by glacial diamicton, so it cannot be avoided, however the presence of this material needs to be acknowledged and taken into account in the cable burial and protection design

6.6 ROUTE DESCRIPTIONS

The following route descriptions give a brief summary of the likely shallow geology and seabed sediments to be encountered.

Note, that in the area of the cable route options, there is no contiguous stratigraphic sediment chart, and as such, areas in the central part of the southern North Sea are not described in as much detail as those in the UK and Danish Sectors. In addition, there is no Quaternary map available for the Danish sector, so the seabed sediments, especially where associated with diamicton and coarse sediment areas are suggested to overly harder materials of glacigenic origin. The descriptions are general and should be treated as an indication of what is to be encountered, and are not definitive. The detailed interpretation and description of the routes from the acquired survey data will supersede the general information presented in this report.

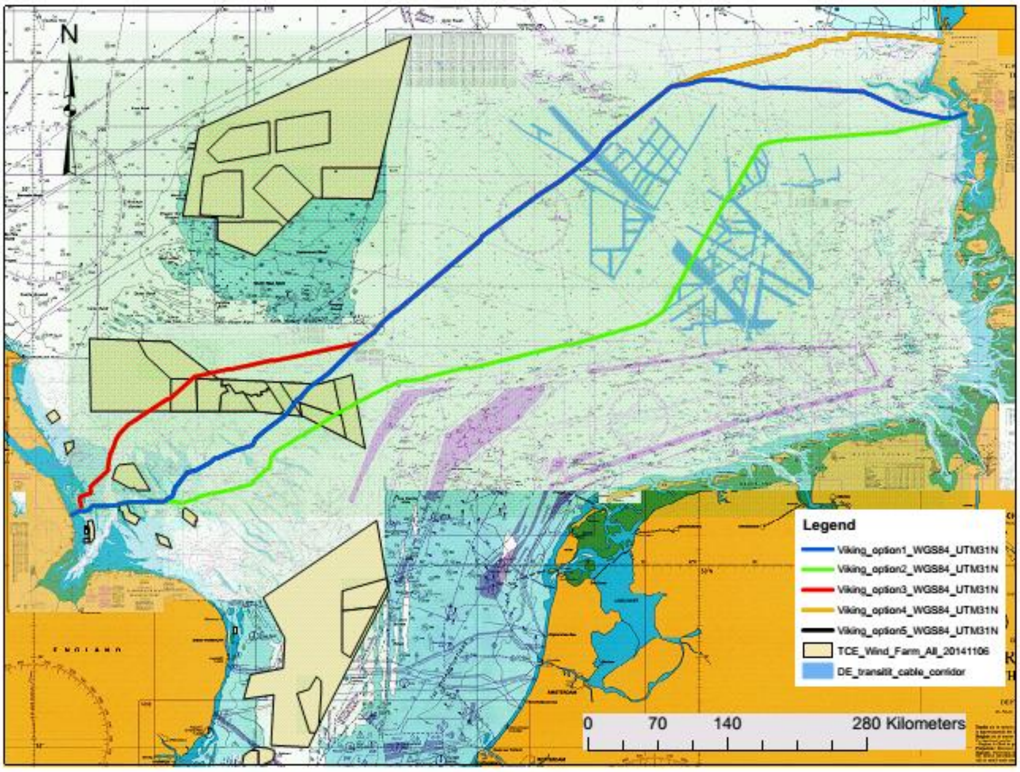

Figure 11. Route Option Overview

Note: Route Option 5 is not displayed on the overview due to being common with sections of routes 1 and 4, for details of route 5 see Figure 7.

Note: Route option 5 is not displayed on the overview.

Route options 1, 3, 4 and 5 all represent variations on the northerly route, ie, traversing the Hornsea development area to the east (Route Option 1) and west (Route Options 3, 4 and 5) of current and ongoing windfarm developments (SMartWind and Hornsea), and alternate Danish landfalls at Fanø (Route Options 1 and 3) and Blaaberg (Route Options 4 and 5).

Route Option 2 is the southerly route, with the Danish landfall at Fanø.

6.6.1 Route Option 1

Route Option 1 is the northerly route which passes the Hornsea development area to the east of the current windfarm development, and terminates at Fanø.

The route passes between the sand ridges associated with the Cromer Knoll and Outer Dowsing, the seabed is predominantly sand, with coarser sand, and occasionally gravelly sand to sandy gravel between the ridges. Locally these are likely to be minor outcrops of the underlying Bolders Bank Formation (glacial diamicton), and reworked material cannot be excluded. The route passes across the southern part of the Sole Pit which is infilled with the well-laminated softer sediments of the Botney Cut Formation, although a veneer of sand is probable above the softer material. The route then passes across a shallow area, characterised by coarse sands to sandy gravels, where the Bolders Bank Formation crops out at seabed. The route crosses the Markham's Hole which is characterised by muddy Sand and represents a soft infill unit of the Botney Cut Formation. The route then crosses over more outcropping Bolders Bank Formation (glacial diamicton) before crossing the finer, muddy Sands and sandy Muds of the Outer Silver Pit and the Botney Cut, which are infilled with sediments of the softer Botney Cut Formation. The route then intersects with and shares the same corridor as Route Option 3, on the margins of a slight bank near the South Rough.

Moving eastwards, the route crosses over the sand and sandy muds in the centre of the Southern North Sea, approaching the Netherland/German boundary across the Clay Deep, which provides another indication of the nature of the seabed sediments and shallow geology. The sediments within the German sector are a mixture of gravelly sands and muddy sand, which is indicative of the underlying Dogger Bank Formation equivalent.

The route then passes into areas of sandy mud becoming more sand-dominated as the route moves eastwards. Route Option 1 crosses large areas of sand dominated seabed, with a band of gravel and coarse sands, overlying glacial diamicton, but with occasional outcrops of glacial material at seabed.

Some micro-routing may be required on the approaches to Fanø, where the route crosses over a larger expanse of gravel and coarse sand.

6.6.2 Route Option 3

Route Option 3 has a different route from the UK nearshore, crossing the shallows of the Humber Estuary Approaches to the northeast and keeping to the western margins of the Silver Pit to the north of Amethyst Field, before swinging to the north east across the northern limb of the Silver Pit. This section is routed via the western side of the Silver Pit in order to avoid the high seabed gradients. The route avoids the most extensive gravel accumulations, which are found offshore from the Humber Estuary, and hence the marine aggregate extraction areas, which target this resource.

The shallow geology is dominated by the glacial diamicton of the Bolders Bank Formation., Where outcrops of this occur at the seabed the surficial sediments typically comprise gravelly sands and sandy gravels. Where the route crosses over the margins of the less deeply incised pit features, such as the Outer Silver Pit, the sediment will be softer, infilling silts and clays of the Botney Cut Formation, and the older Outer Silver Pit Formation of shallow marine sediments.

The route then passes the Hornsea Wind Farm on the west side of the development area, emerging into the western part of the Skate Hole. This deeper area of sea forms the western limb of the Outer Silver Pit. The sediments within the depression are expected to comprise of the softer silts and clays of the Botney Cut Formation, and, to the east, the older Outer Silver Pit Formation of shallow marine sediments (soft silts and clays). The route then continues to the north east, passing to the north of the Schooner Oil Field, continuing eastward across the Outer Silver Pit to the intersection point with the Route Option 1, in the vicinity of the South Rough.

Moving eastwards, the route crosses over the sand and sandy muds in the centre of the Southern North Sea, approaching the Netherland/German boundary across the Clay Deep, which provides another indication of the nature of the seabed sediments and shallow geology. The sediments within the German sector are a mixture of gravelly sands and muddy sand, indicative of the underlying Dogger Bank Formation equivalent.

The route then passes into areas of sandy mud which become more sand-dominated to the east. Some micro-routing may be required where the route crosses over a larger expanse of gravel and coarse sand. Be aware that the southerly continuation of the second (inner) band of gravel and coarse sand, along with a possible subcrop of glacial diamicton, is much narrower and comprises thin features of gravel and coarse sand, and areas of Quaternary clay and silt.

6.6.3 Route Option 4

This comprises Route Option 3 for most of the route, crossing the western side of the Hornsea Windfarm and the common segment to the CPA of the northern boundary of the German EEZ, where this option diverges to the north, and terminates at the landfall at Blaaberg.

The relevant descriptions presented above show the expected shallow geology and seabed sediments and features for the coincident legs of the route, and are not presented here, to avoid repetition.

From the point of divergence, Route 4 continues to the east northeast and passes across large areas of sand dominated seabed, with a band of gravel and coarse sands, overlying glacial diamicton, with occasional outcrops of diamicton, for c. 10-15km. To the east of this is a thinner band of sand, which then passes into a second band of gravel and coarse sand, with outcrops of glacial diamicton. To the east the sediment is again dominated by sand, but with a large area of muddy sand on the approaches to the landfall. Several pipes and cables approaches land in this corridor, so it is likely that the constraint on the route will be the other infrastructure, rather than the nature of the seabed sediments.

6.6.4 Route Option 5

Route Option 5 follows the same route as Route Option 1 from the UK landfall, to the intersection point with the CPA of the northern boundary of the German EEZ, where this option diverges to the north, and terminates at the landfall at Blaaberg.

The route passes between the sand ridges associated with the Cromer Knoll and Outer Dowsing, the seabed is predominantly sand, with coarser sand, and occasionally gravelly sand to sandy gravel between the ridges. Locally these are likely to be minor outcrops of the underlying Bolders Bank Formation (glacial diamicton), and reworked material cannot be excluded. The route passes across the southern part of the Sole Pit which is infilled with the well-laminated softer sediments of the Botney Cut Formation, although a veneer of sand is probable above the softer material. The route then passes across a shallow area, characterised by coarse sands to sandy gravels, where the Bolders Bank Formation crops out at seabed. The route crosses the Markham's Hole which is characterised by muddy Sand and represents a soft infill unit of the Botney Cut Formation. The route then crosses over more outcropping Bolders Bank Formation (glacial diamicton) before crossing the finer, muddy Sands and sandy Muds of the Outer Silver Pit and the Botney Cut, which are infilled with sediments of the softer Botney Cut Formation. The route then intersects with and shares the same corridor as Route Option 3, on the margins of a slight bank near the South Rough.

Moving eastwards, the route crosses over the sand and sandy muds in the centre of the Southern North Sea, approaching the Netherland/German boundary across the Clay Deep, which provides another indication of the nature of the seabed sediments and shallow geology. The sediments within the German sector are a mixture of gravelly sands and muddy sand, which is indicative of the underlying Dogger Bank Formation equivalent.

From the CPA with the German EEZ boundary, Route Option 5 continues to the east northeast and passes across large areas of sand dominated seabed, with a band of gravel and coarse sands, overlying glacial diamicton, with occasional outcrops of diamicton, for c. 10-15km. To the east of this is a thinner band of sand, which then passes into a second band of gravel and coarse sand, with outcrops of glacial diamicton. To the east the sediment is again dominated by sand, but with a large area of muddy sand on the approaches to the landfall.

Several pipes and cables approaches land in this corridor, so it is likely that the constraint on the route will be the other infrastructure, rather than the nature of the seabed sediments.

6.6.5 Route Option 2 – Southerly Route

Route Option 2 is the southerly route from the UK landfall to Fanø. It passes from the UK coastal zone which is dominated by the extensive sand bodies that have accumulated across the mouth of the channel from The Wash, into the areas of offshore sand banks and linear ridges. The route crosses the Dungeon Shoals, which are composed of sands with coarse gravels, and sands in the deeper areas. The coarser sediments are associated with the glacial diamicton of the Bolders Bank Formation. The route then passes into the area where the Southern Gas Fields are located, and the routing is constrained more by the subsea architecture than any specific geological and seabed sediment factors. However, the route does avoid the Norfolk Bank area where there are significant linear sand ridges. These features trend in a northwest to southeast orientation and are associated with strong tidal current activity and sediment transport, which would consequently form significant obstacles to routing.

The route follows a north easterly direction, crosses the southern part of the Well Hole linear deep, and encounters the softer and finer sediments of the Botney Cut Formation. The route then turns eastward to parallel existing infrastructure, and crosses both sand-dominated areas and areas where coarser sediment indicates outcrops of the Bolders Bank Formation.

The route continues eastward until it crosses into the traffic separation area, where the heading changes to north northeast (Figure 11). This part of the route falls between sands and the Bolders Bank Formation outcrops to the northwest of the route, and the softer muddy Sands which are found in the western Mud Hole. This also marks a transition from the glacial diamicton of the Bolders Bank Formation to the Eemian Formation. The Eem Formation is an older unit associated with the warmer, marine high stand of the Eemian Stage, and comprises of fine to very fine, shelly marine sands. There are also localised deposits of the older (Saalian) Cleaver Bank Formation which subcrop the Eem Formation to the south of the Cleaver Bank and consist of proglacial silty clays and fluvioglacial very fine to fine outwash sands interbedded with silt and clay.

The route then continues across the deeper, central area of the Southern North Sea towards the border between Dutch and German sectors, with sand dominated seabed sediments, and the Eem Formation underlying the sand.

The route is constrained in the German sector by restricted crossing corridors which have been defined by the German authorities to regulate the numerous HVDC and HVAC cables, which will be installed to serve the planned offshore wind parks development strategy. As such, the seabed sediment and shallow geology are secondary constraints for routing, and the route head to the north east along one of the defined corridors. The German seabed sediment chart indicates that sand is still present over approximately half of the area crossed by the cable route, but that increasing quantities of muddy sand occur. Additionally, there is an increase in areas of gravelly sand, interspersed between the sand-dominated zone towards the north eastern third of the German section of the route.

The cable route swings to the east to enter Danish waters, and is again constrained by a boundary delineating an environmentally sensitive area. As such, the route crosses from a predominantly sandy seabed to a feature comprising gravel and coarse sand, with an outcrop of glacial diamicton, back to sand, and then across a significant area of gravel and coarse sand. The route passes over sand, and then over the Quaternary clay and silt which was described for Route Option 3, before crossing the final sand area to the landing point.

Note that the Danish chart does not map peats, but as discussed in Section 6.5, these have been identified in the Danish Sector and can be a hazard.

7.0 EXISTING & PLANNED SUBSEA INFRASTRUCTURE

7.1 GENERAL

The route development process has addressed existing infrastructure, including wells, platforms, pipelines, umbilicals, power cables and telecoms cables.

7.2 OIL & GAS

The Southern North Sea is heavily exploited for its gas reserves, and significant infrastructure associated with gas exploitation is therefore present. Within the study area there are numerous hydrocarbon fields, platforms, wells and subsea structures. In addition, there are a significant number of pipelines transporting gas back to terminals at the coast and linking Europe and Scandinavia.

