APPENDIX A

Project Description

SHEPD – PENTLAND FIRTH EAST CABLE REPLACEMENT

Project Description

2742-GO-S-SW-0001

REVISION	DATE	ISSUE DETAILS	PREPARED	CHECKED	APPROVED
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REVISION	SECTION	PAGES	BRIEF DESCRIPTION OF CHANGES	AUTHOR/S OF CHANGE
02	All	All	Client Comments Incorporated.	GMSL
03	All	All	Client Comments Incorporated.	GMSL
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06	All	All	Client Comments Incorporated.	GMSL
07	All	All	Client Comments Incorporated.	GMSL
08	App A	29	Chart Updated	GMSL

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Abbreviations and Definitions

The Table below shows a list of abbreviations and definitions used in this document.

List of Abbreviations and Definitions

Abbreviation	Definition
A/C	Alter Course
BGS	British Geological Society
CBA	Cost Benefit Analysis
CBRA	Cable Burial Risk Assessment
CLV	Cable Lay Vessel
CPSP	Cable Protection and Stabilisation Plan
CR	Client Representative
DSE	Direct Shore End
DP	Dynamic Positioning
DWA	Double Wire Armoured
FO	Fibre Optic
GMSL	Global Marine Systems Ltd.
HDD	Horizontal Directional Drilled
HVAC	High Voltage Alternating Current
KP	Kilometre Point
LP	Landing Point
MBR	Minimum Ben Radius
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
NAVTEX	Navigational Telex
NTM	Notice to Mariners
OBS	On-Bottom Stability
OOS	Out or Service
PLGR	Pre-lay Grapnel Run
PFE	Pentland Firth East
RPL	Route Position List
SIMOPS	Simultaneous Operations
TJP	Transition Joint Pit
WD	Water Depth

1.0 Introduction and Background

1.1 Introduction

Scottish and Southern Electricity Networks (SSEN) operating under licence as Scottish Hydro Electric Power Distribution plc (SHEPD) is responsible for monitoring and maintaining the efficiency and integrity of the subsea electricity cable networks which provide power supplies to 59 Scottish islands.

Two subsea cables in the Pentland Firth connect the Scottish Mainland to the Orkney Islands via the island of Hoy. Routine inspections have identified that the Pentland Firth East cable is coming to the end of its operational life and needs replacing. More recently, two faults have occurred on the cable requiring emergency repairs. These repairs were successful, and the cable was re-energised, but a long-term solution is needed to maintain a safe, secure and reliable power supply to homes and businesses on the islands.

SHEPD is therefore now proposing to install a replacement 33kV subsea electric power cable across the Pentland Firth, between the existing subsea cables, landing at Murkle Bay on the Scottish Mainland and Rackwick Bay on the island of Hoy and is applying to Marine Scotland for a licence to carry out these works.

From the landfall points the replacement cable will connect into the existing electricity networks of both Orkney and the Scottish Mainland. This project description sets out the methodology proposed by Global Offshore to undertake the cable replacement works. The estimated installation schedule is presented below in Table 1-1.

Table 1-1: Estimated installation schedule

Activity	Estimated Timeframe (worst case scenario)
Seabed preparation (Crossing Construction and PLGR)	7 days
Landfall preparation	21 days (each landfall)
Nearshore cable lay	3 days
Offshore cable lay	7 days
Rock/grout bag placement	Offshore – 51 days Nearshore – 18 days
Post-lay burial	10 days
Post-lay survey	2 days
Nearshore split pipe installation	10 days (both landfalls)

This document provides a description of the project, detailing the physical construction of the cable, the routing, and method of installation and operation of the cable and should be read in conjunction with the following:

- Marine Licence Application Form
- Pre-application Consultation (PAC) Report (appended by Cost Benefit Analysis (CBA) model)
- Environmental Supporting Information (ESI) Report
- Fisheries Liaison and Mitigation Action Plan (FLMAP)
- Navigational Risk Assessment (NRA)
- Construction Environment Management Plan (CEMP)
- Operation, Inspection, Maintenance and Decommissioning Strategy (OIMD)

1.2 Background

The route for the replacement cable is shown in red in Figure 1-1. The proposed installation corridor for the cable is 500m wide (250m either side of the route centre-line).

Figure 1-1: Replacement Cable Route

2.0 Proposed Cable Construction

Electricity will be transmitted using High Voltage Alternating Current (HVAC) submarine cable technology. The typical structure is shown below in Figures 2-1 and 2-2.

Figure 2-1: Proposed Cable Structure

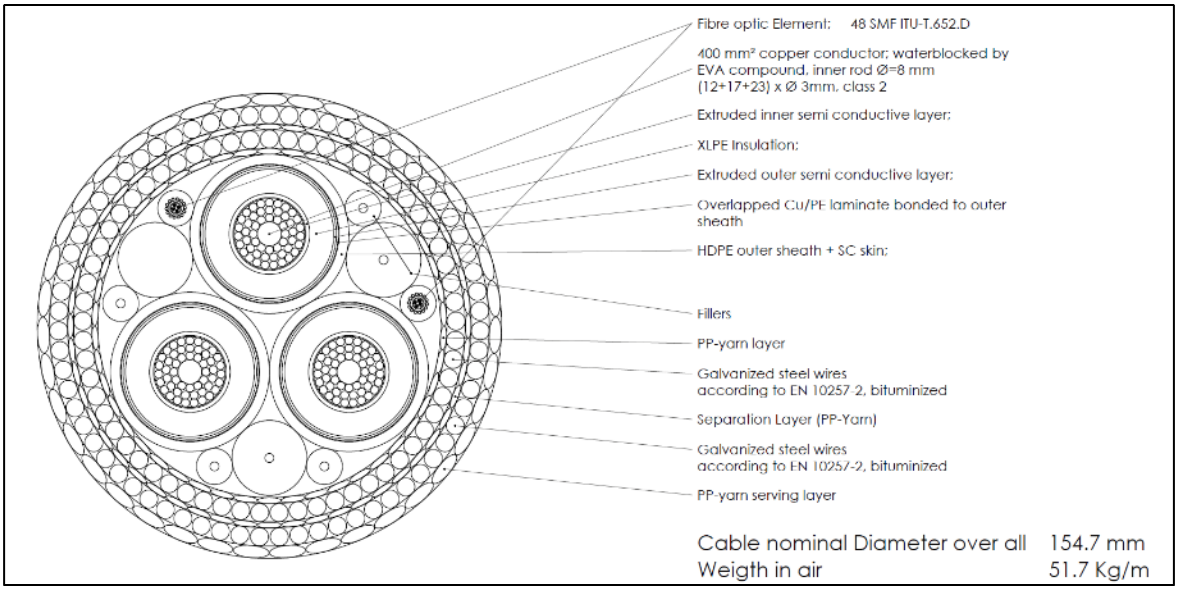


Figure 2-2: Proposed Cable - Cross Sectional Drawing *Source: Prysmian*

The 33 kV subsea cable that is proposed for installation is a 400 mm^2 three core XLPE conductor with two 48 mm fibre optic (FO) cables, encased and protected with a double layer of 6mm steel wire armour. The proposed double wired armour (DWA) construction will provide the cable with additional mechanical protection and weight thus providing additional stability for the surface laid cable.

Fibre optics are installed integral to the submarine cable for the purpose of cable condition monitoring, control and power system protection.

The subsea cable conductor cores specification and power rating has been selected through the assessment of historic demand on the existing network and with consideration given to future demand growth on the network.

A summary of the key mechanical properties of the replacement cable is shown below in Table 2-1.

Table 2-1: Proposed Cable – Key Mechanical Properties

Cable Weight (in Air) kg/m	Max Tension (kN)	MBR (m)	Cable Diameter (mm)	Max Crush Resistance (kN/m)	Specific Gravity
51.7	215 +> Maximum Bend Radius (MBR) above 3mtrs	2.3	154.7	40	~2.7

Prior to installation, dynamic simulations using OrcaFlex software will be run of the proposed installation methodology, taking into account the mechanical parameters shown in Table 2-1. The outputs of this analysis will be a set of operational weather parameters.

3.0 Pre-Installation Survey Works

Pre-installation survey works were undertaken during August/September 2019 and included the following:

- Offshore Geophysical Survey
- Offshore Geotechnical and Environmental Survey
- Nearshore Geophysical Survey
- Landfall Geotechnical and Topographic Survey

The key outputs of the surveys were as follows:

- Seabed Bathymetry and Land Topography
- Soil Classification and Strength along the proposed cable route
- Benthic sampling to support classification of existing marine habitats
- Identification of archaeological features along the proposed cable route
- Identification of hazards (debris, existing cables etc.) along the route

The survey works have allowed Global Offshore to effectively plan the subsea cable installation and have allowed more detail to be submitted as part of the marine consents process.

The survey works have also informed the environmental assessment provided in the supporting ESI Report, based on what has been found as part of the environmental sampling.

4.0 Cable Protection and Stabilisation Plan

4.1 Overview

A Cable Protection and Stabilisation Plan (CPSP) has been developed as part of the Marine License application, see Table 4-1 below.

The CPSP conservatively outlines the number of deposits required and is the basis of the assessment made in the Environmental Supporting Information.

Engineering studies are ongoing which may reduce the number of deposits required.

The total area of the works proposed is 17,897,500 m^2.

