SSE – ED1 CABLE REPLACEMENT

Orkney – Hoy (North)

Project Description – Orkney – Hoy (North)

GO Reference : 3234-GO-O-TB-0002

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05	5.1 5.2		Update of cable stabilisation measures and CBA text	RB (SSEN)

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Abbreviation and Definitions

The table below show a list of abbreviations and definitions used in this document:

List of Abbreviations and Definitions

Abbreviation	Definition
A/C	Alter Course
ADCP	Acoustic Doppler Current Profiler
AHC	Active Heave Compensation
AToN	Aid to Navigation
AWAC	Acoustic Wave and Current profiler
CBRA	Cable Burial Risk Assessment
C/L	Centreline
CLV	Cable Lay Vessel
CPSP	Cable Protection and Stabilisation Plan
CPT	Cone Penetration Test
CR	Client Representative
DGPS	Differential Global Positioning System
DP	Dynamic Positioning
DWA	Double Wire Armoured
FAT	Factory Acceptance Test
FLMAP	Fishing Liaison Mitigation Action Plan
FO	Fibre Optic
FOC	Fibre Optic Cable
GB	Gigabyte
GMG	Global Marine Group
GMSL	Global Marine Systems Ltd.
GPS	Global Positioning System
HDPE	High Density Poly Ethylene
HP	Horse Power
HV	High Voltage
HVAC	High Voltage Alternating Current
ID	Inner Diameter
ISM	International Safety Management
ISO	International Organization for Standardization
km	kilometre
kN	Kilo Newton

KP	Kilometre Point
kV	Kilo Volt
LAT	Lowest Astronomical Tide
LGP	Low Ground Pressure
LP	Landing Point
MBES	Multi-Beam Echosounder
MBR	Minimum Bend Radius
MCA	Maritime Coastguard Agency
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
msw	Meters Sea Water
nm	Nautical Mile
NTM	Notice to Mariners
OBS	On-Bottom Stability
OCMA	Oil Company Materials Association
OD	Outer Diameter
OHSAS	Occupational Health and Safety Assessment Series
OOS	Out or Service
OTDR	Optical Time Domain Reflectometer
PE	Poly-ethylene
PLGR	Pre-lay Grapnel Run
RB	Rock Bag
RHIB	Rigid Hulled Inflatable Boat
ROV	Remote Operated Vehicle
RPL	Route Position List
SDR	Standard Dimension Ratio
SHEPD	Scottish Hydro Electric Power Distributions
SIMOPS	Simultaneous Operations
SOLAS	Safety of Life at Sea
SSEN	Scottish and Southern Electricity Networks (SSE plc)
TDR	Time Domain Reflectometer
TJP	Transition Joint Pit / Terminal Junction Pit
TMS	Tether Management System
UAV	Unmanned Air Vehicle
UDL	Uniformly Distributed Load
UXO	Unexploded Ordnance
WD	Water Depth

1.0 Introduction and Background

1.1 Introduction

Scottish Hydro Electric Power Distribution (SHEPD) has contracted Global Marine for the installation of a replacement 33kV circuit between Mainland Orkney and Hoy utilising the land falls of the existing Mainland Orkney to Hoy North cable. Figure 1 outlines the location of the route in red.