The proposed route options have been developed to avoid major oil and gas infrastructure and well heads.

Pipeline crossings have been avoided when the route development associated with avoiding them has not significantly increased the route length.

Minimising pipeline crossings has two benefits:

- Improved cable security
- Potential installation cost savings

There is ultimately an economic trade-off between an increase in cable length, to reduce the number of pipeline crossings, and the construction costs of crossing the pipeline.

As a general principle, it has been assumed, that the break-even point, is an increase in cable length of approximately 0.75km. The assumed installed cost of bundled HVDC cables being in the region of £1M/ 0.75 km and the cost of a typical pipeline crossing being in the region of£1M.

These cost estimates have been applied as a rule of thumb during the cable route development process.

7.3 POWER CABLES

There is currently only one HVDC interconnector (NorNed) that is crossed by the proposed routes, but there are also two platform supply power cables crossed by route option 3. However these are laid in parallel to pipelines so a single crossing operation should be feasible.

Additionally, there are two proposed wind farm export cables, Triton Knoll and Hornsea, which cross route options 1,2 & 5 and 3 & 4 respectively.

Triton Knoll is known to be planning an HVAC system, whilst Hornsea are still looking at both HVDC and HVAC options. Both crossing points will potentially be multiple cables, in relatively shallow water and early consultation is recommended to discuss feasibility and crossing engineering options.

7.4 TELECOMS CABLES

The route options cross a number of fibre optic telecoms cables, crossing angles at cable crossings are generally less critical than pipelines, but these have also been engineered to 90° in the first instance.

7.5 ROUTE SPECIFIC

The following tables list the crossings on route options 1 to 4 and there is also a summary table of existing crossings for comparison. For clarity; out of use, under construction and proposed infrastructure have been omitted from the summary table.

Asset *	Option 1	Option 2	Option 3	Option 4	Option 5
Pipeline	16	20	21	24	19
Umbilical	0	1	0	0	0
FO Cables	7	5	7	5	5
Power Cables	1	1	3	3	1
Totals	24	27	31	31	25

* Proposed, Under construction and Out of Use excluded.

Table 5. Summary Crossing List

7.5.1 Route Option 1 Crossing List

ID	Asset Type	Status	Name	Owner/Operator	Comments
001	Power Cable	Proposed	Triton Knoll Export	Triton Knoll	HVAC
002	28" Gas Pipeline	In Use	Viking to Theddlethorpe	ConocoPhillips	
003	36" Gas Pipeline	In Use	Loggs to Theddlethorpe	ConocoPhillips	4" Methanol Piggyback
004	12" Gas Pipeline	In Use	Lancelot to Galahad	Perenco	3" Chemical Piggyback
005	34" Gas Pipeline	In Use	Shearwater to Bacton	Shell	(SEAL)
006	16" Gas Pipeline	In Use	Barque to Clipper	Shell	
007	24" Gas Pipeline	In Use	Esmond to Bacton	Perenco	
008	10" Gas Pipeline	In Use	Annabel to Audrey	Centrica	Control Umbilical
009	14" Gas Pipeline	In Use	Saturn ND to Loggs PR	ConocoPhillips	3" Methanol Piggyback
010	FO Cable	In Use	Tampnet	Tampnet	
011	36" Gas Pipeline	In Use	?	Noordgass Transport BV	
012	40" Gas Pipeline	In Use	Sleipner (N)	Statoil ASA/GASCO	
013	42" Gas Pipeline	In Use	Franpipe	Statoil ASA	
014	FO Cable	Out of Use	UK-GER 6	BT	
015	FO Cable	In Use	Tata North Europe	Tata Communications	
016	20" Gas Pipeline	In Use	?	Wintershall Nordzee BV	4" Condensate Piggyback
017	26" Gas Pipeline	In Use	?	Maersk Oil	
018	36" Gas Pipeline	In Use	Ekofisk	ConocoPhillips	
019	40"Gas Pipeline	In Use	Draupner-Emshaven	Statoil ASA	
020	FO Cable	Out of Use	TAT 10B	DTAG	
021	FO Cable	In Use	Pangea North	ASN	
022	FO Cable	In Use	Atlantic Crossing 1	Level 3	
023	HVDC Cable	In Use	NorNed	Statnett	
024	FO Cable	In Use	TAT 14 (Seg N)	Teliasonera	
025	42" Gas Pipeline	In Use	Europipe II	Statoil ASA/GASCO	
026	FO Cable	In Use	Cantat 3 (Seg F7)	Faroese Telecom	
027	FO Cable	In Use	Pangea North	ASN	

Table 6. Route Option 1 Crossing List

7.5.2 Route Option 2 Crossing List

ID	Asset Type	Status	Name	Owner/Operator	Comments
001	Power Cable	Proposed	Triton Knoll Export	Triton Knoll	
002	6" Gas Pipeline	In Use	Durango to Waveney	Perenco	
003	20" Gas Pipeline	In Use	Lancelot to Bacton	Perenco	3" Chemical Piggyback
004	34" Gas Pipeline	In Use	Shearwater to Bacton	Shell	(SEAL)
005	36" Gas Pipeline	In Use	Loggs to Theddlethorpe	ConocoPhillips	4" Methanal Piggyback
006	24" Gas Pipeline	In Use	Esmond to Bacton	Perenco	
007	24" Gas Pipeline	In Use	Clipper PT to Bacton	Shell	
008	3.5" Chemical Line	In Use	Bacton to Clipper PT	Shell	
009	28" Gas Pipeline	In Use	Viking to Theddelthorpe	ConocoPhillips	
010	20" Gas Pipeline	In Use	Audrey to Loggs	Centrica	3" Methanol Piggyback
011	14" Gas Pipeline	In Use	Saturn to Loggs	ConocoPhillips	3" Methanol Piggyback
012	Umbilical	In Use	Audery to Alison	ConocoPhillips	
013	12" Gas Pipeline	In Use	Ann XM to Loggs	Centrica	
014	20" Gas Pipeline	In Use	Carrack to Clipper	Shell	4" MEG Line Piggyback
015	FO Cable	In Use	Tampnet	Tampnet	3" MEG Line Piggyback
016	10" Gas Pipeline	Inuse	Chiswick to Markham	Certrica	
017	40" Gas Pipeline	In Use	Sleipner (N)	Statoil ASA/GASCO	
018	42" Gas Pipeline	In Use	Franpipe	Statoil ASA/GASCO	
019	36" Gas Pipeline	In Use	?	Noordgass Transport BV	
020	24" Gas Pipeline	In Use	?	Wintershall Nordzee BV	
021	24" Gas Pipeline	In Use	?	GDF Suez	
022	FO Cable	Out of Use	UK-GER 6	BT	
023	FO Cable	In Use	Tata North Europe	Tata Communications	
024	36" Gas Pipeline	In Use	Ekofisk	ConocoPhillips	
025	40"Gas Pipeline	In Use	Draupner-Emshaven	Statoil ASA/GASCO	Europipe 1
026	FO Cable	Out of Use	TAT 10B	DTAG	
027	HVDC Cable	In Use	NorNed	Statnett	
028	FO Cable	In Use	Atlantic Crossing 1	Level 3	
029	FO Cable	In Use	TAT 14 (Seg N)	Teliasonera	
030	42" Gas Pipeline	In Use	Europipe II	Statoil ASA/GASCO	
031	FO Cable	In Use	Cantat 3 (Seg F7)	Faroese Telecom	

Table 7. Route Option 2 Crossing List

7.5.3 Route Option 3 Crossing List

ID	Asset Type	Status	Name	Owner/Operator	Comments
001	28" Gas Pipeline	In Use	Viking to Theddlethorpe	ConocoPhillips	
002	36" Gas Pipeline	In Use	Loggs to Theddlethorpe	ConocoPhillips	4" Methanal Piggyback
003	24" Chemical	In Use	Pickerall to Theddlethorpe	Perenco	
004	26" Gas Pipeline	In Use	Murdoch to Theddlethorpe	ConocoPhillips	4" Methanal Piggyback
005	Power Cables	Proposed	Hornsea Export cables	Dong/SMartWind	
006	30" Gas pipeline	In Use	Amethyst to Easington	Perenco	
007	Power Cable	In Use	Amethyst to Easington	Perenco	
008	12" Gas Pipeline	In Use	Amethyst C1D to Amethyst A1D	Perenco	
009	Power Cable	In Use	Amethyst C1D to Amethyst A1D	Perenco	
010	24" Gas Pipeline	In Use	Sole to Easington	Perenco	
011	12" Gas Pipeline	In Use	Babbage Export	EON	
012	34" Gas Pipeline	In Use	Shearwater to Bacton	Shell	
013	24" Gas Pipeline	In Use	Esmond to Bacton	Perenco	
014	4" Methonol	In Use	Theddlethorpe to Murdoch	ConocoPhillips	
015	6" Gas Pipeline	In Use	Topaz to Schooner	RWE	
016	FO Cable	In Use	Tampnet	Tampnet	
017	18" Gas Pipeline	In Use	Ketch to Murdoch	Tullow	
018	36" Gas Pipeline	In Use	?	Noordgass Transport BV	
019	40" Gas Pipeline	In Use	Sleipner (N)	Statoil ASA/GASCO	
020	42" Gas Pipeline	In Use	Franpipe	Statoil ASA	
021	FO Cable	Out of Use	UK-GER 6	BT	
022	FO Cable	In Use	Tata North Europe	Tata Communications	
023	20" Gas Pipeline	In Use	?	Wintershall Nordzee BV	4" Condensate Piggyback
024	26" Gas Pipeline	In Use	?	Maersk Oil	
025	36" Gas Pipeline	In Use	Ekofisk	ConocoPhillips	
026	40"Gas Pipeline	In Use	Draupner-Emshaven	Statoil ASA/GASCO	
027	FO Cable	Out of Use	TAT 10B	DTAG	
028	FO Cable	In Use	Pangea North	ASN	
029	FO Cable	In Use	Atlantic Crossing 1	Level 3	
030	HVDC Cable	In Use	NorNed	Statnett	
031	FO Cable	In Use	TAT 14 (Seg N)	Teliasonera	
032	42" Gas Pipeline	In Use	Europipe II	Statoil ASA/GASCO	
033	FO Cable	In Use	Cantat 3 (Seg F7)	Faroese Telecom	
034	FO Cable	In Use	Pangea North	ASN	

Table 8. Route Option 3 Crossing List

7.5.4 Route Option 4 Crossing List

ID	Asset Type	Status	Name	Owner/Operator	Comments
001	28" Gas Pipeline	In Use	Viking to Theddlethorpe	ConocoPhillips	
002	36" Gas Pipeline	In Use	Loggs to Theddlethorpe	ConocoPhillips	4" Methanal Piggyback
003	24" Chemical	In Use	Pickerall to Theddlethorpe	Pernco	
004	26" Gas Pipeline	In Use	Murdoch to Theddlethorpe	ConocoPhillips	4" Methanal Piggyback
005	Power Cables	Proposed	Hornsea Export cables	Dong/SMartWind	
006	30" Gas pipeline	In Use	Amethyst to Easington	Perenco	
007	Power Cable	In Use	Amethyst to Easington	Perenco	
008	12" Gas Pipeline	In Use	Amethyst C1D to Amethyst A1D	Perenco	
009	Power Cable	In Use	Amethyst C1D to Amethyst A1D	Perenco	
010	24" Gas Pipeline	In Use	Sole to Easington	Perenco	
011	12" Gas Pipeline	In Use	Babbage Export	EON	
012	34" Gas Pipeline	In Use	Shearwater to Bacton	Shell	
013	24" Gas Pipeline	In Use	Esmond to Bacton	Perenco	
014	4" Methonol	In Use	Theddlethorpe to Murdoch	ConocoPhillips	
015	6" Gas Pipeline	In Use	Topaz to Schooner	RWE	
016	FO Cable	In Use	Tampnet	Tampnet	
017	18" Gas Pipeline	In Use	Ketch to Murdoch	Tullow	
018	36" Gas Pipeline	In Use	?	Noordgass Transport BV	
019	40" Gas Pipeline	In Use	Sleipner (N)	Statoil ASA/GASCO	
020	42" Gas Pipeline	In Use	Franpipe	Statoil ASA	
021	FO Cable	Out of Use	UK-GER 6	BT	
022	FO Cable	In Use	Tata North Europe	Tata Communications	
023	20" Gas Pipeline	In Use	?	Wintershall Nordzee BV	4" Condensate Piggyback
024	26" Gas Pipeline	In Use	?	Maersk Oil	
025	36" Gas Pipeline	In Use	Ekofisk	ConocoPhillips	
026	40"Gas Pipeline	In Use	Draupner-Emshaven	Statoil ASA/GASCO	
027	FO Cable	Out of Use	TAT 10B	DTAG	
028	FO Cable	In Use	Pangea North	ASN	
029	FO Cable	In Use	Atlantic Crossing 1	Level 3	
030	HVDC Cable	In Use	Norned	Statnett	
031	FO Cable	In Use	TAT 14 (Seg N)	Teliasonera	
032	42" Gas Pipeline	In Use	Europipe II	Statoil ASA/GASCO	
033	20" Oil Pipeline	In Use	Grome-DK	Maersk Oil	
034	30" Gas Pipeline	In Use	Tyra TE-E -DK	Maersk Oil	
035	Gas Pipeline	In use	Harald - DK	Dong	

Table 9. Route Option 4 Crossing List

7.5.5 Route Option 5 Crossing List

ID	Asset Type	Status	Name	Owner/Operator	Comments
001	Power Cable	Proposed	Triton Knoll Export	Triton Knoll	HVAC
002	28" Gas Pipeline	In Use	Viking to Theddlethorpe	ConocoPhillips	
003	36" Gas Pipeline	In Use	Loggs to Theddlethorpe	ConocoPhillips	4" Methanol Piggyback
004	12" Gas Pipeline	In Use	Lancelot to Galahad	Perenco	3" Chemical Piggyback
005	34" Gas Pipeline	In Use	Shearwater to Bacton	Shell	(SEAL)
006	16" Gas Pipeline	In Use	Barque to Clipper	Shell	
007	24" Gas Pipeline	In Use	Esmond to Bacton	Perenco	
008	10" Gas Pipeline	In Use	Annabel to Audrey	Centrica	Control Umbilical
009	14" Gas Pipeline	In Use	Saturn ND to Loggs PR	ConocoPhillips	3" Methanol Piggyback
010	FO Cable	In Use	Tampnet	Tampnet	
011	36" Gas Pipeline	In Use	?	Noordgass Transport BV	
012	40" Gas Pipeline	In Use	Sleipner (N)	Statoil ASA/GASCO	
013	42" Gas Pipeline	In Use	Franpipe	Statoil ASA	
014	FO Cable	Out of Use	UK-GER 6	BT	
015	FO Cable	In Use	Tata North Europe	Tata Communications	
016	20" Gas Pipeline	In Use	?	Wintershall Nordzee BV	4" Condensate Piggyback
017	26" Gas Pipeline	In Use	?	Maersk Oil	
018	36" Gas Pipeline	In Use	Ekofisk	ConocoPhillips	
019	40"Gas Pipeline	In Use	Draupner-Emshaven	Statoil ASA	
020	FO Cable	Out of Use	TAT 10B	DTAG	
021	FO Cable	In Use	Pangea North	ASN	
022	FO Cable	In Use	Atlantic Crossing 1	Level 3	
023	HVDC Cable	In Use	NorNed	Statnett	
024	FO Cable	In Use	TAT 14 (Seg N)	Teliasonera	
025	42" Gas Pipeline	In Use	Europipe II	Statoil ASA/GASCO	
026	20” Oil Pipeline	In Use	Grome-DK	Maersk Oil	
027	30” Gas Pipeline	In Use	Tyra TE-E - DK	Maersk OIl	
028	Gas Pipeline	In Use	Harald – DK	Dong	

Table 10. Route Option 5 Crossing List

8.0 WIND FARMS

Wind farms, including those constructed, under construction and planned, are present in the region of the proposed route options, both in the UK territorial waters and Danish territorial waters.