Table 4-1: Cable Protection and Stabilisation Plan

Location Description	Kilometre Point (KP) Range	Installation Type	Length of Cable (m)	No. of Rock Bags*	Grout Bags (1 Te)	Concrete Mattresses
Rackwick TJB to MHWS	0.000 - 0.046	Cable burial by excavator. Possible cast iron pipe**	46	0		
MHWS-MLWS	0.046 - 0.122	Cable Burial by excavator. Possible cast iron pipe**	76	0		
MLWS to foot of coastal boulder area	0.122 - 0.308	Cable laid on surface with possible cast iron pipe or Uraduct***	186	30		
Foot of coastal boulder area to Vessel Set Up Position	0.308 - 0.597	Cable laid on surface	289	22		30 + 4 (OOS)
Vessel Set Up Position to Stony Reef	0.597- 2.935	Surface lay with possible post lay burial	2338	123		4 (OOS)
Stony Reef feature (approx. KP3)	2.935 - 3.195	Cable laid on surface with possible Uraduct*** protection	260	2		
Rocky reef to seabed ridge	3.195- 4.280	Surface lay with possible post lay burial	1085	26		
Seabed Ridge	4.280- 4.380	Cable laid on surface	100	3		
Seabed Ridge to Start of Sandwave Area	4.380 - 6.955	Surface lay with possible post lay burial	2575	65		
Sandwave Area	6.955 - 17.355	Surface lay with possible post lay burial	10400	260		
Mid Channel	17.355 - 19.355	Surface lay with possible post lay burial	2000	50		

Location Description	Kilometre Point (KP) Range	Installation Type	Length of Cable (m)	No. of Rock Bags*	Grout Bags (1 Te)	Concrete Mattresses
Southern Channel Boulder Field	19.355 - 27.755	Surface lay with possible post lay burial	8400	210		
The Sands	27.755 - 29.587	Surface lay with possible post lay burial	1832	46		
Northern Lights FO Cable Crossing	29.587 - 29.687	Cable laid on surface with possible Uraduct*** protection and concrete mattresses (Up to 8)	100	5		8
Between Crossings	29.687 - 30.012	Surface lay with possible post lay burial	325	17		
Farice FO Cable Crossing	30.012 - 30.112	Cable laid on surface with possible Uraduct*** protection and concrete mattresses (Up to 8)	100	5		8
Dunnet Bay Boulder Field	30.112 - 31.902	Surface lay with possible post lay burial	1790	89		
Dunnet Bay	31.902 - 34.034	Surface lay with possible post lay burial	2132	110		
Murkle Bay over rock to MLWS	34.034 - 35.641	Cable laid on surface with possible cast iron pipe** or Uraduct***	1607	82		30
MLWS-MHWS	35.641 - 35.745	Cable burial by excavator. Possible cast iron pipe**	104	0		
MHWS at Murkle Bay to Murkle Bay JTB	35.745 - 35.795	Cable burial by excavator. Possible cast iron pipe**	50	0		
		TOTALS =	**35,795**	1145 +20% = **1375***	**20**	**84**

* 20% contingency allowed for in Rock Bag quantities to take account of possible minor free spans, which require 2 x Rock Bags installed either side of the cable rather than 1 on top of the cable.

** Note that for every 1 m of cast iron split pipe, six cast iron half shells are needed.

*** Area of Uraduct applied for in Marine License is taken as the total length allowed for in Table 4-1 multiplied by the diameter of the Uraduct (251 mm).

4.2 Cable Protection and Stabilisation – Cost Benefit Analysis

A Cost Benefit Analysis (CBA) has been conducted which has recommended that the following combination of cable protection and stabilisation is adopted, in terms of achieving best value to society:

- 28% burial;
- 9% rock bags; and
- 63% surface lay (4% variance in cost to society).

The final design of cable protection and stabilisation is in progress, from which the exact combination of protection that will be required along the replacement cable route will be decided. The CPSP (Table 4-1) is intended to provide a footprint of all of the possible protection and stabilisation methods that could be adopted. This has been included to ensure that the maximum amount of seabed deposits has been assessed and included in the marine licence application. The environmental assessment in the supporting ESI Report has been based upon the tabulated amounts which demonstrates the footprint for the worst case scenario and maximum possible protection. Any refinements may result in a reduction of deposits thereby decreasing seabed footprint.

Note that the percentages shown for burial, rock bags and surface is lay is subject to rounding.

5.0 Project Description

5.1 Proposed Route

The position of the replacement cable route in relation to existing power and telecom cables is shown in the chart provided in Appendix A.

The cable routeing decisions taken as part of the development of the route is outlined below in Section 5.1.1.

5.1.1 Routing Decision Making Process

Landing points at the eastern end of Rackwick Bay, Hoy and the coastline just east of Murkle Bay on mainland Scotland were initially selected with Horizontal Directional Drilling (HDD) being proposed for the latter. However it was subsequently identified that a conventional trenched cable landing solution at Murkle Bay, with a floated shore end could be achieved with significant cost and risk reductions to the project. This solution simplifies the required onshore works in order to connect into the existing onshore network.

The assessment of the replacement cable route from an engineering perspective was informed by inputs from the marine survey reports, the environmental assessment undertaken as part of the ESI Report and fisheries considerations outlined as part of the FLMAP.

During the Desk Top Study phase of the project, SHEPD identified that a landing point at Rackwick Bay was preferred at the western end of the beach taking into account routing considerations for the land based cable route. The offshore cable route was therefore designed to remain between the two existing cables as this best suited both landing points. This routeing decision has several cable route engineering benefits as follows:

- Routeing between the existing cables minimises the number of cable crossings and avoids the need for any power cable over power cable crossings;
- The two existing cables landing at Murkle Bay have more space for the replacement cable to land in-between them than to either side. Landing the replacement cable to the west or east of the existing cables would be challenging;
- The security of the replacement cable is enhanced by being between the two existing cables – the Pentland Firth distribution 'cable footprint' is not extended beyond the existing power cables and remains within the area already known to existing marine industries operating in the Firth. These marine industries are detailed further in the supporting ESI Report and FLMAP. In particular this decision should benefit the fishing industry.

As discussed in Section 4.0 rock bags are proposed for cable protection and stability, however the NRA requires that chart datum is not altered by more than 5% without consultation with the Maritime and Coastguard Agency (MCA). Therefore the decision was taken to use concrete mattresses in the very shallow water due to the lower profile of the structure (see Section 5.2.3 for further detail).

Following the pre-construction survey, micro-routeing of the RPL was undertaken to optimise the route within a natural gulley close to the Murkle Bay landing to provide additional stability and to reduce the requirement for further rock bag deposits for stability.

A summary of the timing of key cable route engineering design decisions is provided below in Table 5-1.

Table 5-1: Key Route Engineering Timeline

Stage	Date	Description
1	19 June 2019	Murkle Bay beach selected as Scottish Mainland primary landing point (LP).
2	14 August 2019	RPL produced as part of DTS process for survey using route between the existing cables. This route also informed by fisheries considerations (see FLMAP).
3	22 August 2019	Western side of Rackwick Bay selected as Hoy, Orkney primary landing point (LP).
4	9 September 2019	In field selected route produced immediately after marine survey completed using preliminary field data
5	7 November 2019	Final reporting route produced based on draft survey results, micro-routeing to improve the approach to Rackwick and Murkle and to maximise boulder avoidance resulting in small adjustment to the fibre optic crossing points.

5.1.2 Route Description

One of the main constraints on route design is the maximum lay curvature, or rate of turn, chosen. The lay curvature of a route during installation depends on two factors; the installation method and the depth of water. For the replacement cable the maximum alter course (A/C) angle used in route planning is 24.2° with a 53m separation in the approach to Murkle Bay. All A/Cs are expected to be achievable by a cable installation ship using standard equipment.

The replacement cable route is described below by Kilometre Point (KP). The route starts at KP0, the northern end of the cable route at Rackwick Bay, Hoy. It progresses to the south with increasing KP values as it crosses the Pentland Firth towards Murkle Bay on the Scottish Mainland.

The Rackwick Bay Transition Joint Pit (TJP), where the offshore cable connects to the onshore cable, is located at 58°52.1880’N, 003°23.0560’W, at the north western end of Rackwick Bay. A key requirement for the routeing of the replacement cable has been to avoid crossing the existing Pentland Firth distribution cables and so the replacement cable Landing Point (LP) is positioned between them. The replacement cable lies approximately 300m southeast of Pentland Firth West and 700m northwest of the existing Pentland Firth East cable.

The Rackwick Bay beach and the immediate inter-tidal area is characterised by boulders and the replacement cable may require additional protection for the first 320m of the route. Once past the inshore area the seabed is expected to become sandy. The cable route deepens relatively quickly towards 13m water depth at KP 0.597, with this point being designated the end of the shore end. The cable lay vessel (CLV) will lay away from this point to the southwest with the geophysical survey data confirming seabed conditions to be relatively even.

From KP2.3 the seabed begins to steepen to around 5° as the cable route exits Rackwick Bay, descending the slope until KP3.5 where the seabed flattens out again at approximately 75m water depth. The cable route as designed avoids a small valley cut into this offshore slope which has an increased abrasion risk, and has then been routed to pass through the “saddle” between two bathymetric features interpreted as large, low relief sandwaves at KP4.2 as shown in Figure 5-1.

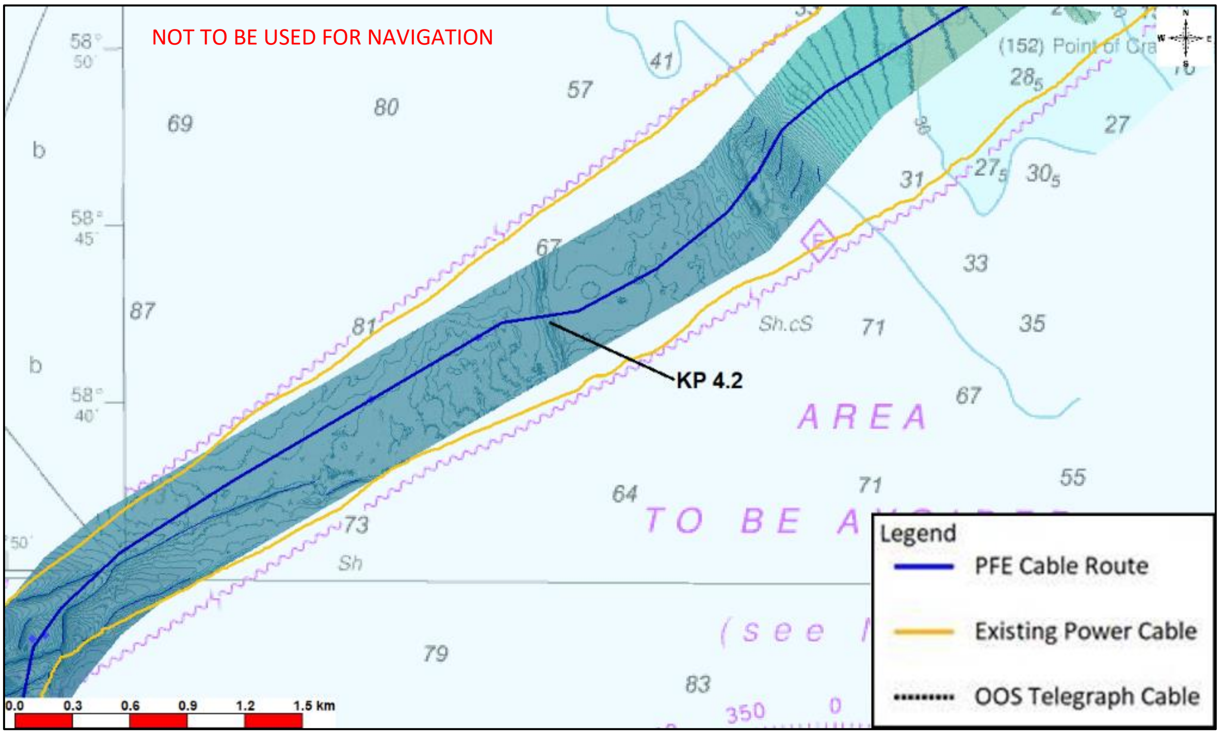


Figure 5-1: Cable Route Close to Hoy

From here the cable route proceeds southwest, remaining between the two existing cables. At KP6.8 it begins to turn onto a more southerly heading and shortly afterwards enters an area of complex bathymetry which has been assessed as large sandwaves. The cable route passes between two of these features, attaining the deepest point along the cable route at 89m water depth (WD), before altering course to climb the slope of a third sandwave feature at a relatively good angle. This course avoids the peak of the sandwave as this is the area of greatest movement and steepest slopes. This point on the route represents the maximum side slope encountered but does not exceed 5° and is within the capability of a standard Remote Operated Vehicle (ROV) for inspection and/or burial operations. This area of the cable route is shown in Figure 5-2.