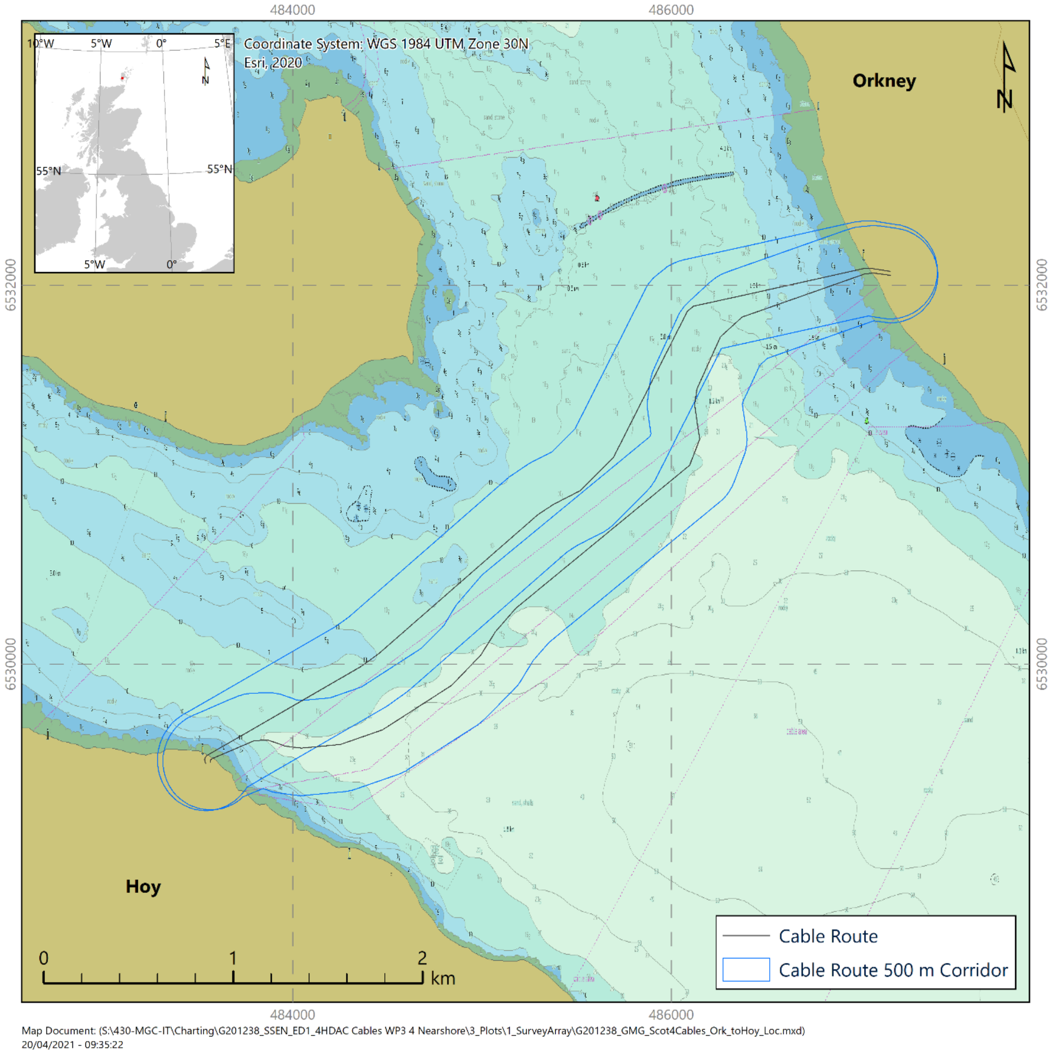


Figure 1: Route Overview Mainland Orkney - Hoy

There are currently three 33kV cables connecting the mainland of Orkney with Hoy. Two of these cables, Mainland Orkney to Hoy North and Mainland Orkney to Hoy Centre, have been identified for replacement from asset integrity inspections. This document presents information relating to replacement of the Mainland Orkney to Hoy North Cable. The replacement of this cable is required to maintain the integrity and resilience of the power distribution network.