8.1 UK WATERS DEVELOPMENT AREAS

In the UK territorial waters the most significant developments are Triton Knoll, Race Bank, Inner Dowsing and Hornsea, each of which present routing constraints.

Inner Dowsing lies to the South East of the proposed UK landing point., Its proximity and the routing of its export cables, combined with the presence of shallow sand banks, effectively rule out an approach from the South East.

Triton Knoll lies to the North East of the proposed landing, and the options for routing to the East are constrained by the presence of both this wind farm and the Race Bank wind farm. As a consequence Route Options 1 & 2 have, by necessity, been routed within the area between the two developments.

The Round 3 Hornsea development area lies 30km North East of the proposed landing and represents a large area, orientated West to East, that is a potential constraint for Route Options 1, 2, 3 & 4. The area is being developed in stages, with Dong currently developing Project 1, SMartWind planning project 2 and the project 3 Areas still in pre-planning. The Viking routes have been developed to avoid the project 1 & 2 areas as follows: options 1 & 2 have been routed to the East of project 1 & 2 and options 3 & 4 to the West.

The project 3 sub sections are assigned to SMartWind and cable Route Options 1,2, 3 & 4 all pass through the project 3 zones, on the basis that these are currently development options, which may or may not be developed prior to the installation of the Viking system.

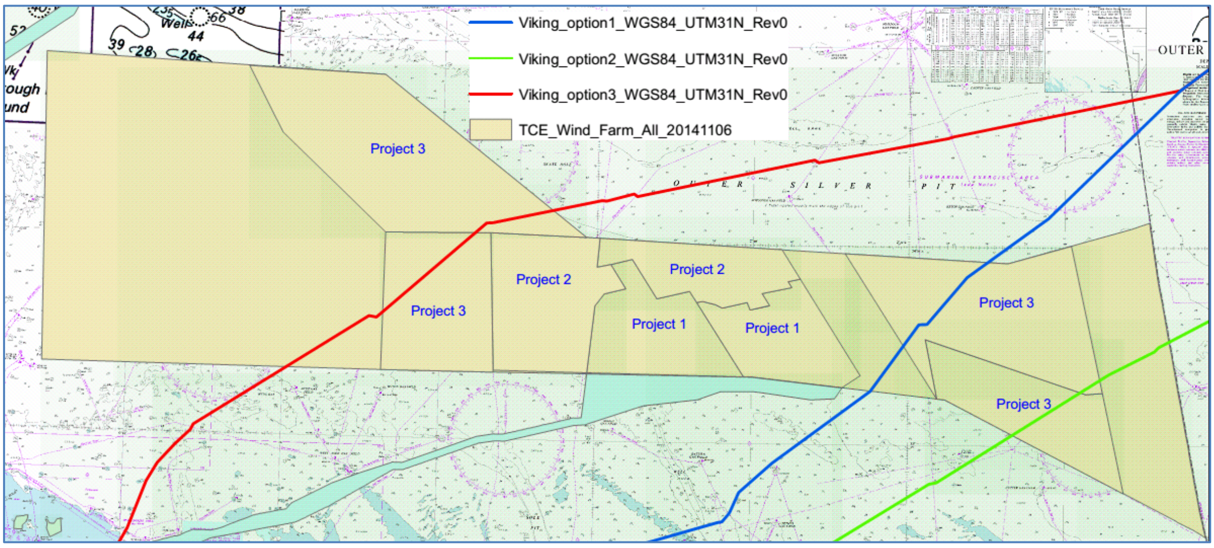

Figure 12. Hornsea Windfarm Project Areas

8.1.1 UK Waters Export Cables

There are two UK Windfarm Export Cable routes which present a potential conflict with the Viking cable route options, Hornsea and Triton Knoll.

Both cables are yet to be built, but they have corridors agreed with The Crown Estate. The Hornsea export cable will have a landfall at Horseshoe Point, approximately 25km north of the proposed Viking landfall areas. The Triton Knoll cables will have a landfall at Moggs Eye, which is within the proposed Viking landfall areas.

Depending on which Viking landfall is selected and which route option is selected, there could potentially be no crossings with either of the windfarm export cables or a crossing of both windfarm export cables. The various scenarios are illustrated in figure 13.

Three UK landfall areas have been identified, designated N 1, N 2 & N3, within the N1 areas 4 landfall sites have been identified, these have been designated N 1 A through D.

In the case of the Moggs Eye landfall, there could be an option to land the Viking cable either to the North of the Triton Knoll cables or to the south of the Triton Knoll cables. This decision will be influenced by the Viking land route and whether a crossing of the land cables is considered preferable to a crossing of the marine cables.

Table 11 lists the current UK landfall options, the route options and identifies the crossing scenarios.

UK Landfall	**Route Options 3 & 4**	**Hornsea**	**Triton Knoll**
N1 A Sandilands		Yes	No
N1 B Huttoft Car Terrace		Yes	No
N1 C Marsh Yard		Yes	No
N1 D Moggs Eye*		Yes	Yes/No
N2 Anderby Creek		Yes	Yes
N3 Chapel St Loenards		Yes	Yes
UK Landfall	**Route Options 1,2 & 5**	**Hornsea**	**Triton Knoll**
N1 A Sandilands		No	Yes
N1 B Huttoft Car Terrace		No	Yes
N1 C Marsh Yard		No	Yes
N1 D Moggs Eye**		No	No/Yes
N2 Anderby Creek		No	No
N3 Chapel St Leonards		No	No

Table 11. Potential Windfarm export cable crossing scenarios

* No for Triton Knoll if Viking landfall is North of TK landfall
** No for Triton Knoll if Viking landfall is South of TK landfall

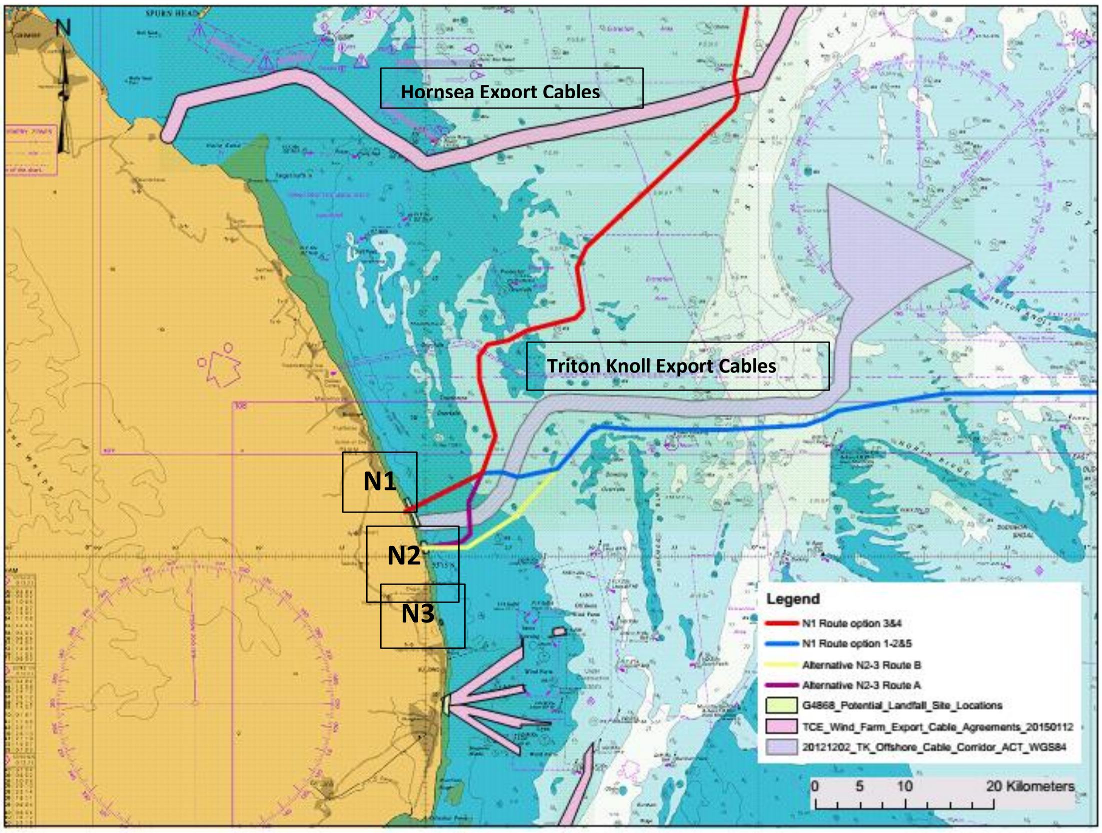

Figure 13. Potential Windfarm export cable crossing scenarios

Figure 13 illustrates the potential crossing scenarios, the two nearshore Viking route options are indicated by the Red line (Route options 3 and 4)and the Blue line (Route options 2,3,and 5) with a provisional landfall at N1 north of the Triton Knoll landfall. The yellow and magenta lines illustrate the scenarios if a land fall south of the Triton Knoll landfall (N2 or N3) is selected.

In conclusion, the least desirable scenario is a landfall at N2 or N3 combined with route options 3 or 4, which will result in crossings with both Hornsea and Triton Knoll; and the best scenario is a landfall at N 2 or N3 combined with route options 1,2 or 5, which will result in no crossings.

The potential crossings situation is one factor that should be bourn in mind when making the final selection of the location of the UK landfall.

8.2 DANISH WATERS

There are three windfarm developments in the waters adjacent to the proposed Danish landfalls; these are Hornsrev 1, 2 & 3. Hornsrev 1 & 2 developments did not present a significant constraint to the route development exercise. Hornsrev 3 presented a constraint on the approaches to the Blabjerg landfall, this necessitated a route diversion to the north of the development area and a landfall location to the north of the export cable corridor. The landfall is also constrained by 3 pipelines and a FO cable. RPA recommend that further investigation and a site survey are carried out to confirm the feasibility of this landfall.

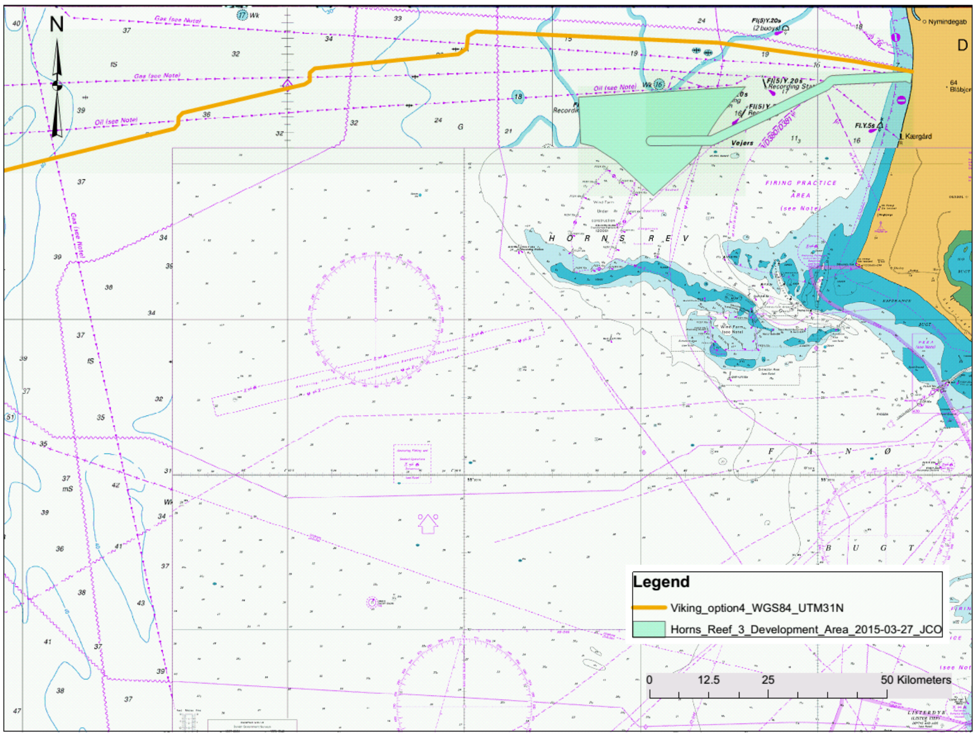

Figure 14. Hornsrev 3 Development Area

9.0 FISHING ACTIVITIES

9.1 INTRODUCTION

This section details current fishing practices and fishing activity in the Southern North Sea. At this stage, four provisional route options have been identified as part of the initial route development (see Viking Route Overview Chart - Fig.15).

Details of the provisional near-shore cable route and beach landing sites are unidentified, however, for the purposes of this fishing summary they are considered to be in the vicinity of the coastal hamlet of Huttoft on the English Lincolnshire coast (Lat 53 15N Long 000 20E) and the Island of Fanø in Denmark (Lat 55 24N Long 008 23E), with a second provisional Danish landing to the south of Nymindegab in the vicinity of Blabjerg, (Lat 55 42N Long 008 09E).

As a guide, and for the purposes of this summary, referencing of fishing grounds, fishing activity and the level of fishing risk in the sea areas covered by the summary will relate to lines of Longitude and Latitude.