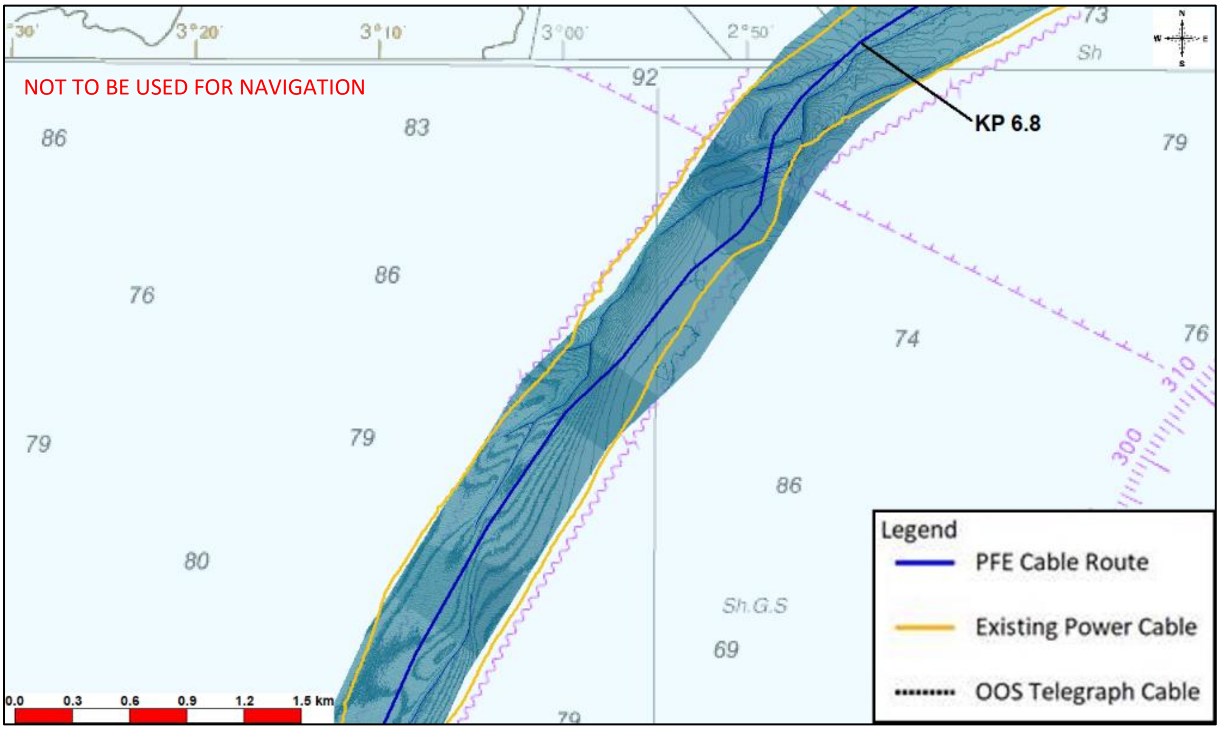


Figure 5-2: Cable Route at KP6.8

Once over this sandwave the replacement cable travels south for around 3km before entering another patch of sandwaves centred 10km southwest of Hoy. The cable is expected to be within the sandwave field for around 4km and this area is anticipated to be a focus of post-survey route engineering efforts as the exact position and orientation of bedforms becomes known.

At ~KP17 (approximately halfway along the cable route) the cable route emerges from the main body of the sandwave field onto seabed of lower relief, although smaller bedforms are still expected to occur along the entirety of the route. At KP18 the cable route climbs a slope and re-enters the normal transit passage corridor for the Scrabster-Orkney ferry route, which in turn merges with the main shipping channel through the Pentland Firth. The seabed here is relatively flat with water depth averaging around 75m. The cable route then exits the main shipping channel at around KP23.3 and leaves the Scrabster-Orkney ferry route at KP25.6. Shipping routes such as the ferry route mentioned earlier can be viewed in the supporting FLMAP.

At KP27.5 the cable route ascends a large sandbank at the mouth of Dunnet Bay known as "The Sands" with the seabed in this area being characterised by the British Geological Survey (BGS) as gravelly sand. The Sands causes a notable bump in the cable route profile between KP27.5 and KP30, where the cable enters Dunnet Bay (Section 5.1.3). To the south of the sandbank the cable route crosses first the Northern Lights then the FARICE fibre optic cables, both in service, and also avoids a disused spoil ground lying to the west (Figure 5-3).

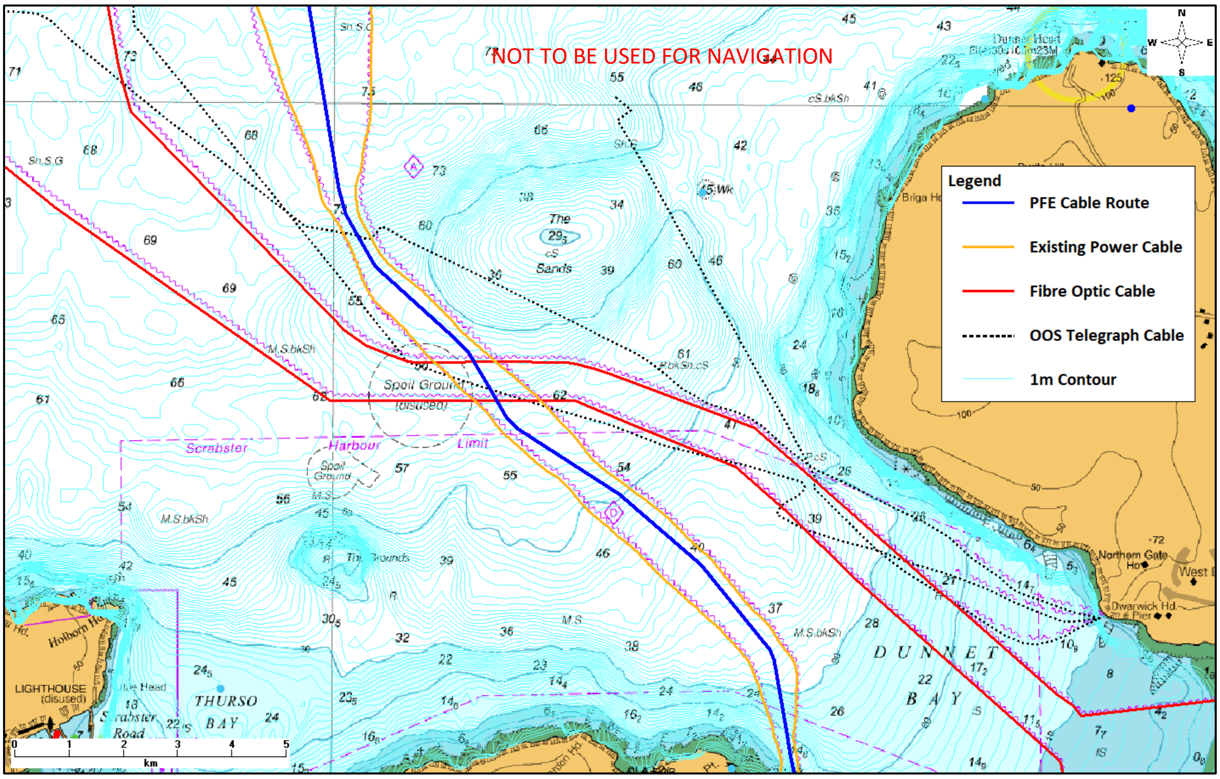


Figure 5-3: Cable Route outside Dunnet Bay

At KP30.28 the cable route enters Scrabster Harbour Limit. The seabed of Dunnet Bay is relatively flat and shelves toward the LP at less than 3° on average before turning south towards Murkle Bay. The end of the Direct Shore End (DSE) is approximately 740m offshore of the cable LP. This DSE has been permitted by the relatively steep bathymetry of Murkle bay which allows a typical installation vessel to approach close inshore.

The 17m WD contour has been chosen as the nominal setup position, the setup position is the position the vessel takes during the cable pull in operation, as this should allow even a laden installation vessel to approach to this point with enough room to manoeuvre to avoid running aground. The replacement cable will be floated from the DSE position to the LP between the existing Pentland Firth West and East cables. Some rock outcrops may occur in the bay but overall the route is expected to be north of the majority of bedrock. Careful cable handling may be required in the bay to avoid overlying the existing cables, which have been accurately mapped as part of the inshore survey.

The Murkle Bay TJP is positioned at 58°36.1790'N, 003°26.0280'W, halfway between the existing cable termination points.

5.1.3 Route Profile

The replacement cable route profile shown in Figure 5-4 shows the cable route water depth profile in the upper panel and the slope gradient in degrees, along the route from Rackwick Bay to Murkle Bay in the lower panel.