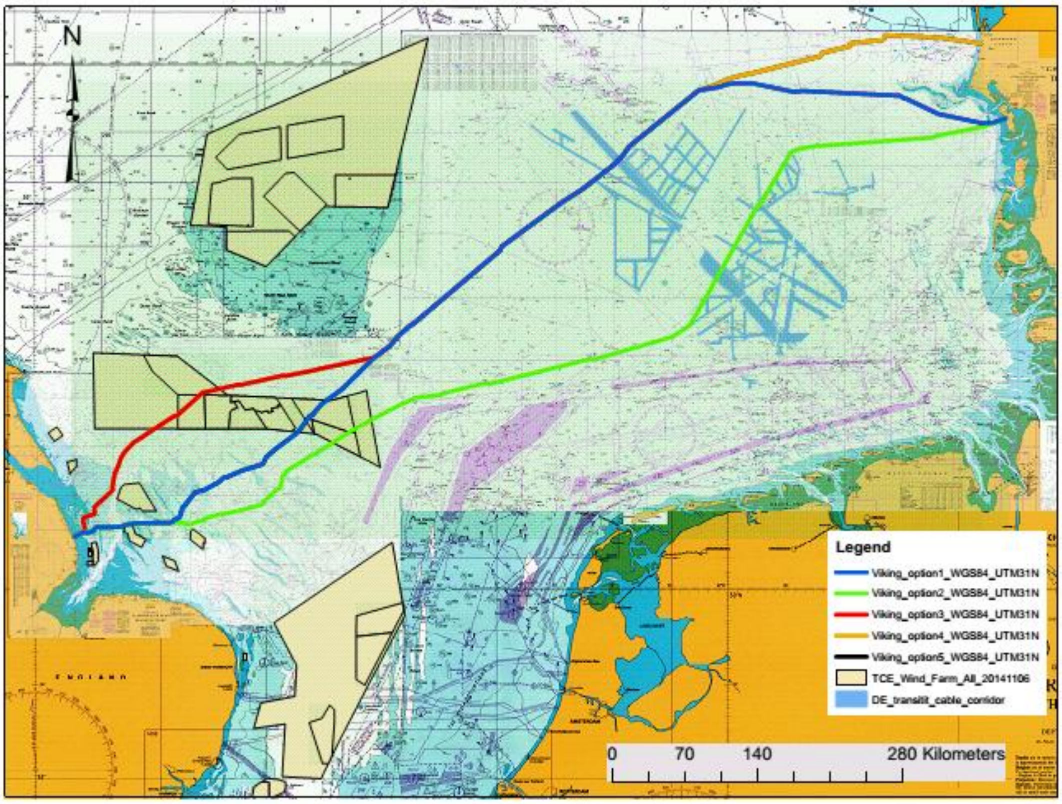

Figure 15. Viking Overview Chart

Note: Route Option 5 is not displayed on the overview due to being common with sections of routes 1 and 4, for details of route 5 see Figure 7

9.2 UK LANDFALL – INSHORE FISHING

The coastal region of Lincolnshire where the beach landing for the Viking cable is being considered could be said to be rather bleak and is generally quiet in fishing terms. The only near-shore fishing carried out in the local area is by static gear boats working from either Grimsby to the north, or boats based in the north Norfolk ports such as Kings Lynn and Wells. Most of the fishing in the inshore waters along the south Lincolnshire coast and out to the 6-mile fishery limit involves traditional static gear fishing with pots, gill nets and lines. There are still, however, a small number of beach boats operating from the nearby towns of Skegness to the south and from Mablethorpe and Saltfleet to the north during the summer months, although this level of fishing is small scale. There is a traditional coastal shrimp trawl fishery that extends near-shore along the coast and south of Skegness, extending south east from Skegness and out to around 6nm and into the Wash Channel.

A combination of static gear gill netting and potting takes place in the inshore waters and in the vicinity of the proposed beach landing out to around 12nm. There are also areas of ground further offshore where static gear fishing takes place, with an emphasis on gill netting to the north in the vicinity of Route Option 3, and potting to the east and south in the vicinity of Route Options 1 and 2.

Figure 16. Typical East Coast Static Gear Beach Boats

9.3 UK WATERS – ROUTE OPTIONS 1 TO 5

Further offshore in UK waters, all four route options would transit fishing grounds where intense static gear fishing takes place, particularly during the spring and summer months. Most of this fishing activity takes place in the area between the coast and east to around Long 001 40E. The Route Option 3 segment transits north east across the Dowsing ground and the Little Silver Pits and Off Ground, where static gear boats based in Grimsby and Bridlington fish. The southerly options 1 and 2 would transit close to the Race Bank grounds and north of Cromer Knoll, which are regular fishing grounds for the north Norfolk static gear fleets.

All these areas are traditional trawling grounds, however, the decline in the east coast and North Sea demersal trawling fleets and the recent growth of east coast static gear fishing in the region has transformed the fishing map in more recent years and this particular area is now predominantly static gear fishing ground. Trawlers are still permitted to fish these grounds; however, the presence of static fishing gear usually prevents trawler skippers from actively fishing the area. Some goodwill agreements are in place between these two fishing sectors to prevent interaction and conflict on the fishing grounds. There are, however, still areas of ground where the nomadic UK scallop dredging fleet will sometimes operate, although these vessels will usually concentrate on dredging the harder grounds to the north of Flamborough Head.

9.4 NORTHERN ROUTE OPTIONS 3 & 4

Moving east of Long 001 40E and further offshore, the northern option 3 & 4 segment transits north east and through the trawling grounds of the South Dogger and South Rough before joining up with the Option 1 route.

The whole area between Long 001 40E and Long 006 00E is trawling ground that is moderately fished by vessels of all the EU member states that border the Southern North Sea. Most of the demersal trawling activity in this region and in the vicinity of the northern Route Option 1 is carried out by Belgian and Dutch beam trawlers of around 30 metres in length and 1600hp and, to a lesser extent, by Danish otterboard trawlers of around 24 metres in length with 500hp. Danish gill netters will also occasionally fish the area.

East of Long 006 00E the Route Options 3 & 4 continue to transit traditional trawling ground. However, the area between Long 006 00E and the Danish coast is softer ground and is an area where Danish, Dutch and German shrimp beam trawlers operate. Most of these trawlers are around 22 metres in length with some 300hp. A number of the modern, Danish Euro-cutter-type trawlers are dual-purpose trawlers that are rigged for trawling with lightweight shrimp beam trawl gear or with demersal otterboard trawl gear. The additional Danish landfall Route Option 4 also transits the softer shrimp trawling grounds where these Danish, Dutch and German shrimp trawlers fish.

Figure 17. Typical 22 metre, 300hp Euro-cutter Shrimp Beam Trawler

9.5 SOUTHERN ROUTE OPTION 2

Continuing east of Long 001 40E the southern Route Option 2 transits shared potting and trawling grounds and continues on to the Botney ground as it deviates north east in the vicinity of Lat 54 00N Long 003 30E and then east again, passing south of Puzzle Hole in the vicinity of Long 005 00E. Dutch and Belgian beam trawlers using open or electronic pulse Sumwing beam gear will occasionally fish all these grounds and in the vicinity of the Green Route Option 2. However, most of the beam trawlers will usually fish further east and in the vicinity of Lat 54 10N and between Long 005 00E and Long 006 00E.

Most of the Dutch beam trawlers that fish in the region are around 38 metres in length with between 1600hp and 2000hp. Some of these Dutch trawlers are Anglo-Dutch flag ships, UK-registered and Dutch owned, operating under the UK flag in order to take advantage of the UK sole and fish quota in the Southern North Sea. In recent years, a number of the large Dutch beam trawlers have been converted for demersal twin-rig otterboard trawling and these vessels also fish in this region. There is also a fleet of Dutch/German-registered beam trawlers that regularly fish this area and north east to around Lat 54 40N Long 006 20E, south of the Weisse Bank.

Although this whole area is predominantly trawling ground, there is an area of ground to the east of Long 006 00E where UK-registered offshore potters operate. Most of this fishing activity is understood to take place in the general area between Lat 54 40N and Lat 55 00N and between Long 006 10E and Long 007 10E. Route Option 2 may transit this area.

To the east of this potting ground Route Option 2 transits the softer Horn Reef and Sylt Aussen shrimp trawling ground. As mentioned, Danish, Dutch and German shrimp beam trawlers fish these grounds. Most of these trawlers are around 22 metres in length with some 300hp. A number of the Danish trawlers are dual-purpose trawlers rigged for trawling with lightweight shrimp beam trawl gear and/or demersal otterboard trawl gear.

The local Danish shrimp beam trawlers fish all the Danish inshore grounds and close inshore in the vicinity of the provisional Danish beach landfall sites. The Dutch and German shrimp beam trawler fleet also fish the whole coastal region of the Danish west coast east of Long 006 30E, and the fishery extends west around the coast of Germany and The Netherlands.

Information regarding the level of any near-shore static gear fishing activity in the vicinity of the two Danish beach landfall sites on the Island of Fanø and further north is currently unavailable. However, given that shrimp trawlers fish this whole coastal region and the near-shore grounds all along this coast and in the vicinity of the two Danish beach landing sites, then it would seem unlikely that any large scale static gear fishing takes place.

9.6 FISHING RISK

All the provisional Viking interconnector cable route options between the UK Lincolnshire coast and Denmark would transit the rich fishing grounds of the North Sea. Most of the fishing grounds in UK waters are sand, shell and stones with shingle banks and sand waves. Most of the shrimp trawling grounds in Danish waters are sand and muddy clay.

The type of demersal trawl gear used in the North Sea and in the vicinity of the provisional Viking cable route options is unlikely to penetrate the seabed to a depth of > 0.40m.

However, the fishing risk that this demersal trawl gear can represent could be increased, by frequent overfishing, at cable crossing points if cable protection is reduced and also if the cables were to be left unburied or in suspension along the route.

We recommend that a risk based burial assessment is undertaken for the preferred route. However an initial analysis of the fishing activity indicates that it is unlikely that there would be any potential fishing risk to the Viking cable if the cable were to be securely buried to a depth of at least 0.70m.

Static fishing gear and its associated ballast weights and securing anchors has minimum seabed penetration, particularly when the gear is being regularly fished, hauled to the surface and re-deployed.

9.6.1 Demersal Trawl Gear

Demersal trawl boards are designed to have continuous ground contact when being towed and it is estimated that they can penetrate soft seabed to a depth of approximately 0.30m. Some research has been carried out with regard to trawl board penetration and results have indicated that subsea cables buried to a depth greater than 0.30m should be safe from trawl board damage, regardless of vessel horsepower and trawl board size and weight.

Although there are various different types of demersal (bottom) trawling used in the North Sea, the basic principle of trawling is the same whereby a cone-shaped net or trawl with a wide mouth is towed through the water by means of wires attached to a vessel or vessels.

The design and size of the trawl gear varies depending on seabed contours, fish species sought, fisheries regulations and legislation and on vessel design, size and horsepower. Demersal trawled fishing equipment is the most likely type of fishing gear to foul and cause damage to a subsea cable.

The trawl net is towed over the seabed to catch bottom-feeding, demersal fish. The mouth of the net is kept open by floats which are attached to the top edge or headline of the trawl. The bottom edge or fishing line is attached to a wire or chain footrope with round rubber or steel bobbins/rockhopper discs of a given diameter in order to negotiate the seabed contours and to protect the trawl net from chafe and damage.

Large trawl (otter) boards are attached ahead of the trawl net by wire or chain bridles. The boards are usually constructed from steel or wood. The trawl is towed by means of wires, known as warps, attached to the inside leading edge of each trawl board. When towed through the water the trawl boards are trimmed to "swim" away from each other, thus keeping the net spread horizontally in the water.

Trawl board penetration can vary depending on the nature of the seabed, the turning effect of the vessel and the weight of the trawl boards in relation to vessel speed. The new generation of trawl board design is focussed on reducing the weight and seabed penetration of the boards, whilst retaining their spreading efficiency and ground contact.

9.6.2 Twin/Multi-Rig Trawling

A variation to the conventional single trawl rig is twin-trawling and Danish fishermen have perfected twin and multi-rig trawl fishing techniques in Europe, primarily to improve efficiency in the North Sea shrimp fishery.

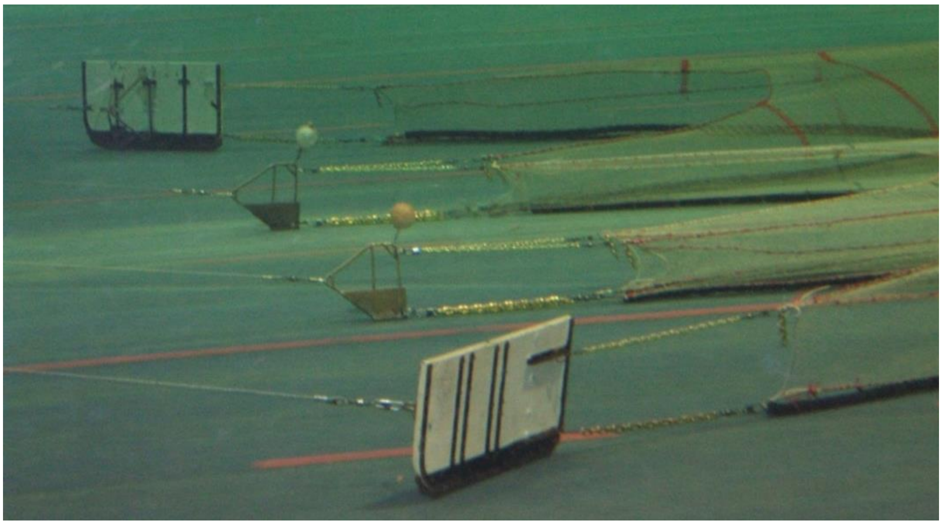

Figure 18. Scale Model Demersal Multi-Rig (3 trawl) Prawn/Shrimp Gear

This method of fishing involves the use of two or more trawls that are towed side by side by one vessel. One pair of trawl boards is used in order to keep the two trawls open in a similar manner to the single trawl rig. In addition, a centre sledge or roller assembly is towed between the two trawl boards from a third trawl warp and this centre sledge/roller assembly is attached to bridles supporting the inside wings of each trawl.

Trawl boards are generally designed so that they will slide over most seabed obstacles, since they are often towed over rock and uneven seabed contours. Due to the pivoting point at which the trawl warp is attached to the trawl board, a trawl board will have the tendency to flip over an obstacle, rather than to foul it. However, trawl boards and centre sledge and roller assemblies are likely to foul a subsea cable in suspension. Unburied cables would be at risk from heavy trawl boards or centre roller assemblies running along or over the cable. Most of the demersal otterboard trawlers operating in the North Sea now use demersal twin-rig or multi-rig trawl gear.

Figure 19. Twin-Rig Trawl Boards and Centre Roller Assembly on board Danish Shrimp Trawler

9.6.3 Beam Trawling

Belgian, Dutch, Danish, German and UK-registered beam trawlers regularly fish the North Sea grounds and in the vicinity of the provisional Viking route options targeting dover (black) sole, plaice and shrimp. The beam trawl consists of a net bag (the trawl) being suspended from a tubular steel beam with steel shoes supporting the beam at either end. Vessel horsepower and fisheries regulations determine the length of beam permissible.

Although small inshore shrimp trawlers may operate with a single lightweight beam rig, vessels of over 250hp will tow two beam trawl rigs, one from each side of the vessel, with a single towing warp attached to each beam rig. Vessels of between 250hp and 300hp would usually tow 2 x 4-metre beams and the length of beam increases with vessel horsepower.

Some of the modern Euro-cutter class beam trawlers with 300hp are capable of towing up to 2 x 8-metre beam trawl rigs. However, fishing regulations can restrict the size of trawler and beam gear used in coastal fisheries. The maximum size beam permissible in EU waters is 2 x 12-metres and vessels of at least 1500hp would be required to tow this size of gear efficiently.

Most of the large Belgian, Dutch and UK (Anglo-Dutch) beam trawlers targeting fish species in the North Sea use open beam gear. The smaller shrimp beam trawlers use lightweight open beam gear for fishing soft, clean sand and muddy/clay grounds.

9.6.4 Open Beam Gear

Open beam gear is generally used on soft, clean ground. A number of loops of chain, known as "tickler" chains, are used to increase the gear's catching efficiency. Beam trawlers operating with open beam gear will often tow the gear at speeds in excess of 6 knots through the water when fishing for sole. Shrimp beam trawlers will tow at much slower speeds.

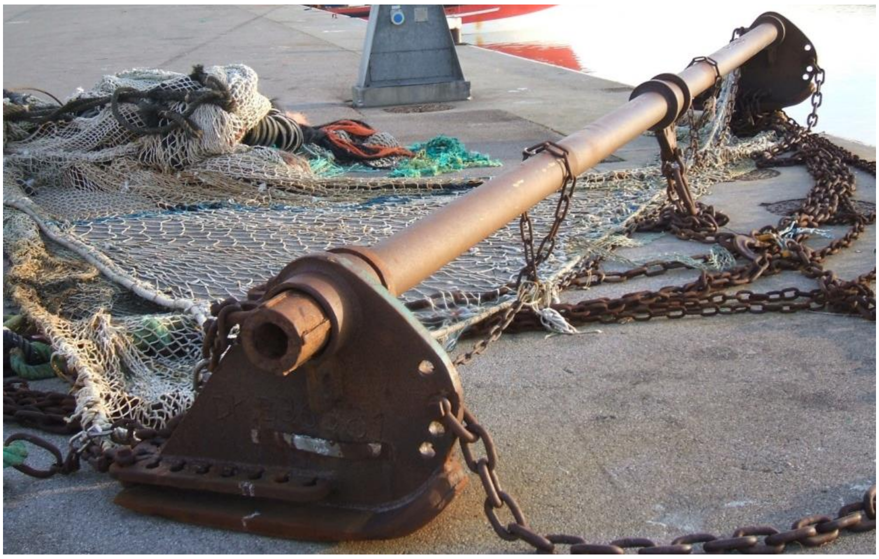

Figure 20. 10-metre Open Beam Trawl Rig with "Tickler" Chains

9.6.5 Sumwing Beam

The concept of reducing the weight and seabed penetration of beam gear has been the subject of debate between fishermen and marine environmentalists for many years. Most fishermen believe that it is the weight of the gear, coupled with towing speed, that is the major factor in the gear's catching efficiency, particularly when fishing for dover (black) sole.

The Sumwing beam replaces the conventional, heavy tubular steel beam with a hydrofoil wing which is designed to fish just off the seabed at the same height as the conventional beam (1 metre), but without the use of the heavy steel beam shoes required to suspend the beam. The Sumwing beam was first used by the Dutch in 2007 in the North Sea as a fuel efficient alternative to conventional open beam gear. After successful fishing trials by the Dutch in the North Sea the Sumwing beam gear is now in more general use. This gear has less impact on the marine environment and is reported to reduce beam trawler fuel consumption by some 15%.

Figure 21. Sumwing Beam on board Belgian Beam Trawler

Photo: Network Services

Due to the reduced weight of the Sumwing beam gear compared to conventional beam gear, skippers have found that they can fish over softer ground with the Sumwing gear. In recent years, most of the Dutch beam trawlers that concentrate on fishing for sole in the southern North Sea have changed over to using Sumwing electronic pulse beam gear. Some Dutch and German shrimp beam trawlers are now also using a hydrofoil wing beam similar to the Sumwing beam.

Although the Sumwing beam itself "swims" just above the sea floor, it has a protruding stabilising "snout" that makes bottom contact and this snout has the potential to foul an unburied subsea cable or a cable in suspension. This design feature; and the fact that trawlers using this gear are able to fish more of the banks and the soft ground; is being blamed for an increase in fishing related cable faults in the Southern North Sea.

Most beam trawling activity by the larger class of Belgian, Dutch and UK registered beam trawlers targeting sole and plaice is carried out in the vicinity of the Green route option between Long 003 00E and Long 006 00E and this significantly increases the overall fishing risk on the Option 3 route . Intense beam trawling activity by the smaller shrimp beam trawlers that concentrate most of their fishing effort on the grounds to the east of Long 006 00E is fairly evenly spread across all three provisional routes into the Danish beach landfall sites. However, it is anticipated that the soft ground conditions in this region should allow for increased cable burial and associated long term security.

9.7 FISHING AUTHORITIES AND ASSOCIATIONS

Most of the UK fishermen with vessels of over 10 metres in length that concentrate on trawl fishing for whitefish are likely to be members of the NFFO (National Federation of Fishermen's Organisations). The Belgian, Danish, Dutch and German fishermen are likely to be members of their own similar national Fishermen's Organisations. All these fishermen will also be members of regional FPOs (Fish Producer Organisations). Most static gear fishermen and fishermen that operate trawlers of under 10 metres in length (non-Sector) will usually be members of their own local Fishermen's Association. Details of principal fishing representatives are listed in Appendix A.

Due to the likely location of static fishing gear (pots/gill nets) in the inshore waters of the Lincolnshire coast landfall sites and the anticipated level of fishing activity in the area extending offshore and in the vicinity of the provisional Viking route options, it is recommended that comprehensive fishing liaison with inshore fishermen is carried out once a preferred route is selected and the beach shore end site is confirmed and in advance of any marine works taking place.

10.0 ANCHORING AND DREDGING AREAS

10.1 INTRODUCTION

As a general principle the route development has avoided marine aggregate dredging areas. However, in the UK sector there are a number of dredging areas which present a significant constraint if they are avoided in their entirety. The Crown Estate database designates dredging areas as either, application areas, option areas, consented areas or active extraction areas. This means that while an area may have been approved for extraction, some or all of the area may never be utilised. We have therefore adopted the strategy of avoiding active extraction areas, while routing through the remaining categories, where routing around them required a significant increase in route length or additional pipeline crossings.

Initial enquiries with the Crown Estate indicate that there is scope for discussion with the licensees to agree a route through a licensed area. These discussions should be undertaken before any route survey investigations are carried out..

10.2 DREDGING AREAS

The following Table lists the Dredging areas crossed by the routes and their status.

ID	Status	Route Options	Name	Licence Holder
439	Application Area	1 2 & 5	Inner Dowsing	Hanson Aggregates Marine Ltd
492	Extended Option	1 & 5	Sole Pit	Hanson Aggregates Marine Ltd
490	Extended Option	1 & 5	Humber 4	DEME Building Materials Ltd
491	Extended Option	1 & 5	Humber 7	DEME Building Materials Ltd
484	Extended Option	2	Humber 3	DEME Building Materials Ltd
483	Extended Option	2	Humber 5	DEME Building Materials Ltd
493	Extended Option	3 & 4	Humber Overfalls	Lefarge Tarmac Marine Ltd
197	Application Area	3 & 4	Off Shalfleet	Lefarge Tarmac Marine Ltd
400	Application Area	3 & 4	North Dowsing	Hanson Aggregates Marine Ltd
120	Application Area	3 & 4	Humber Estuary	Hanson Aggregates Marine Ltd

Table 12. Dredging Areas

10.2.1 De-conflict With Dredging Areas

To inform the discussions an assessment of the impact of de-conflicting the routes and the extraction areas has been included in this section

Figures 22 and 23 illustrate the potential conflict with Dredging Areas and proposed alternative routes which avoid the areas

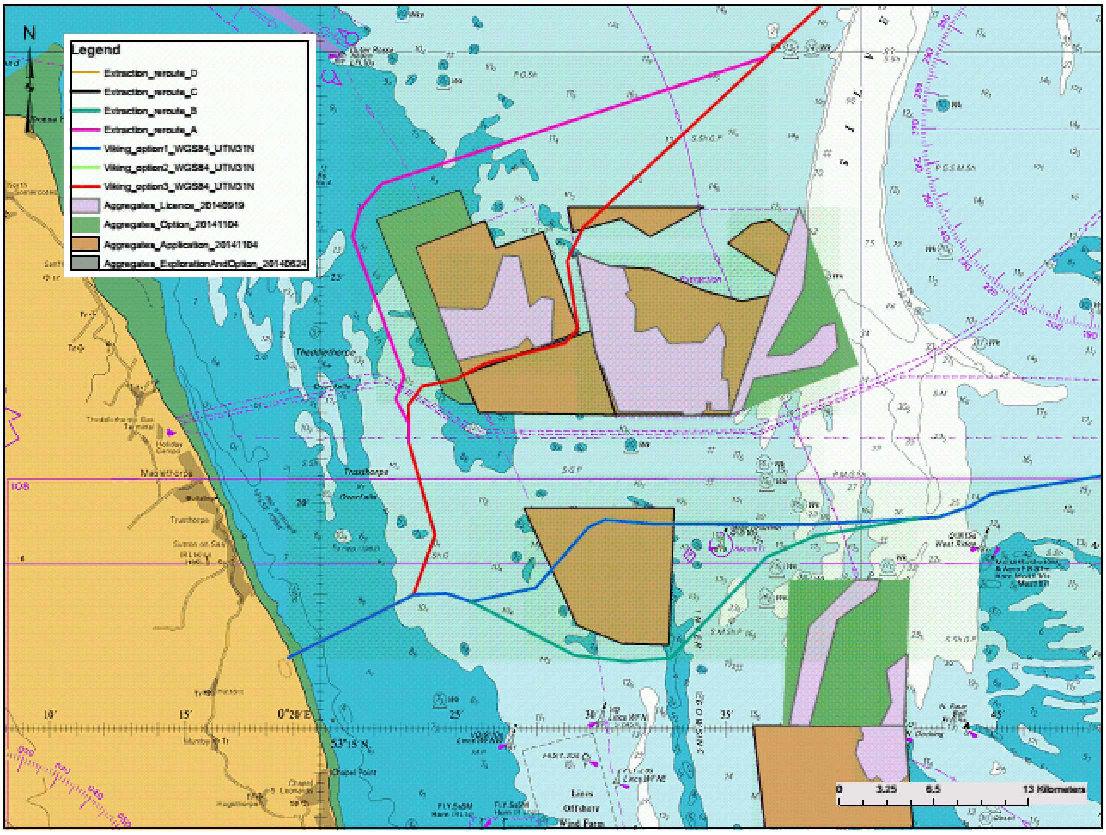

Figure 22. Extraction Areas Chart 1

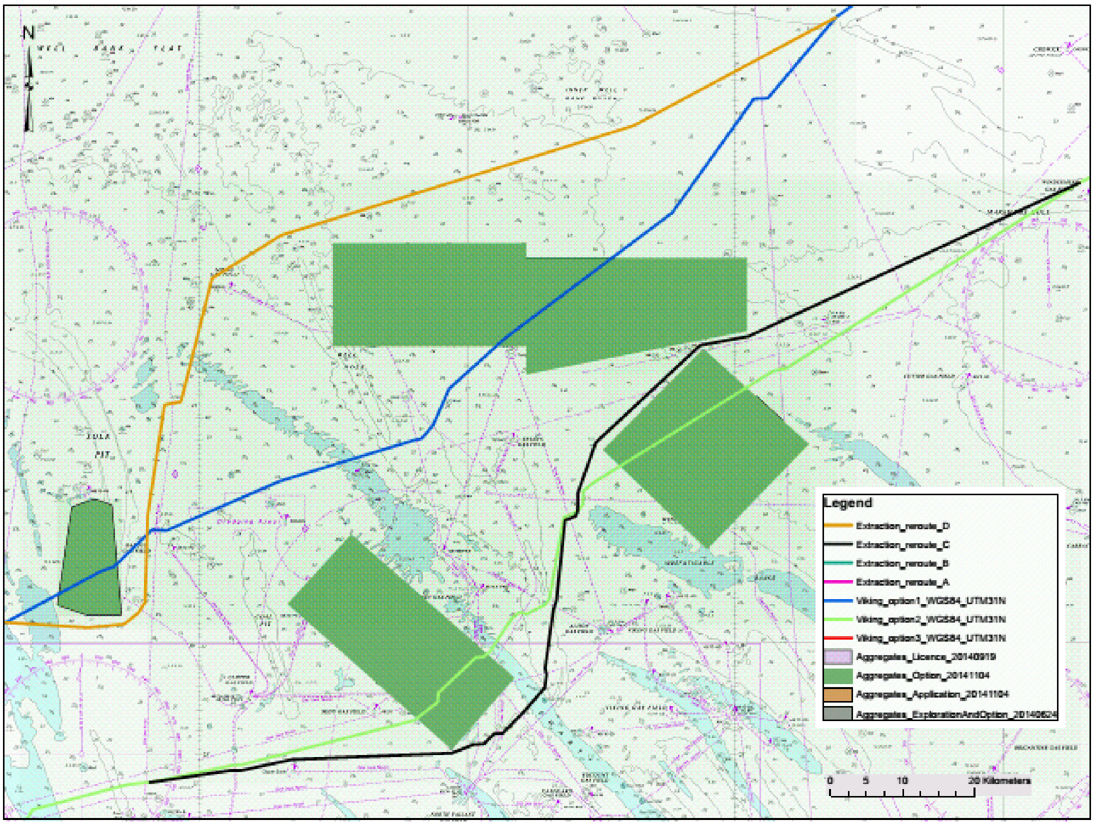

Figure 23. Extraction Areas Chart 2

Re-routing to avoid extraction areas impacts on the various route options, in all instances the route length is increased, in some instances the route is required to transit additional areas of shallow water or cross sand banks. There is also an impact on the number of pipeline crossings, with instances of both a net increase and a net reduction. Table 13 lists the impact of de-conflicting the routes and the dredging areas.