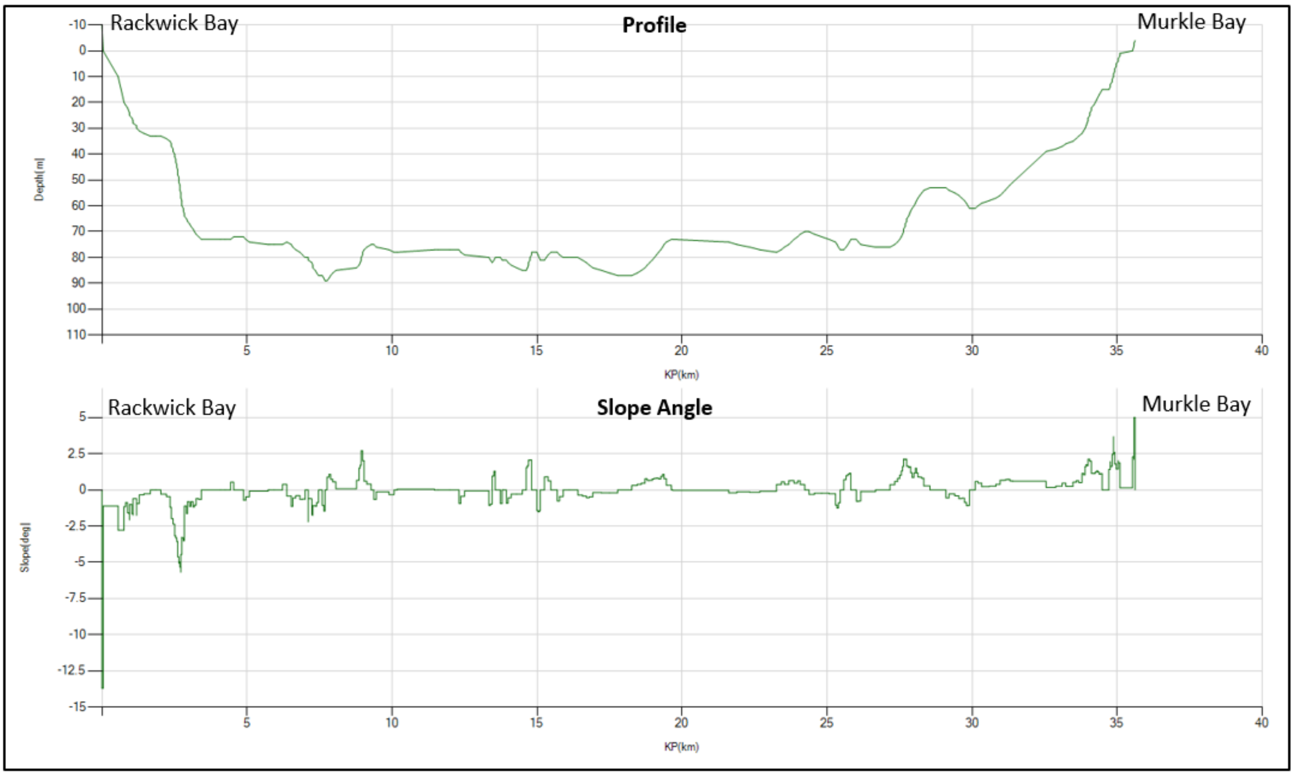


Figure 5-4 Pentland Firth East Route Profile

5.1.4 Proposed Murkle Bay Landing

An overview of the proposed LP at Murkle Bay is shown below in Figure 5-5.

Figure 5-5: Proposed Murkle Bay Landing Point

5.1.5 Proposed Rackwick Bay Landing

An overview of the proposed LP at Rackwick Bay is shown below in Figure 5-6.

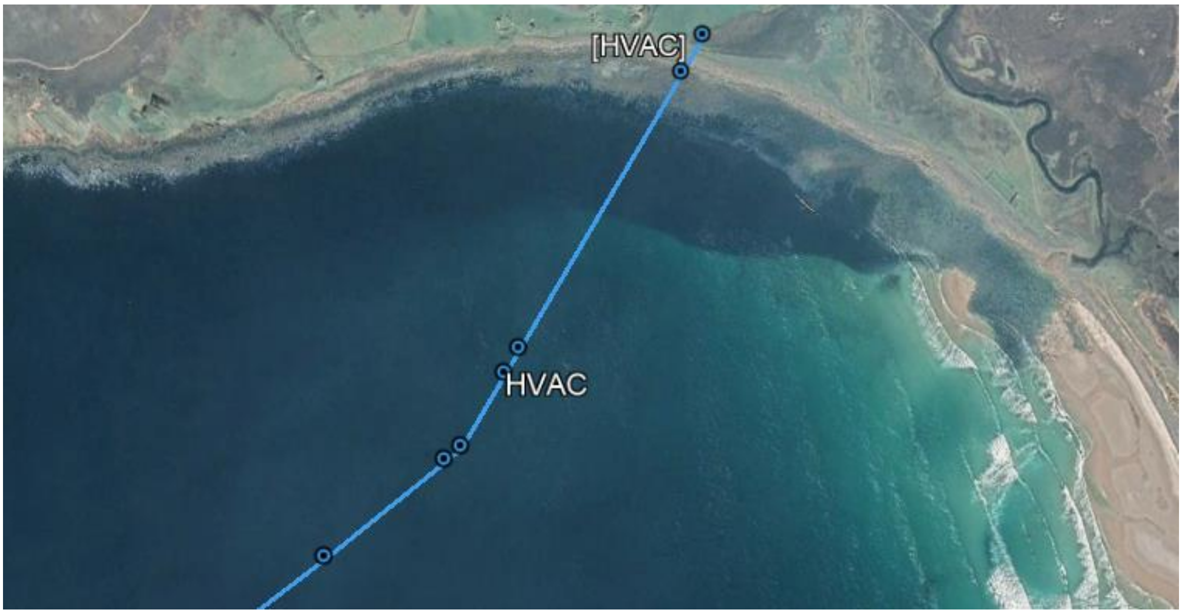


Figure 5-6: Proposed Rackwick Bay Landing Point

5.2 Proposed Installation Method

An indicative installation methodology is outlined below in Sections 5.2.1 to 5.2.13. Note that the final methodology will be engineered following the results of the pre-installation survey operations and on completion of the On-Bottom Stability (OBS) and Cable Burial Risk Assessment (CBRA). The outline below is intended to give an overview of the options available to the cable installation contractor.

5.2.1 Pre Lay Debris and OOS Cable Removal

Prior to lay operations commencing, a pre-lay survey will be conducted. The objective of the survey will be to:

- Identify and investigate possible debris;
- Identify any obstructions on the proposed route; and
- Identify FO cables as well as OOS cables that cross the proposed route.

Any obstructions or debris will be removed, if possible. A work class ROV or Pre-Lay Grapnel Run (PLGR) will be undertaken to remove debris from the proposed route. The pre-construction survey has identified possible OOS cables at Rackwick Bay, see Figure 5-7 below. In the nearshore area, a diver may be required to remove debris.

If debris or an obstruction cannot be removed from the planned route, the offshore surveyors will micro-route around the debris/obstruction in consultation with the on board Client Representative (CR) – at all times staying within the licensed installation corridor.

Debris identified and removed along the route will be disposed of as outlined in the offshore CEMP (Document Reference: 2742-GO-G-TB-0005).

5.2.2 Pre Lay Grapnel Run (PLGR)

A PLGR may be required to remove OOS cables and/or to prepare the route for burial where deemed appropriate. A typical grapnel train is shown below in Figure 5-8. Multiple pre-lay grapnel runs both end to end and perpendicular to the route may be required within the licensed installation corridor to remove OOS cables and as part of pre-burial activity, where appropriate.

Please note that a PLGR will NOT be conducted within any Annex 1 stony reef habitat identified during marine survey. Please refer to Section 4 – Benthic and Intertidal Ecology of the supporting ESI Report.

The pre-construction survey has identified several magnetometer hits in the nearshore area at Rackwick Bay consistent with OOS cables as shown in below in Figure 5-7 which presents an extract from survey chart 103320-GMG-MMT-SUR-DWG-AL10K001.

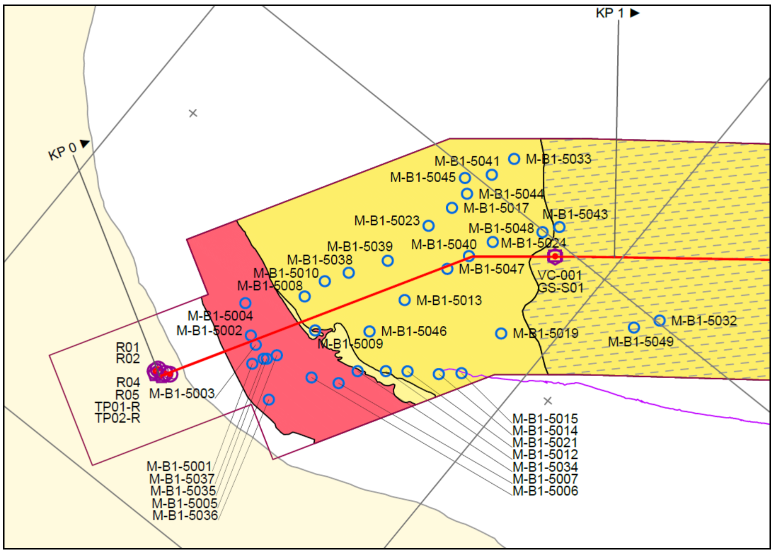
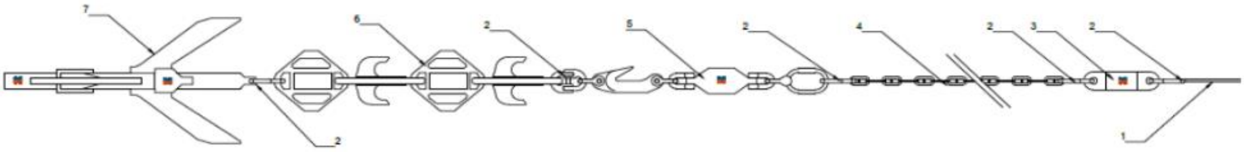


Figure 5-7: Magnetometer Hits at Rackwick Bay



	ITEM	QUANTITY	SWL	WEIGHT
1	VESSEL WINCH WIRE 48mm x 1000m	1	200TE	-
2	HAMMER LOCK	5	26TE	6Kg
3	BEARING SWIVEL	1	25TE	59Kg
4	Ø32MM CHAIN	Approx 7m	+25TE	-
5	GIFFORD TYPE HOOKS	1	13TE	240.4Kg
6	RENNIE TYPE HOOKS	1	13TE	237.2Kg
7	SLIDING PRONG GRAPNEL	1	13TE	223Kg

Figure 5-8: Typical Grapnel Train

5.2.3 Mattress Installation

Two FO cable crossings are expected along the cable route. In order to cross the FO cable, concrete mattresses are proposed to be placed to protect both the FO cable and the replacement cable.