Route options	Increase in route length to de-conflict	Pipeline Crossings	Comments
1 & 5	17.360	Minus 2	Additional 2km in WD < 10m, crosses Inner Dowsing Bank
2	12.012	Plus 2	Additional 2km in WD < 10m, crosses Inner Dowsing Bank
3 & 4	6.890	No Change	Additional 17km in WD <10m

Table 13. Impact on cable routes of de-conflicting and dredging areas

10.2.2 Conclusions

Amending the proposed route options to de-conflict extraction areas is feasible, as detailed above it will have an impact on the cost and the installation of the system, the primary impact on the cost being due to an in increase in cable length, the primary impact on installation, being additional route length in shallow water which may require longer shore end sections, to be installed by shallow draft vessels, possibly resulting in additional cable joints.

Further analysis of the pros and cons of the impact of a re-route compared with reaching an agreement with TCE are required, before making a final routing decision.

10.3 ANCHORAGES

No designated anchorages have been identified within 5km of the proposed route options.

11.0 SHIPPING

In relation to the route development exercise, the most significant shipping lanes in the vicinity are the "Off Botney Ground", Deep Water, Traffic Separation Scheme (TSS) and the West Friesland Traffic Separation Schemes. Route Option 2 is routed close to the North of the South Bound "Off Botney Ground" TSS at a distance of 2km. Route Options 3 and 4 are routed close to the entrance to the River Humber. Whilst the routes do not cross any designated shipping lanes there will be a concentration of shipping in this region.

12.0 WRECKS AND ARCHAEOLOGY

12.1 WRECKS

An inventory of wrecks within 1km of the route, taken from the UKHO charts of the southern North Sea, has been compiled for each route option and is presented in Table 4. Note that the wrecks shown on the charts have been avoided as part of the routing.

Route Option	1	2	3	4	5	Comment
Route	Northerly	Southerly	Northerly	Northerly	Northerly	
Wrecks within 1km	0	2	1	0	0	The Option 2 route crosses the edge of an area of wrecks to the south east of Weisse Bank within the German cable development route corridor, it is unclear whether this will be an obstacle. A second wreck is crossed on the approach Fanøe, approximately 40 km from shore. The Option 3 route crosses close to a wreck immediately to the south of the Hornsea Windfarm, within the Hyde Field. It is unclear whether this will be an obstruction.

Table 14. Initial Wreck Inventory

There are a large number of wrecks in the UK sector that are typically associated with the sand bank and sand ridge areas. Wrecks can be covered by sediment movement, and it is not uncommon for unknown wrecks to be found after storms or as part of the migration of sediments. By the same process, uncharted wrecks within the Danish sector may also be revealed.

It is recommended that as part of the preparation for the survey, a wreck search is undertaken along each route option with a search radius of 250 m. This service will provide a listing of known and reported wrecks, as well as their current status, and can be used as a guide for identifying potential targets during the survey, and highlighting any unknown wrecks observed during the course of the survey. The UKHO provide a wreck search service.

The Closet Point of Approach (CPA) will vary from country to country, depending on the age, type of vessel and cargo of a wreck, as well as the number of fatalities remaining on the wreck. Wrecks older than 100 years are defined as of archaeological importance, and need to be avoided by a minimum offset of 100 m. Non historic wrecks and large debris must be avoided, and if there is a chance that hazardous waste or explosives are involved the clearance to the cable should be increased. It should also be noted that debris (anchor chains, objects that have fallen off the ship while sinking) is often concentrated in the vicinity of the wrecks. Small debris (lost fishing gear, cables, wires, barrels, steel poles etc.) may be avoided with minor route deviations, or alternatively such debris may be removed before cable installation.

The routing principles with regard to wrecks and debris are normally taken to be:

a) Keep minimum 500 m separation from wrecks which may contain hazardous waste or explosives.
b) Keep minimum 100 m distance to archaeological sites (requirement).
c) Keep at least 100 m distance, or two times the water depth to other wrecks and large debris.

12.2 ARCHAEOLOGY

As part of UNCLOS Article 149 (1982) and the UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001) there is a greater emphasis on the protection of submerged archaeological sites, and cultural landforms. Due to the shallow seas and the lag in the rising sea level as the ice sheets retreated, the Southern North Sea was dry land 9000 years ago, and was only completely submerged c. 7,800 yrs ago, with Dogger Bank persisting as a diminishing island until c. 7,700 yrs ago. As such, this area is potentially rich in archaeological sites, and constitutes a landscape that is of cultural value, as it was extant when there was a population of hunter gatherers and nomadic people in Europe.

The margins of the Southern North Sea and especially on the European coast are rich in archaeological sites, and the east coast of England also has examples of pre-historic settlements and religious sites, some of which extend into the nearshore environment. The archaeological potential of the area is highlighted in Offshore Energy SEA Appendix 3.

There are no known marine archaeology sites or designated cultural landscapes in the area of interest, although the Dogger Bank area to the north of the area is being extensively researched as 'Doggerland'.

13.0 DUMPING GROUNDS

No designated dumping areas have been identified within 5km of any of the proposed routes.

The status of the central North Sea incineration zone is uncertain at this time, but it is suspected that the area is no longer designated. Further investigation is recommended to establish if there is any legacy chemical pollution of the seabed, which could be disturbed during cable burial operations. The proposed routes currently cross the edges of the zone. If this is area is confirmed to be a hard constraint, minor re-routing will be required at a later date.

14.0 UXO & PROHIBITED AREAS

The only prohibited areas that have been identified within 5km of the route are located in Danish waters in the region of Horns Rev. There are two areas marked on the Admiralty chart with the note "Former mined area, mines could still present hazard for vessels anchoring, fishing or engaged in submarine of seabed operations". The proposed routes have been developed to avoid these areas by a minimum of 1km. A danger area is also noted on the Admiralty chart adjacent to the Fanø landfall, it is not possible to avoid transiting this area.

ID	Type	Name	Route Option	Closest Approach	Comments
D307	Firing Practice Area	Dona Nook	3 & 4	11km	Noted on Admiralty Chart
N/A	Submarine Exercise area	Southern North Sea	1,2,3 4 & 5	N/A	General warning noted on Admiralty Chart
N/A	Former Mined Area	Horns Rev South	1 & 3	1 km	Noted on Admiralty Chart
N/A	Danger Area	Off Fanø coast line	1,2,& 3	N/A	Routes transit through area (2km)
D380/D381	Firing Practice Area	Off Blabjerg	4 & 5	2km	Noted on Admiralty Chart
N/A	Former Mined Area	Horns Rev North	4 & 5	1.5km	Noted on Admiralty Chart

Table 15. UXO and Prohibited Areas

15.0 PERMITS AND CONSENTS UPDATE

15.1 INTRODUCTION

Following the publication of the Ramboll Viking Link Offshore Desktop Route Study, there have been a number of meetings with national permitting authorities and stakeholders.

New Information relevant to the route development process, which has come to light as a consequence of these meeting, has been summarised below.

15.2 UK

15.2.1 RWE (Triton Knoll)

A meeting with RWE was held on the 4th December 2014, attended by NGIL, Red Penguin and TEP.

The interaction between the projects was discussed and following the meeting RWE provided a shape file of the Triton Knoll export cable corridor, which has been used during the Viking route development process.

15.2.2 SMartWind

A meeting was held between NGIL and SMartWind on the 12th February 2015 to introduce the Viking project and discuss the routing options and the potential interaction between the projects.

The meeting confirmed that development of Project 1 areas is currently in progress by Dong Energy; that Project 2 areas are in the advanced stages of planning and that project 3 areas are development options.

Following the meeting the proposed routes were edited to completely avoid entering Project 1 & 2 areas. The proposed routes pass through the project 3 development option areas.

It was also noted that Dong are still considering an AC export cable for Project 1 and that the project 2 export cables will follow the same proposed cable corridor. If project 2 also adopts an AC solution, this could result in a total of 12 cables within the corridor. This would have a potential impact on Viking Route Options 3 & 4.

It is recommended that dialogue continues with SMartWind during the project planning process.

15.2.3 Dong Energy

A conference call was held with Dong Energy on the 17th February 2015, to introduce the project and discuss the routing options and the potential interaction between the projects.

There were no particular concerns as the routes already avoid the Hornsea Project 1 areas. Potential issues with the export cables and Route Options 3 & 4 were also noted.

15.3 NETHERLANDS

15.3.1 RWS

NGIL and Promo Marine held a meeting with the Rijkswaterstaat (RWS) on the 22nd January. There were a number of issues that the meeting explored which are summarised below:

- The RWS were in favour of the Northern route going through the narrow corridor in German territory to avoid constraints in Dutch territory;
- Changes are planned for the Friesland Junction TSS in 2016, the information on the proposed changes was analysed and found not significant for the Viking route development;
- The RWS were not aware of the status of the 'North Sea Incinerator' area and do not recognise it as a constraint to routing;
- Oil and gas licence areas due for exploration in the southern part of the Dutch EEZ which could be problematical for the most southerly Route Option 2;
- Environmental designations are planned for the Oyster Ground and Frisian Fronts, these areas were plotted, some of the route options pass through the areas but they are considered to be a minor constraint.

15.4 GERMANY

15.4.1 BSH

Energinet and Ramboll attended a meeting with the Bundesamt für Seeschifffahrt und Hydrographie (BSH) on the 23rd January 2015. There were a number of issues explored which are summarised below:

- Some routes had been avoided in the desktop study because of supposedly planned windfarms defined as major constraints. For these areas planning applications for offshore wind farms have already been submitted to the BSH. However, according to the BSH these applications are not treated as reservations for wind farms and BSH does not expect any wind farms there within the next many years. Furthermore, the interconnector is of priority interest, because it is secured by public international law obligations.
- BSH explained that part of the preferred northern-most route crosses an area reserved for periodic long-term research , as per the "Spatial Plan for the German Exclusive Economic Zone in the North Sea". This area was plotted and a minor re-route of options 1,3,4 & 5 was undertaken to avoid the areas by passing to the South
- The BSH pointed out which areas they would recommend to cross the German EEZ and which gates to use. These were plotted and the entry and exit points coincided closely with those planned for Route Options 1, 3, 4 & 5. Therefore no route edit has been undertaken in response to this point at this time.

16.0 CABLE ROUTE OPTIONS SUMMARY

The purpose of this section is to summarise the route options and generate an issue list of areas where there are critical gaps in the available database, which require to be closed in order to deliver a more robust route, and/or reduce risks to the cable installation and protection.

16.1 ROUTE OPTIONS SUMMARY

Route Option	**1**	**2**	**3**	**4**	**5**
Route Length km	620.993	619.502	627.238	615.276	610.024
Pipeline crossings	16	20	21	24	19
Umbilical Crossings	0	1	0	0	0
FO Cable crossings	7	5	7	5	5
Power Cable crossings	1	1	3	3	1
Bathymetry	Route length<10m WD 11.5km	Route length<10m WD 11.5km Route crosses significant bathy features, side slopes of these features need further investigation to confirm installation is feasible	Route length<10m WD 11.2km	Route length<10m WD 7.2 km	Route length<10m WD 6.9 km

Geology	Sand ridges associated with the Cromer Knoll and Outer Dowsing, underlying Bolders Bank Formation, finer muddy Sands and sandy Muds of the Outer Silver Pit and the Botney Cut. Within the Dutch Sector the seabed sediments are sand and sandy muds, especially in the centre of the southern North Sea. German sector seabed sediments are a mixture of gravelly sands and muddy sand. The route crosses over a larger expanse of gravel and coarse sand in Danish sector of a glacigenic origin. Risk of buried peats.	Sand is found across the mouth of the channel from The Wash, areas of sand banks and linear sand ridges, outcrops of the Bolders Bank Formation (glacigenic) ,sand dominated seabed sediments between German and Dutch sectors, sand and gravel in Danish sector of glacigenic origin. Risk of buried peats.	Bolders Bank Formation of gravelly sand and sandy gravel (glacigenic origin) ,with infilling silts and clays of the Botney Cut Formation in the deeper areas. Sand and sandy muds are found in the Dutch Sector of the southern North Sea. The German sector seabed sediments are a mixture of gravelly sands and muddy sand. The route then crosses a larger expanse of gravel and coarse sand in Danish sector, of glacigenic origin. Risk of buried peats.	Bolders Bank Formation of gravelly sand & sandy gravel (glacigenic origin) with infilling silts and clays of the Botney Cut Formation in the deeper areas. Sand and sandy muds are found in the Dutch Sector in the centre of the southern North Sea. The German sector seabed sediments are a mixture of gravelly sands and muddy sand. The route crosses over occasional bands of gravel and coarse sand in Danish sector, of a glacigenic origin. Risk of buried peats.	Sand ridges associated with the Cromer Knoll and Outer Dowsing, underlying Bolders Bank Formation, finer muddy Sands and sandy Muds of the Outer Silver Pit and the Botney Cut. Within the Dutch Sector the seabed sediments are sand and sandy muds, especially in the centre of the southern North Sea. German sector seabed sediments are a mixture of gravelly sands and muddy sand. The route crosses over a larger expanse of gravel and coarse sand in Danish sector of a glacigenic origin. Risk of buried peats.
Wind Farms	Crossing with Triton Knoll export cable, route constrained by position of Triton Knoll and Race Bank, crosses Hornsea Project 3 areas	Crossing with Triton Knoll export cable, route constrained by position of Triton Knoll and Race Bank, crosses Hornsea Project 3 areas.	Crossing with Hornsea Export Cable, routed to avoid Hornsea Projects 1 & 2, crosses Hornsea Project 3 areas.	Crossing with Hornsea Export Cable, routed to avoid Hornsea Projects 1 & 2, crosses Hornsea Project 3 areas. Route adjacent to Hornsrev Development 3 export cable corridor	Crossing with Triton Knoll export cable, route constrained by position of Triton Knoll and Race Bank, crosses Hornsea Project 3 areas Route adjacent to Hornsrev Development 3 export cable corridor
Wrecks & Archaeology	N o significant issues	One wreck within 1km of route	2 wrecks within 1km of route. Proximity to DoggerLand and cultural landscapes where there is evidence of human activity in this area during the period of lowered sea level.	Proximity to DoggerLand and cultural landscapes where there is evidence of human activity in this area during the period of lowered sea level.	N o significant issues
Fishing	Static gear in UK waters in spring and summer, crosses Dutch and Belgian Beam trawling grounds, crosses Dutch, German and Danish Shrimp trawling grounds	Static gear in UK waters in spring and summer, crosses Dutch and Belgian Beam trawling grounds, crosses Dutch, German and Danish Shrimp trawling grounds	Static gear in UK waters in spring and summer, cross South Dogger and South Rough Trawling grounds, cross Dutch, German and Danish Shrimp trawling grounds	Static gear in UK waters in spring and summer, cross South Dogger and South Rough Trawling grounds, cross Dutch, German and Danish Shrimp trawling grounds	Static gear in UK waters in spring and summer, cross South Dogger and South Rough Trawling grounds, cross Dutch, German and Danish Shrimp trawling grounds
Dredging	Crosses one application area and three extended option area	Crosses one application area and two extended option area	Cross one application area and three extended option areas, route constrained by extraction areas in vicinity of Humber Estuary	Cross one application area and three extended option areas, route constrained by extraction areas in vicinity of Humber Estuary	Crosses one application area and three extended option area

Anchoring	N o significant issues	N o significant issues	N o significant issues	N o significant issues	N o significant issues
Prohibited Areas	Proximity to Hors Rev South former mined area, passes through Fanø coastal danger area.	Passes through Fanø coastal danger area	Proximity to Hors Rev South former mined area, passes through Fanø coastal danger area	Proximity to Hors Rev North former mined area and Firing Practice area off Blabjerg landfall	Proximity to Hors Rev North former mined area and Firing Practice area off Blabjerg landfall
Shipping	N o significant issues	Proximity to "Off Botney Ground" TSS	Concentration of traffic around Humber Approaches	Concentration of traffic around Humber Approaches	N o significant issues
Military	Transits Southern North Sea Submarine Exercise Areas	Transits Southern North Sea Submarine Exercise Areas	Transits Southern North Sea Submarine Exercise Areas	Transits Southern North Sea Submarine Exercise Areas	Transits Southern North Sea Submarine Exercise Areas

Table 16. Cable route options summary of issues

16.2 ISSUES LIST

Listed below are a number of issues for which we recommend additional data is sourced and further investigations are undertaken prior to the final selection of the route.

- Shallow geology in the Danish, German and eastern Dutch sector (NOT seabed sediments)
- More archaeological constraints information – archaeological policy from German, Danish and Dutch sectors
- JNCC guidelines / liaison for season-dependant limitations for operations
- Wreck search from UKHO and other countries along the preferred route
- Review of guidelines for HVDC cable burial / protection levels
- Identification of oil and gas licence block holders
- Planned oil and gas developments
- Identification of owners of subsea infrastructure (Pipelines & Cables)
- Initial Burial Assessment study
- Cable installation methodology review
- Investigation and Identification of the UK landfalls
- Confirmation of the Danish Landfall
- Confirm status of major environmental constraints identified in Ramboll report
- UXO investigation of preferred route
- Analyse UK Vessel Management System (VMS) data to better get understanding of fishing activities
- Detailed bathymetry to assess side slopes of significant features and least depths on Banks

17.0 CONCLUSIONS

The initial Ramboll and Technical Working Group studies identified two principal route options: a Southern option which utilised the designated German cable corridors; and a Northern route, which aims to minimise the route distance in the German waters by crossing the narrow Northern Western arm of the German EEZ.

During the preparation of this route development report, it has become apparent from meetings with the German and Dutch authorities that, in principle, they favour the Northern option.

RPA have taken these initial routes and developed five route options: Route Options 1, 3,4 & 45 are based on the Northern route as detailed above and Route Option 2 is based on the Southern route as described above.

In terms of overall route length there is a relatively little difference between the three options that land in Fanø (Route Options 1, 2 & 3), the longest being 627km and the shortest being 620 km. The options that lands in Blabjerg (Route Options 4 & 5) are respectively 615km and 610kmin length. In our opinion, in the overall scale of the project, the difference in route lengths of the Fanø route options does not significantly favour one option against another. The Blabjerg routes are marginally shorter and may offer some advantage.

The route development exercise has identified numerous features that needed to be taken into consideration, particularly in the UK EEZ, where there is significant oil and gas and windfarm infrastructure, both existing and planned.

While the routing exercise has minimised crossings with other subsea infrastructure, all the route options have a significant number of crossings with existing infrastructure which are unavoidable. The route with the least number of crossings is Route Option 1 with 24 in total, Route Option 5 has 25, Route Option 2 has 27; and Route Options 3 and 4 each have 31.

Following liaison with the developers, planned windfarm export cables have been identified as a significant constraint. Route Options 3 &4 have a crossing with the Hornsea export cable corridor and Route Options 1 , 2 & 5have a crossing with the Triton Knoll export cable corridor. Of these two, Hornsea is considered the most significant constraint as it is planned to utilise the corridor for both projects 1 & 2, which could have a total of 12 cables if both projects adopt an HVAC transmission system.

When analysing the overall density of constraints on the routes, Route Options 3 & 4 are subject to significant congestion in the first 50km from the UK landfall, due to mineral extraction dredging areas, pipeline crossings, bathymetric features and windfarm corridors.

Seabed conditions are likely to be more favourable on Route Option 2 as this route is on the edge of the most recent glacial sedimentation in older more stable deposits.

Taking the issues highlighted above and the other issues discussed in report in to consideration, Route Options 1 and 5 appear to be the preferred options at this time. Route Option 1 & 5 avoid the worst constraints close to the UK landfall and take the Northern route preferred by both the Dutch and German permitting authorities.

While this report has focussed primarily on the physical constraints present in the southern North Sea, we acknowledge that the final route selection will also be determined by high level permitting and environmental issues and compromises may be needed to reconcile these two elements.

We recommend that further route development is undertaken in relation to identifying the UK landfall and other issues are investigated further where data gaps have been identified.

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APPENDICES

APPENDIX A - FISHING ORGANISATION CONTACT DETAILS

National Federation of Fishermen's Organisations
Monkgate
York
YO31 7PF

Eastern IFCA (Inshore Fisheries and Conservation Authority)
North Lynn Business Village
Bergen Way
King's Lynn
Norfolk
PE30 2JG

King's Lynn Fishing Vessel Owners and Skippers Association
3 Roase Hill Park
Emmer Green
READING
Berkshire
RG8 8XE

North Norfolk Fishermen's Society
13 Sand Hill Estate
Salthouse,
NORTH HOLT
Norfolk
NR25 7XD

German Fisheries
Federal Ministry of Food and Agriculture (BMEL)
PO Box 14 02 70
53107
Bonn
Germany

Danish Fishermen's Association
Nordensvej 3
Taulov
DK-7000
Fredericia
Denmark

Dutch Fishermen's Association
Onder de Toren
30 Emmeloord
8302
BV Netherlands

APPENDIX B - PROPOSED ROUTE POSITION LISTS

Viking Route Development Route Option 1 WGS84-UTM-31N					
Position	EASTING	NORTHING	LATTITUDE NORTH	LONGITUDE EAST	Comments
0	320852.21	5906289.00	53.2755	0.3131	UK Huttoft Landfall
1	326080.40	5908682.37	53.2988	0.3901	
2	327411.32	5908702.63	53.2994	0.4101	
3	328444.28	5908322.81	53.2963	0.4258	
4	331116.69	5908793.38	53.3014	0.4656	
5	333363.14	5911197.78	53.3237	0.4980	
6	334057.49	5911487.40	53.3265	0.5083	
7	336061.89	5911245.41	53.3250	0.5385	
8	342538.91	5911007.28	53.3248	0.6357	
9	347771.11	5911137.02	53.3275	0.7142	
10	349137.10	5911569.94	53.3318	0.7344	
11	349955.41	5912027.30	53.3361	0.7465	
12	357122.76	5912963.40	53.3465	0.8536	
13	376552.73	5912598.78	53.3481	1.1455	
14	378312.75	5913258.77	53.3544	1.1717	
15	378346.28	5913862.28	53.3599	1.1719	
16	381871.28	5915486.04	53.3753	1.2243	
17	382118.19	5916259.54	53.3823	1.2277	
18	383624.15	5920579.28	53.4214	1.2487	
19	391258.18	5929901.96	53.5068	1.3603	
20	392247.33	5930073.98	53.5086	1.3752	
21	394225.61	5930676.07	53.5144	1.4048	
22	395472.79	5930547.05	53.5135	1.4236	
23	403385.94	5934589.64	53.5513	1.5417	
24	404547.11	5934976.69	53.5550	1.5591	
25	407746.26	5937959.35	53.5824	1.6065	
26	408936.88	5937879.98	53.5819	1.6245	
27	418334.13	5941774.72	53.6184	1.7654	
28	429483.46	5944975.61	53.6488	1.9332	
29	430096.09	5945091.16	53.6499	1.9424	
30	430942.76	5946064.83	53.6588	1.9550	
31	431175.59	5946445.83	53.6622	1.9584	
32	432414.25	5949173.20	53.6869	1.9766	
33	437144.60	5953325.01	53.7248	2.0474	
34	450905.17	5963390.33	53.8167	2.2543	
35	457698.83	5972710.43	53.9011	2.3562	
36	458863.00	5972763.35	53.9017	2.3739	
37	464472.17	5979325.03	53.9611	2.4585	
38	475917.66	5987538.91	54.0355	2.6323	
39	494449.61	6005505.24	54.1976	2.9149	
40	503016.83	6011857.89	54.2547	3.0463	
41	504266.50	6013198.06	54.2667	3.0655	
42	507641.76	6017445.90	54.3048	3.1174	
43	515106.91	6024022.51	54.3638	3.2325	
44	515940.35	6024125.69	54.3647	3.2453	
45	564651.50	6066141.28	54.7384	4.0042	
46	565762.75	6068522.54	54.7596	4.0220	

47	596719.06	6092176.33	54.9671	4.5108	
48	598782.82	6093763.84	54.9810	4.5436	
49	610054.09	6101383.85	55.0471	4.7225	
50	616271.93	6106321.04	55.0900	4.8218	
51	627378.96	6115628.97	55.1709	4.9999	
52	631281.57	6119796.16	55.2073	5.0631	
53	635155.25	6125678.93	55.2590	5.1267	
54	672153.17	6157759.58	55.5355	5.7280	
55	683741.94	6160127.60	55.5525	5.9130	
56	686705.28	6161503.44	55.5637	5.9608	
57	692102.79	6162561.78	55.5711	6.0470	
58	701416.15	6162879.28	55.5702	6.1947	
59	723515.40	6159557.74	55.5308	6.5419	
60	725903.38	6159505.83	55.5292	6.5796	
61	729012.24	6160167.29	55.5337	6.6293	
62	782590.48	6160564.17	55.5092	7.4761	
63	785415.86	6159158.68	55.4950	7.5193	
64	786217.85	6159123.57	55.4942	7.5319	
65	804275.77	6151951.96	55.4191	7.8089	
66	826818.31	6148946.29	55.3777	8.1601	
67	827796.11	6148535.33	55.3734	8.1750	
68	834885.25	6149491.81	55.3771	8.2875	
69	841338.33	6152310.83	55.3979	8.3923	Fano Landfall DK

Viking Route Development Route Option 2 WGS84-UTM-31N					
Position	EASTING	NORTHING	LATTITUDE NORTH	LONGITUDE EAST	Comments
0	320852.21	5906289.00	53.2755	0.3131	UK Huttoft Landfall
1	326080.40	5908682.37	53.2988	0.3901	
2	327411.32	5908702.63	53.2994	0.4101	
3	328444.28	5908322.81	53.2963	0.4258	
4	331116.69	5908793.38	53.3014	0.4656	
5	333363.14	5911197.78	53.3237	0.4980	
6	334057.49	5911487.40	53.3265	0.5083	
7	336061.89	5911245.41	53.3250	0.5385	
8	342538.91	5911007.28	53.3248	0.6357	
9	347771.11	5911137.02	53.3275	0.7142	
10	349137.10	5911569.94	53.3318	0.7344	
11	349955.41	5912027.30	53.3361	0.7465	
12	357122.76	5912963.40	53.3465	0.8536	
13	382511.39	5912486.96	53.3485	1.2350	
14	385233.77	5912115.63	53.3457	1.2760	
15	385789.40	5911533.54	53.3406	1.2846	
16	386715.44	5911295.42	53.3387	1.2986	
17	393409.41	5913147.50	53.3567	1.3984	
18	394578.59	5913268.27	53.3580	1.4159	
19	396963.95	5914286.90	53.3676	1.4514	
20	397393.90	5914981.43	53.3740	1.4577	
21	405265.09	5916897.73	53.3927	1.5754	
22	406606.44	5917021.77	53.3940	1.5955	
23	407169.01	5917038.60	53.3943	1.6040	
24	413994.04	5918333.35	53.4071	1.7062	
25	414787.79	5918359.81	53.4074	1.7181	
26	429145.12	5921814.54	53.4406	1.9333	
27	431091.60	5923295.82	53.4542	1.9623	
28	431151.75	5924050.27	53.4610	1.9630	
29	434326.76	5926955.40	53.4875	2.0102	
30	434898.26	5926987.15	53.4878	2.0188	
31	435406.26	5927336.41	53.4910	2.0264	
32	437346.26	5930180.87	53.5168	2.0551	
33	437978.02	5930654.29	53.5212	2.0645	
34	438565.39	5930479.66	53.5197	2.0734	
35	440089.40	5931257.54	53.5268	2.0962	
36	440454.52	5931749.66	53.5313	2.1016	
37	441713.94	5938429.07	53.5915	2.1194	
38	442838.42	5938892.09	53.5957	2.1363	
39	443301.44	5939487.40	53.6011	2.1432	
40	443367.59	5940611.88	53.6113	2.1440	
41	444293.63	5941339.49	53.6179	2.1578	
42	459094.05	5950327.04	53.7000	2.3804	
43	460148.21	5950532.35	53.7020	2.3963	
44	484347.71	5965662.32	53.8392	2.7621	
45	490727.25	5968903.39	53.8685	2.8590	
46	491335.37	5969486.81	53.8738	2.8682	