Up to eight concrete mattresses (6m long by 3m wide) per crossing have been allowed for. The volume of concrete will be dependent on the thickness of mattresses and will be finalised as part of the detailed design process. A typical mattress thickness would be 300mm, so a typical volume per mattress of 5.4 m^3. Figure 5-9 shows concrete mattresses stored on board the vessel and Figure 5-10 shows a mattress being over boarded.

Further mattresses may be required to cross the OOS cables as shown above in Figure 5-7. This may be considered a more economical solution than PLGR described above.

Note that mattresses have also been allowed for stabilisation in the shallow/nearshore areas of the route. Mattresses can be installed to offer stability with less height (150 mm – 300 mm) compared to Rock Bags (0.4 m – 0.6 m) which can help with compliance with MCA restrictions on reduction of water depth as detailed in the supporting NRA as appended to the PAC Report. The intention is not to use concrete mattresses for stabilisation in shallow waters, however it is important for the option to be retained to allow stabilisation to take place if deemed necessary. The footprint is therefore environmentally assessed within the ESI Report based on a worst case scenario.

If shallow water mattress installation is required, a MultiCat type vessel will carry out the installation in shallow water. During the installation in shallow water, the MulitCat will need to drop anchors to assist station keeping during operations. An overview of the likely anchor arrangement is shown in Figure 5-11, note that the anchors are designed to be non-penetrative and rely on the self-weight of the arrangement to provide stability to the vessel. Anchor footprints are assessed in Section 4.4.2 and Section 4.5.2.2 along with Table 2-2 in the Environmental Supporting Information Report.

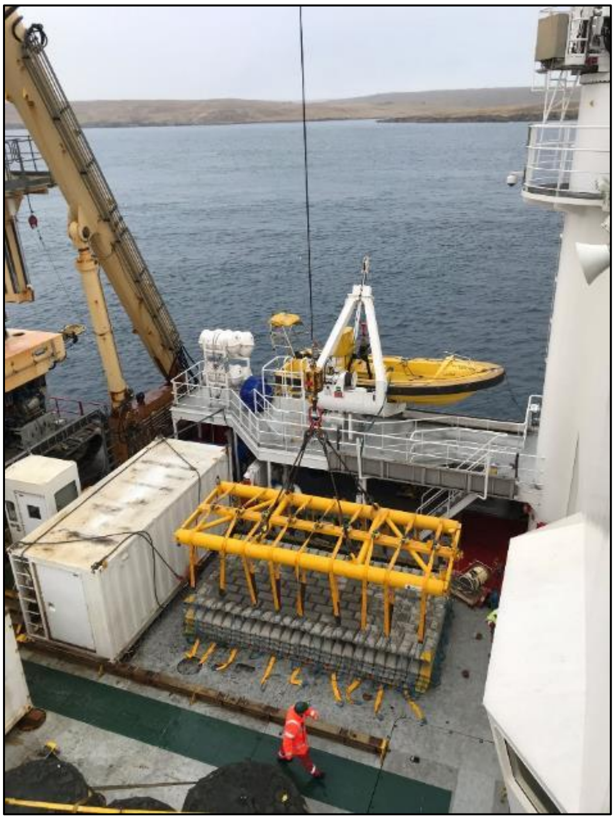


Figure 5-9: Mattress on Deck

Figure 5-10: Mattress Overboard

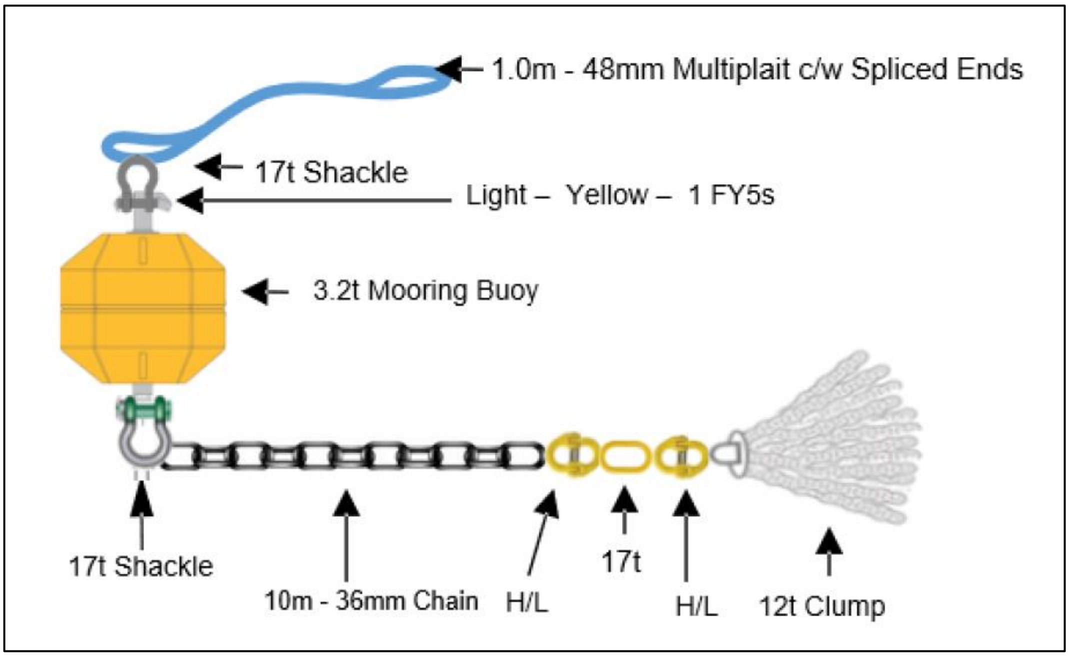


Figure 5-11: Example Anchor Configuration

5.2.4 Sandwave Clearance

Significant sand waves have been identified during the pre-construction survey, sandwave clearance by Mass Flow Excavator (MFE) may be required prior to lay operations. Mass Flow Excavation is the direction of high volume pressurised water jets used to level the seabed in preparation for the cable lay operations.

The total length where MFE operations may take place is between 700 m and 1 km which represents less than 3% of the proposed route.

5.2.5 Landfall Preparations

The Rackwick Bay landfall on the island of Hoy and the Murkle Bay landfall on the Scottish Mainland will be prepared with the following tasks undertaken:

- Site setup, including fencing, signage, welfare units etc.;
- Landfall drone survey and site walkover;
- Nearshore visual survey;
- Excavation works along landfall cable route from MLWS to the TJB; and
- Cable pull-in preparation, including cable rollers, quadrants winches etc.

Figure 5-12 below shows the trench cross-section based on agricultural ground. Ground not considered agricultural is subject to shallower burial requirements.

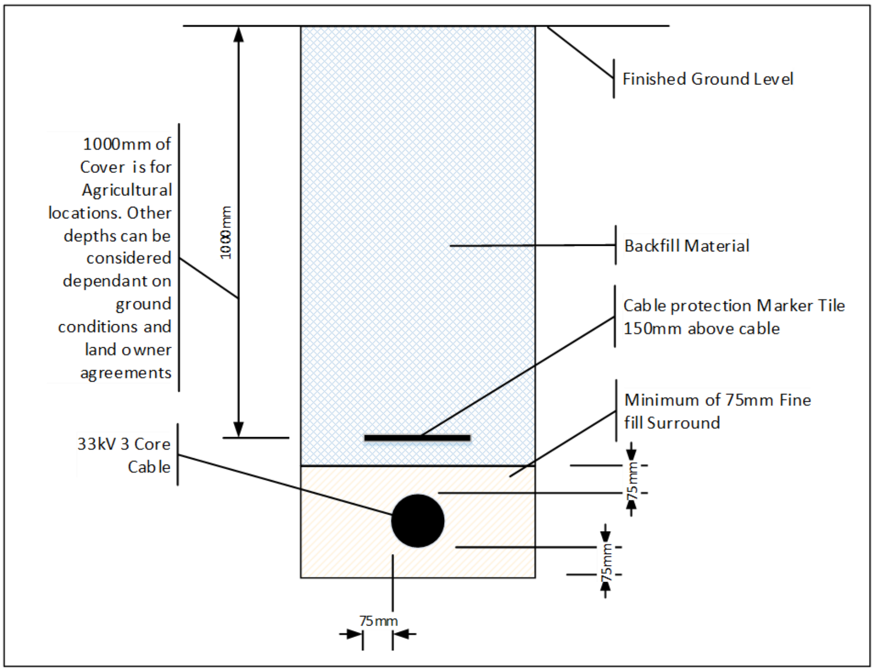


Figure 5-12: Indicative Trench Depth

Note that rock breaking between MHWS and MLWS as well as landward of MHWS is likely to be required at both the Rackwick Bay and Murkle Bay landfalls in order to achieve cable burial requirements.

5.2.6 First End Pull-In

The CLV will position at the First end pull-in site, generally stationed at the 10 m WD contour (this is dependent on the vessel's draft), and deck handling equipment will be used to direct the cable to the over-boarding chute.

A small support craft will then retrieve the pull-in winch wire from the shore and return it to the CLV where it will be connected to the cable end. The shore end winch will commence pulling in the cable with buoyancy units attached onto the cable as it leaves the vessel in order to 'float' the cable ashore.

Figure 5-13 and Figure 5-14 show typical First end pull-in operations.

Figure 5-13: First End Pull In

Figure 5-14: First End Pull In

5.2.7 Cable Lay Operations

Once the cable is successfully pulled to its required position onshore, surface swimmers will gradually remove the buoyancy units allowing the cable to come to rest on the seafloor.

Once all buoyancy units have been removed, the CLV will commence laying the cable on the seabed from the First end to the Second end. The CLV will be a DP2 Class vessel and expected cable laying speed will be between 200 m/h and 450 m/h.

During cable lay operations, the vessel crew will monitor the lay to ensure the cable is laid within the consented installation corridor and that the mechanical parameters of the cable are adhered to; expected lay tensions are between 10 kN and 20 kN.

Monitoring of the cable's touchdown point on the seabed, which is expected to be between 1 x WD and 1.5 x WD away from the installation vessel, will be conducted with the vessel's ROV and/or subsea sonar equipment.

During cable lay operations, the vessel will install the cable within the cable installation corridor. During these operations, the vessel structure may be outside the licenced corridor however all deposits will be installed within the allocated boundary. Vessel movements will be notified by notice to mariners issued to inform other sea users for safety as outlined in the supporting FLMAP.

5.2.8 Second End Pull In

Once the cable is laid across the seabed, the vessel will either manoeuvre off the RPL and float the cable off the vessel or remain in position on the RPL and pay out cable into a floated omega bight. This is in order to allow the cable to be cut at the required length prior to pulling the cable into the Second end landing point.

As for the First end, buoyancy units will be attached to the cable as it is being paid out to float the cable ashore. An example of a Second end bight is shown in Figure 5-15.

Once the cable is floated out into a bight, support craft will retrieve the pull-in wire from the shore end winch and attached it to the cable end. The cable will then be pulled into the Second end landing point with surface swimmers gradually removing the buoyancy units allowing the cable to come to rest on the sea floor.

The bight may be outside of the cable installation corridor whilst in the water column at certain points during deployment, however final installed position will be within the boundary of the licenced area. The supporting FLMAP and NRA reference the notifications issued to sea users to inform which activities are taking place. Navigational broadcasts will be issued via Navigational telex (NAVTEX) and Notices to Mariners (NTMs) distributed by the Kingfisher fortnightly bulletin and on social media.

Figure 5-15: Second End Omega Bight

5.2.9 Rock Bag Installation

The cable protection strategy may include the installation of Rock Bags onto the cable to provide stability. The Rock Bags will be stored on the vessel and lifted into position using the vessel's crane (see Figures 5-15 and 5-16). The vessel's ROV monitors the installation and detaches the crane wire from the Rock Bag once in position.

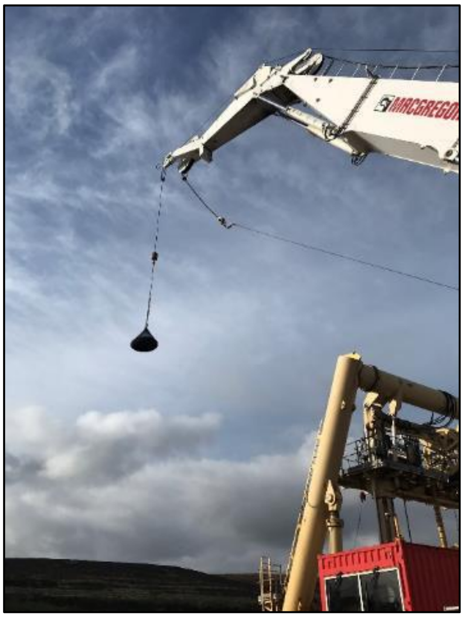


Figure 5-16: Rock Bag Being Lifted off the Vessel

Figure 5-17: Rock Bag in Position Subsea

The placement of 4 Te Rock Bags has been assessed in the supporting ESI Report. Table 5-2 shows the dimensions of a 4 Te Rock Bag.

Table 5-2: Rock Bag Dimensions

Rock Bag Mass in Air (Te)	Diameter (m)	Height (m)	Volume (m^3)
4	2.4	0.6	2.5

Where practicable, the Rock Bags will be filled with stone local to the installation site.

The Rock Bags may be installed as soon as the cable is laid by a separate vessel to the cable lay vessel. Simultaneous Operations (SIMOPS) between the two vessels will be managed in the planning phase as well as the offshore phase via implementation of a SIMOPS plan. Each vessel will be named in the NtM as required in the supporting FLMAP.

5.2.10 Grout Bag Installation

There are currently no pre-installation plans for grout bags to be used, however they may be required to rectify any cable free spans that are observed following cable installation. The use of grout bags has therefore been assessed in the supporting ESI Report to ensure that the option to use grout bags is retained.

Table 4-1 provides an estimate for the worst case scenario of grout bag deposits. Each 1 Te Grout Bag (0.9 m x 0.9 m x 0.9 m) contains 40 x 25 kg individual units. If required divers will position the individual bags where free span rectification is required.

5.2.11 Post Lay Trenching

The cable protection strategy may include the option for post lay burial of the cable. This utilises a subsea trencher which is launched off the trenching support vessel, landing astride the cable. Once in position the trencher will bury the cable either with high pressure water jets (jetting tool) or a mechanical chain cutter (cutting tool), or a combination of both (hybrid tool). During burial operations, the environmental conditions (wind, wave, current etc.) will be monitored by the crew on board the Trenching vessel. An overview of typical burial tools is provided in Table 5-3 and an overview of the hybrid cutting tool is shown in Figures 5-17 – 5-19.

Table 5-3: Burial Tool Overview

Mode	Max Footprint (m)	Length (m)	Weight in Air (Te)	Capability
Jetting	7.0	7.8	40	Soil Strength up to 100 kPa
Cutting / Hybrid	7.0	8.0	40	Soil Strength up to 250 kPa

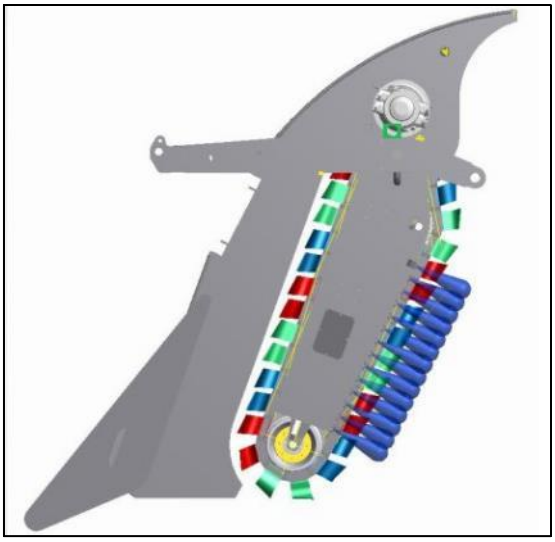


Figure 5-18: Hybrid Cutting Boom Side View

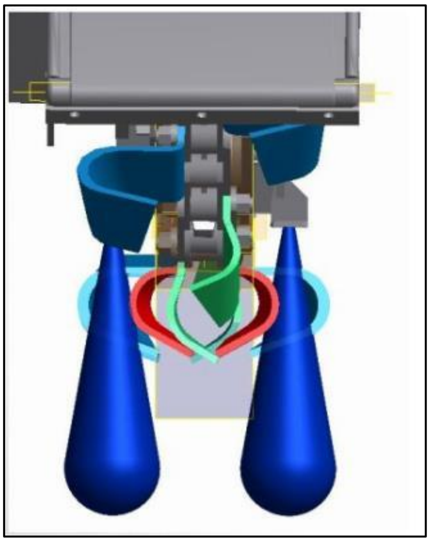


Figure 5-19: Hybrid Cutting Boom Front View

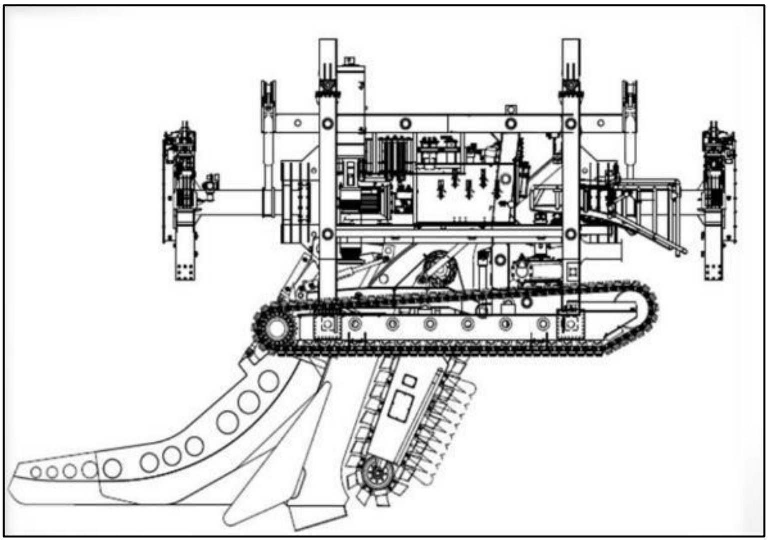


Figure 5-20: Hybrid Cutting Skid Assembly

5.2.12 Split Pipe or Uraduct Installation

The cable protection strategy may include the installation of Split Pipe or Uraduct, generally this is installed following the cable pull-in operations by divers and protects the cable in the nearshore and intertidal section of the cable route. Divers will not be required for installation in the intertidal section.

See Table 4-1 for details of anticipated Split Pipe or Uraduct installation. An example Split Pipe installation is shown in Figure 5-21.