47	511130.22	5979810.21	53.9665	3.1697	
48	512298.62	5979921.88	53.9675	3.1875	
49	518076.96	5982798.22	53.9932	3.2757	
50	532259.94	5984424.82	54.0071	3.4922	
51	533212.44	5985324.41	54.0151	3.5069	
52	558351.97	5991633.70	54.0696	3.8917	
53	559391.90	5990849.23	54.0624	3.9074	
54	616913.65	6006268.89	54.1911	4.7919	
55	618050.58	6005735.95	54.1861	4.8091	
56	661102.27	6019592.81	54.2988	5.4757	
57	663012.32	6020341.83	54.3049	5.5055	
58	672637.18	6027194.26	54.3633	5.6572	
59	707710.16	6096214.46	54.9695	6.2452	
60	708962.50	6096378.84	54.9704	6.2648	
61	724606.15	6126173.47	55.2309	6.5323	
62	729704.99	6128500.49	55.2494	6.6142	
63	731078.00	6128753.94	55.2510	6.6360	
64	735716.23	6129610.13	55.2565	6.7095	
65	737166.26	6130035.08	55.2596	6.7326	
66	802209.79	6138892.02	55.3034	7.7623	
67	803491.42	6139669.65	55.3096	7.7832	
68	828059.64	6146300.37	55.3532	8.1765	
69	833321.56	6148237.68	55.3670	8.2614	
70	841338.33	6152310.83	55.3979	8.3923	Fano Landfall DK

Viking Route Development Route Option 3 WGS84-UTM-31N					
Position	EASTING	NORTHING	LATTITUDE NORTH	LONGITUDE EAST	Comments
0	320852.21	5906289.00	53.2755	0.3131	UK Huttoft Landfall
1	326080.40	5908682.37	53.2988	0.3901	
2	327059.70	5911116.62	53.3209	0.4035	
3	326127.56	5914956.38	53.3551	0.3874	
4	326160.52	5916484.70	53.3688	0.3871	
5	326756.90	5917245.61	53.3759	0.3956	
6	328152.96	5917473.27	53.3784	0.4164	
7	329429.32	5918101.92	53.3844	0.4353	
8	332665.54	5918795.34	53.3917	0.4835	
9	333226.62	5919365.57	53.3970	0.4916	
10	332895.36	5922171.22	53.4221	0.4852	
11	333573.36	5923494.14	53.4342	0.4947	
12	343738.28	5932374.87	53.5170	0.6431	
13	344010.14	5933139.20	53.5240	0.6468	
14	343780.89	5934458.67	53.5358	0.6427	
15	345517.29	5942251.74	53.6063	0.6651	
16	346689.35	5944225.75	53.6244	0.6818	
17	349339.52	5950871.51	53.6848	0.7186	
18	350870.98	5953396.26	53.7079	0.7406	
19	353318.39	5956042.10	53.7324	0.7763	
20	355526.26	5958076.83	53.7513	0.8088	
21	355962.82	5958830.89	53.7582	0.8151	
22	380612.78	5974020.21	53.9009	1.1829	
23	381644.65	5973782.08	53.8989	1.1987	
24	397122.81	5986958.36	54.0206	1.4297	
25	398022.40	5987011.28	54.0213	1.4434	
26	413283.33	5990123.23	54.0520	1.6754	
27	413966.94	5990069.31	54.0517	1.6858	
28	417770.67	5991033.39	54.0610	1.7437	
29	418257.50	5990673.56	54.0578	1.7512	
30	443128.39	5995774.74	54.1070	2.1301	
31	443699.89	5995393.74	54.1036	2.1390	
32	461903.26	5998780.41	54.1357	2.4169	
33	462527.63	5999030.53	54.1380	2.4264	
34	494449.61	6005547.57	54.1979	2.9149	
35	503016.83	6011857.89	54.2547	3.0463	
36	503916.42	6012757.48	54.2627	3.0601	
37	507641.76	6017445.90	54.3048	3.1174	
38	515106.91	6024022.51	54.3638	3.2325	
39	515940.35	6024125.69	54.3647	3.2453	
40	564651.50	6066141.28	54.7384	4.0042	
41	565762.75	6068522.54	54.7596	4.0220	
42	596719.06	6092176.33	54.9671	4.5108	
43	598978.49	6093883.05	54.9820	4.5467	
44	610054.09	6101383.85	55.0471	4.7225	
45	616271.93	6106321.04	55.0900	4.8218	
46	627378.96	6115628.97	55.1709	4.9999	

47	631281.57	6119796.16	55.2073	5.0631	
48	635155.25	6125678.93	55.2590	5.1267	
49	672153.17	6157759.58	55.5355	5.7280	
50	683741.94	6160127.60	55.5525	5.9130	
51	686705.28	6161503.44	55.5637	5.9608	
52	689562.79	6162032.61	55.5674	6.0064	
53	692102.79	6162561.78	55.5711	6.0470	
54	698452.81	6162667.61	55.5695	6.1477	
55	701416.15	6162879.28	55.5702	6.1947	
56	722860.67	6159571.98	55.5312	6.5315	
57	725903.38	6159505.83	55.5292	6.5796	
58	729012.24	6160167.29	55.5337	6.6293	
59	782590.48	6160564.17	55.5092	7.4761	
60	785415.86	6159158.68	55.4950	7.5193	
61	786217.85	6159123.57	55.4942	7.5319	
62	804275.77	6151951.96	55.4191	7.8089	
63	826818.31	6148946.29	55.3777	8.1601	
64	827796.11	6148535.33	55.3734	8.1750	
65	834885.25	6149491.81	55.3771	8.2875	
66	841338.33	6152310.83	55.3979	8.3923	Fano Landfall DK

Viking Route Development Route Option 4 WGS84-UTM-31N					Comments
Position	EASTING	NORTHING	LATITUDE NORTH	LONGITUDE EAST	
0	320852.21	5906289.00	53.2755	0.3131	UK Huttoft Landfall
1	326080.40	5908682.37	53.2988	0.3901	
2	327059.70	5911116.62	53.3209	0.4035	
3	326127.56	5914956.38	53.3551	0.3874	
4	326160.52	5916484.70	53.3688	0.3871	
5	326756.90	5917245.61	53.3759	0.3956	
6	328152.96	5917473.27	53.3784	0.4164	
7	329429.32	5918101.92	53.3844	0.4353	
8	332665.54	5918795.34	53.3917	0.4835	
9	333226.62	5919365.57	53.3970	0.4916	
10	332895.36	5922171.22	53.4221	0.4852	
11	333573.36	5923494.14	53.4342	0.4947	
12	343738.28	5932374.87	53.5170	0.6431	
13	344010.14	5933139.20	53.5240	0.6468	
14	343780.89	5934458.67	53.5358	0.6427	
15	345517.29	5942251.74	53.6063	0.6651	
16	346689.35	5944225.75	53.6244	0.6818	
17	349339.52	5950871.51	53.6848	0.7186	
18	350870.98	5953396.26	53.7079	0.7406	
19	353318.39	5956042.10	53.7324	0.7763	
20	355526.26	5958076.83	53.7513	0.8088	
21	355962.82	5958830.89	53.7582	0.8151	
22	380612.78	5974020.21	53.9009	1.1829	
23	381644.65	5973782.08	53.8989	1.1987	
24	397122.81	5986958.36	54.0206	1.4297	
25	398022.40	5987011.28	54.0213	1.4434	
26	413283.33	5990123.23	54.0520	1.6754	
27	413966.94	5990069.31	54.0517	1.6858	
28	417770.67	5991033.39	54.0610	1.7437	
29	418257.50	5990673.56	54.0578	1.7512	
30	443128.39	5995774.74	54.1070	2.1301	
31	443699.89	5995393.74	54.1036	2.1390	
32	461903.26	5998780.41	54.1357	2.4169	
33	462527.63	5999030.53	54.1380	2.4264	
34	494449.61	6005505.24	54.1976	2.9149	
35	503016.83	6011857.89	54.2547	3.0463	
36	503916.42	6012757.48	54.2627	3.0601	
37	507641.76	6017445.90	54.3048	3.1174	
38	515106.91	6024022.51	54.3638	3.2325	
39	515940.35	6024125.69	54.3647	3.2453	
40	564651.50	6066141.28	54.7384	4.0042	
41	565762.75	6068522.54	54.7596	4.0220	
42	596719.06	6092176.33	54.9671	4.5108	
43	598978.49	6093883.05	54.9820	4.5467	
44	610054.09	6101383.85	55.0471	4.7225	
45	616271.93	6106321.04	55.0900	4.8218	

46	627378.96	6115628.97	55.1709	4.9999	
47	631281.57	6119796.16	55.2073	5.0631	
48	635155.25	6125678.93	55.2590	5.1267	
49	672153.17	6157759.58	55.5355	5.7280	
50	682641.59	6161665.34	55.5667	5.8966	
51	684308.47	6162935.34	55.5775	5.9238	
52	689705.98	6165157.85	55.5953	6.0109	
53	691452.23	6165792.85	55.6004	6.0390	
54	699469.12	6167618.48	55.6135	6.1673	
55	701532.88	6168015.35	55.6162	6.2003	
56	723131.74	6173483.42	55.6559	6.5471	
57	725671.74	6174118.42	55.6604	6.5879	
58	757104.31	6181738.44	55.7131	7.0934	
59	774566.84	6183643.44	55.7206	7.3724	
60	777247.96	6183908.02	55.7214	7.4153	
61	791832.54	6185866.56	55.7304	7.6488	
62	792943.79	6186819.06	55.7383	7.6674	
63	792983.48	6188247.81	55.7510	7.6696	
64	794293.17	6189478.13	55.7613	7.6917	
65	794332.86	6190668.76	55.7719	7.6936	
66	795205.98	6190906.88	55.7735	7.7078	
67	817232.59	6190986.26	55.7603	8.0576	
68	824740.76	6191303.14	55.7581	8.1772	Blabjerg Landfall DK

Viking Route Development Route Option 5 WGS84-UTM-31N					
Position	EASTING	NORTHING	LATITUDE NORTH	LONGITUDE EAST	Comments
0	320852.21	5906289.00	53.2755	0.3131	UK Huttoft Landfall
1	326080.40	5908682.37	53.2988	0.3901	
2	327411.32	5908702.63	53.2994	0.4101	
3	328444.28	5908322.81	53.2963	0.4258	
4	331116.69	5908793.38	53.3014	0.4656	
5	333363.14	5911197.78	53.3237	0.4980	
6	334057.49	5911487.40	53.3265	0.5083	
7	336061.89	5911245.41	53.3250	0.5385	
8	342538.91	5911007.28	53.3248	0.6357	
9	347771.11	5911137.02	53.3275	0.7142	
10	349137.10	5911569.94	53.3318	0.7344	
11	349955.41	5912027.30	53.3361	0.7465	
12	357122.76	5912963.40	53.3465	0.8536	
13	376552.73	5912598.78	53.3481	1.1455	
14	378312.75	5913258.77	53.3544	1.1717	
15	378346.28	5913862.28	53.3599	1.1719	
16	381871.28	5915486.04	53.3753	1.2243	
17	382118.19	5916259.54	53.3823	1.2277	
18	383624.15	5920579.28	53.4214	1.2487	
19	391258.18	5929901.96	53.5068	1.3603	
20	392247.33	5930073.98	53.5086	1.3752	
21	394225.61	5930676.07	53.5144	1.4048	
22	395472.79	5930547.05	53.5135	1.4236	
23	403385.94	5934589.64	53.5513	1.5417	
24	404547.11	5934976.69	53.5550	1.5591	
25	407746.26	5937959.35	53.5824	1.6065	
26	408936.88	5937879.98	53.5819	1.6245	
27	418334.13	5941774.72	53.6184	1.7654	
28	429483.46	5944975.61	53.6488	1.9332	
29	430096.09	5945091.16	53.6499	1.9424	
30	430942.76	5946064.83	53.6588	1.9550	
31	431175.59	5946445.83	53.6622	1.9584	
32	432414.25	5949173.20	53.6869	1.9766	
33	437144.60	5953325.01	53.7248	2.0474	
34	450905.17	5963390.33	53.8167	2.2543	
35	457698.83	5972710.43	53.9011	2.3562	
36	458863.00	5972763.35	53.9017	2.3739	
37	464472.17	5979325.03	53.9611	2.4585	
38	475917.66	5987538.91	54.0355	2.6323	
39	494449.61	6005505.24	54.1976	2.9149	
40	503016.83	6011857.89	54.2547	3.0463	
41	504266.50	6013198.06	54.2667	3.0655	
42	507641.76	6017445.90	54.3048	3.1174	
43	515106.91	6024022.51	54.3638	3.2325	
44	515940.35	6024125.69	54.3647	3.2453	
45	564651.50	6066141.28	54.7384	4.0042	

46	565762.75	6068522.54	54.7596	4.0220	
47	596719.06	6092176.33	54.9671	4.5108	
48	598782.82	6093763.84	54.9810	4.5436	
49	610054.09	6101383.85	55.0471	4.7225	
50	616271.93	6106321.04	55.0900	4.8218	
51	627378.96	6115628.97	55.1709	4.9999	
52	631281.57	6119796.16	55.2073	5.0631	
53	635155.25	6125678.93	55.2590	5.1267	
54	672153.17	6157759.58	55.5355	5.7280	
55	682641.59	6161665.34	55.5667	5.8966	
56	684308.47	6162935.34	55.5775	5.9238	
57	689705.98	6165157.85	55.5953	6.0109	
58	691452.23	6165792.85	55.6004	6.0390	
59	699409.58	6168114.59	55.6180	6.1667	
60	701376.52	6168534.83	55.6210	6.1982	
61	723241.67	6175164.06	55.6709	6.5502	
62	724703.43	6175601.14	55.6741	6.5737	
63	737855.01	6179558.14	55.7033	6.7858	
64	738285.10	6180111.26	55.7081	6.7931	
65	738273.21	6180961.07	55.7157	6.7937	
66	738749.40	6181493.67	55.7202	6.8017	
67	752978.91	6185695.78	55.7507	7.0316	
68	753580.17	6186133.51	55.7543	7.0415	
69	753523.59	6187102.15	55.7630	7.0415	
70	754074.18	6187657.62	55.7677	7.0508	
71	770953.33	6190353.48	55.7827	7.3217	
72	771890.53	6191087.12	55.7888	7.3374	
73	771983.05	6192585.09	55.8021	7.3403	
74	772868.35	6193178.65	55.8070	7.3550	
75	801593.97	6193738.16	55.7949	7.8124	
76	817732.36	6192707.30	55.7753	8.0676	
77	824779.89	6191987.07	55.7642	8.1786	Blabjerg Landfall DK

APPENDIX C - CHARTS

Chart 001	**Overview**
Chart 002	**Western Segment**
Chart 003	**Central Segment**
Chart 004	**Eastern Segment**