Figure 5-21: Example Split Pipe Installation

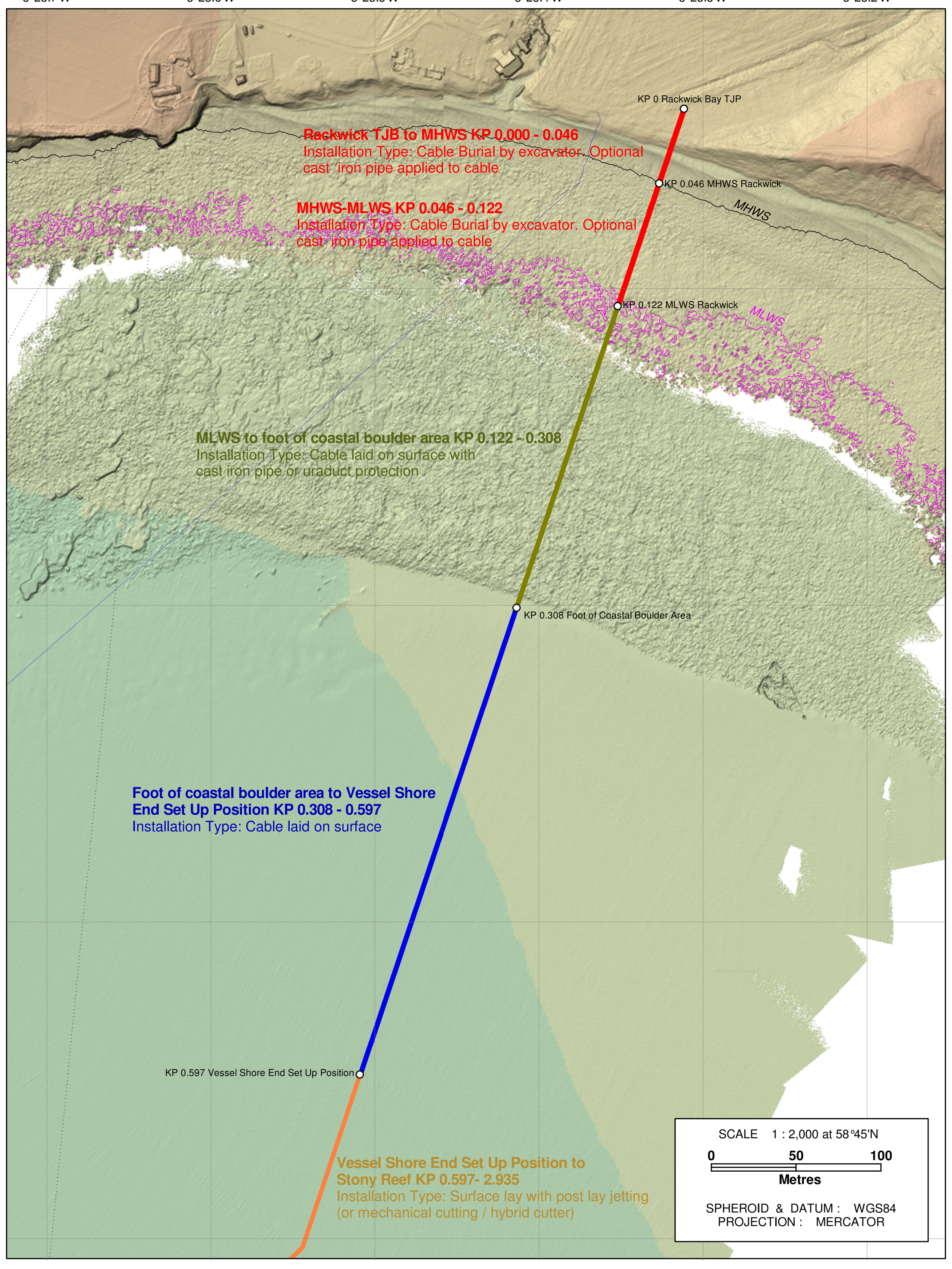
5.2.13 As-Built Survey and Site Re-Instatement

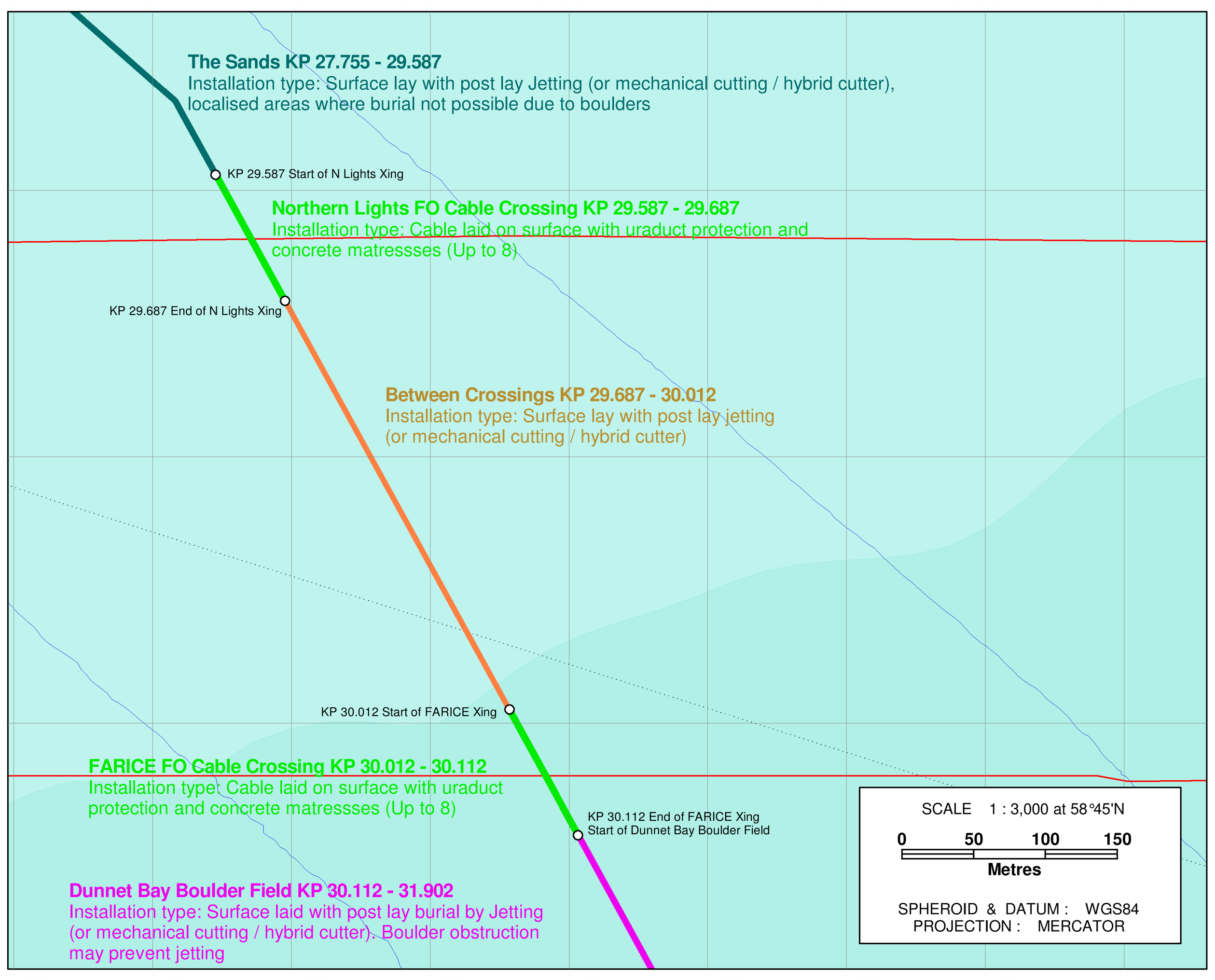
Following completion of operations, an As-Built survey will be undertaken of the replacement cable and protection. This will record the as installed position of the cable and the deposits utilised to stabilise and or protect the cable. The landfall sites will also be re-instated as agreed with landowners.

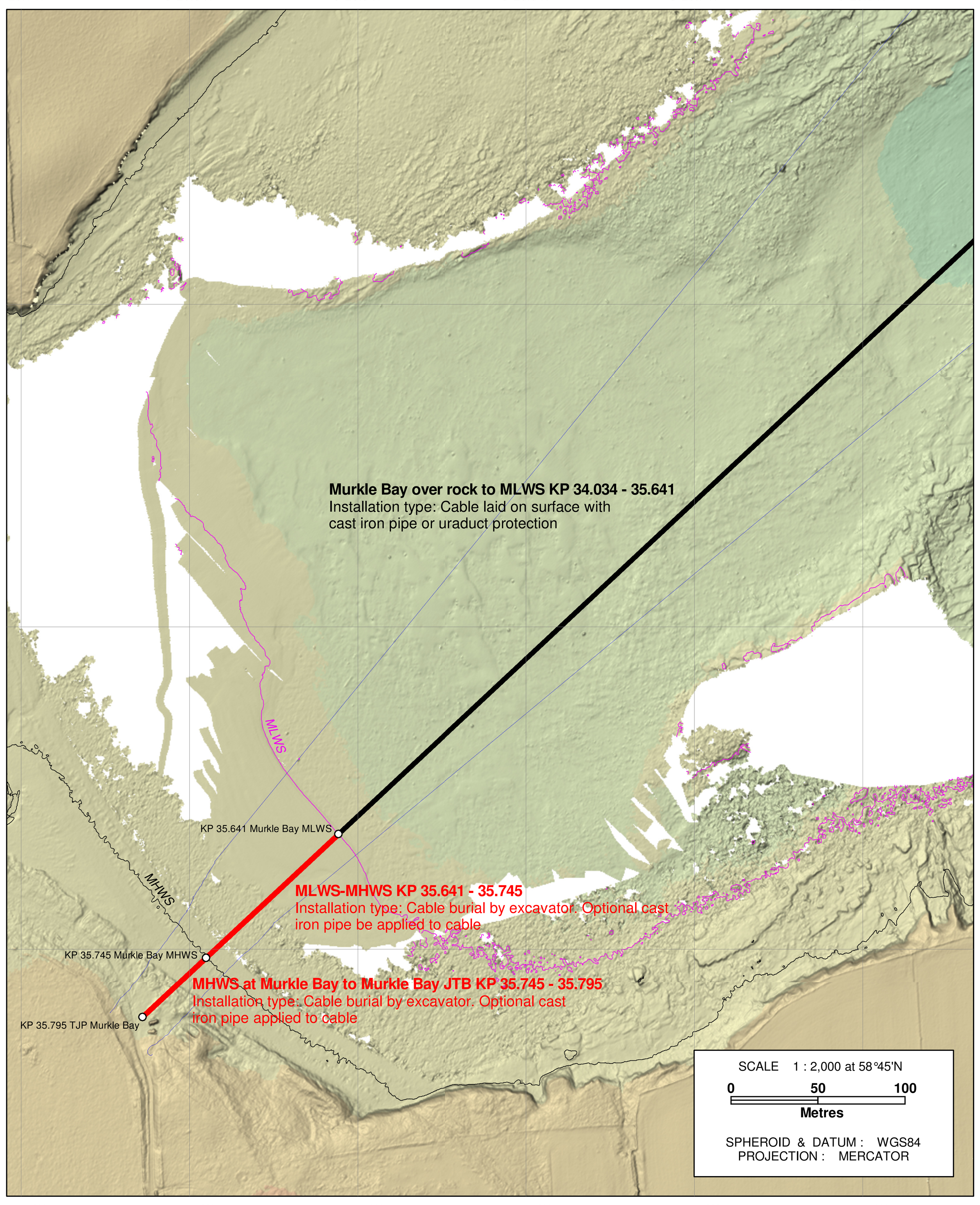
The replacement cable will subsequently be electrically jointed to the land HV infrastructure. The routing and installation of the land HV infrastructure is not covered as part of this Project Description which supports the marine licence application.

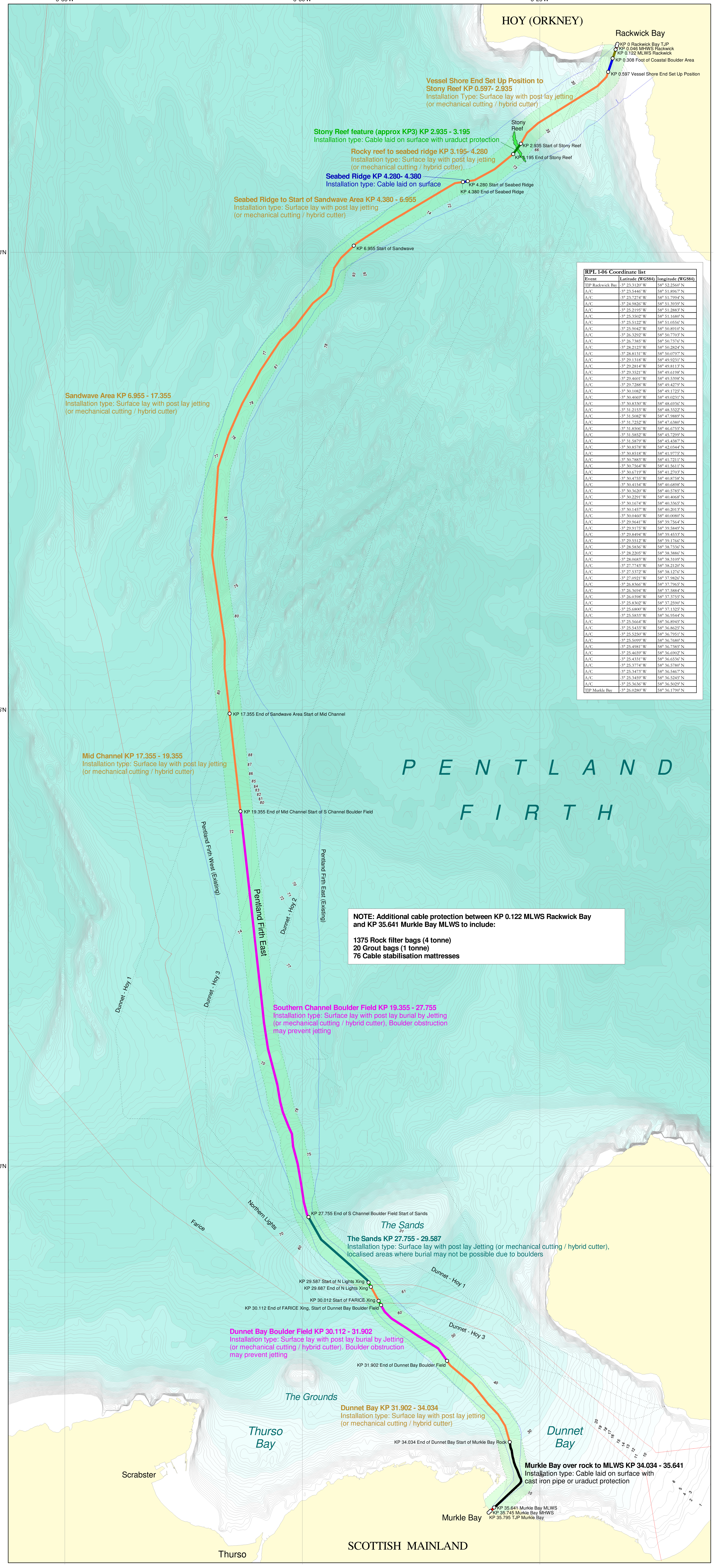
The As-Built survey will document the installed position of the cable from TJP to TJP with events listed and positions given (i.e. Rock Bags, Mattresses, and Split Pipe etc.).

Appendix A – Route Overview Chart



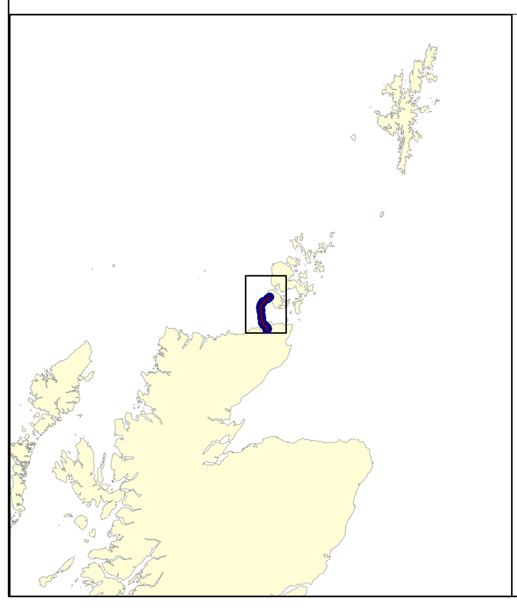






RPL 1-06 Coordinate list

Event	Latitude (WGS84)	longitude (WGS84)
TJP Rackwick Bay	-3° 23.3120' W	58° 52.2560' N
A/C	-3° 23.5446' W	58° 51.8967' N
A/C	-3° 23.7274' W	58° 51.7994' N
A/C	-3° 24.9826' W	58° 51.3939' N
A/C	-3° 25.2195' W	58° 51.2883' N
A/C	-3° 25.3502' W	58° 51.1680' N
A/C	-3° 25.5122' W	58° 51.0556' N
A/C	-3° 25.9042' W	58° 50.8910' N
A/C	-3° 26.3292' W	58° 50.7703' N
A/C	-3° 26.7385' W	58° 50.7376' N
A/C	-3° 28.2123' W	58° 50.2824' N
A/C	-3° 28.8131' W	58° 50.0797' N
A/C	-3° 29.1318' W	58° 49.9231' N
A/C	-3° 29.2814' W	58° 49.8113' N
A/C	-3° 29.3521' W	58° 49.6198' N
A/C	-3° 29.4601' W	58° 49.5398' N
A/C	-3° 29.7288' W	58° 49.4279' N
A/C	-3° 30.1082' W	58° 49.1725' N
A/C	-3° 30.4069' W	58° 49.0231' N
A/C	-3° 30.8330' W	58° 48.6936' N
A/C	-3° 31.2153' W	58° 48.3322' N
A/C	-3° 31.5082' W	58° 47.9889' N
A/C	-3° 31.7252' W	58° 47.6380' N
A/C	-3° 31.8506' W	58° 46.6755' N
A/C	-3° 31.5852' W	58° 45.7299' N
A/C	-3° 31.5879' W	58° 45.4387' N
A/C	-3° 30.8578' W	58° 42.0344' N
A/C	-3° 30.8518' W	58° 41.9775' N
A/C	-3° 30.7883' W	58° 41.7211' N
A/C	-3° 30.7564' W	58° 41.5611' N
A/C	-3° 30.6719' W	58° 41.2703' N
A/C	-3° 30.4755' W	58° 40.8758' N
A/C	-3° 30.4154' W	58° 40.6898' N
A/C	-3° 30.3620' W	58° 40.5785' N
A/C	-3° 30.2291' W	58° 40.4068' N
A/C	-3° 30.1674' W	58° 40.3365' N
A/C	-3° 30.1457' W	58° 40.2013' N
A/C	-3° 30.0460' W	58° 40.0080' N
A/C	-3° 29.9641' W	58° 39.7564' N
A/C	-3° 29.9175' W	58° 39.5849' N
A/C	-3° 29.8494' W	58° 39.4533' N
A/C	-3° 29.5512' W	58° 39.1766' N
A/C	-3° 28.5836' W	58° 38.7336' N
A/C	-3° 28.2205' W	58° 38.3886' N
A/C	-3° 28.0683' W	58° 38.3109' N
A/C	-3° 27.7743' W	58° 38.2120' N
A/C	-3° 27.5372' W	58° 38.1276' N
A/C	-3° 27.0921' W	58° 37.9826' N
A/C	-3° 26.8366' W	58° 37.7965' N
A/C	-3° 26.3694' W	58° 37.5884' N
A/C	-3° 26.0398' W	58° 37.3755' N
A/C	-3° 25.8302' W	58° 37.2590' N
A/C	-3° 25.6800' W	58° 37.1325' N
A/C	-3° 25.5833' W	58° 36.9544' N
A/C	-3° 25.5664' W	58° 36.8945' N
A/C	-3° 25.5433' W	58° 36.8625' N
A/C	-3° 25.5250' W	58° 36.7951' N
A/C	-3° 25.5099' W	58° 36.7680' N
A/C	-3° 25.4981' W	58° 36.7385' N
A/C	-3° 25.4659' W	58° 36.6902' N
A/C	-3° 25.4331' W	58° 36.6536' N
A/C	-3° 25.3774' W	58° 36.5780' N
A/C	-3° 25.3473' W	58° 36.5467' N
A/C	-3° 25.3459' W	58° 36.5245' N
A/C	-3° 25.3636' W	58° 36.5029' N
TJP Murkle Bay	-3° 26.0280' W	58° 36.1790' N



PROPOSED PENTLAND FIRTH EAST ROUTE:

See text on the chart for detailed cable descriptions

RPL Revision 1-06

EXISTING CABLES:

- In Service Fibre Optic Cable
- In Service Power Cable
- Telegraph Cable

Source: Global Marine Systems Limited

BATHYMETRY:

- 0 - 10m
- 10- 20m
- 20 - 30m
- 30 - 40m
- 40 - 50m
- 50 - 60m
- 60 - 70m
- 70 - 80m
- 80 - 90m
- 90 - 100m
- 100m plus
- Intermediate contours every 1m

Source: EMODnet, 2019

OTHER:

- Cable Area to be Licenced (250m either side of route)
- MHWS
- MLWS

Main Overview Chart:

SCALE 1 : 32,500 at 58°45'N

0 1 2 3 4
Kilometres

SPHEROID & DATUM : WGS84
PROJECTION : MERCATOR

ALL DEPTHS IN METRES

Notes:

This chart is intended for general reference only and NOT FOR NAVIGATION PURPOSES.

This chart has been prepared to provide an overview of the proposed cable route. Any further route development should not be done on the basis of this chart alone, but should include consulting the latest navigational charts and other data sources used in the Route Engineering Study.

CHART HISTORY

Rev.	AMENDMENT	UPD	CKD	DATE
Rev. 0	Original Issue			Dec 2019

Global Offshore
GLOBAL MARINE GROUP

Pentland Firth East
Route Overview

CHART NO. 5422-2
Project Reference 4742

Original chart size: A0