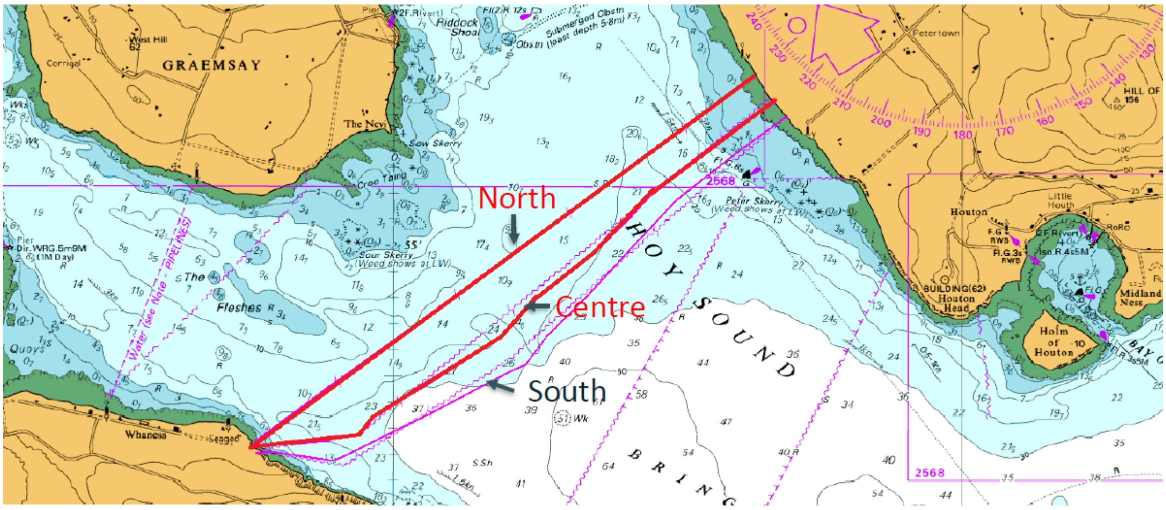


Figure 2: Orkney Hoy Existing Routes

1.2 Overview of Scope of Work

This document provides details of the following activities and scopes of work:

- Pre-Installation Surveys
- Landfall establishment
- Cable Installation
- Cable Protection and Stabilisation
- Post-Installation Surveys
- Landfall re-instatement

1.3 Project Key Dates

Table 1: O-H (N) Operation Durations below sets out an indicative schedule of durations of works relating to the cable replacement activities.

Orkney – Hoy (North) Task Durations	
Onshore Works	44 days
Offshore Works	21 days
Nearshore Works	11 days
Cable Pull-In	5 days
Re-instatement	5 days

Table 1: O-H (N) Operation Durations

2.0 Pre-Installation Survey Works

Due to the close proximity of the two submarine cable systems (Mainland Orkney-Hoy (North) & Mainland Orkney-Hoy (Centre)) the two planned cable routes were combined into a single survey corridor. The combined pre-Installation Survey works were undertaken between December 2020 and February 2021 and were split into marine and land based survey campaigns.

2.1 Marine Operations

The following were conducted as part of the marine surveys:

- Geophysical Area Mapping

- Environmental Survey

The surveys required that the following equipment be mobilised:

Equipment used for Marine survey	
"MV Valkyrie" 12m Inshore Survey Vessel 	
Multibeam echosounder	Side scan sonar
Sub-bottom profiler	Magnetometers (multiple)
Subsea Camera	

Table 2: Equipment used in Marine Survey

The survey vessel investigated a 500m wide geophysical survey corridor (+/- 250m of the RPL C/L) for each cable but where overlap existed the corridors were merged, creating an overall corridor of up to 900m in width. The extent of the inshore survey was from close to the Mean Low Water Springs (MLWS) mark at each beach.

The environmental survey required an environmental specialist's review and assessment of the results of the geophysical data acquired as part of the selected cable route. As a result of this analysis any sites which identified the potential for the presence of habitats of sensitive or conservation interest were then selected for further drop-down video/stills imagery to verify the findings.

2.2 Land Based Operations

- Topographic
- Environmental (Intertidal)

A traditional topographical (levels) survey was undertaken at all the landing sites. The corridor was defined as being +/- 125m from the proposed centre line and runs from MLWS to 200m behind the TJP.

A shore/intertidal environmental survey was conducted during daylight hours at low water springs (or as close as possible). The survey was conducted by a shore walk with GPS and hand-held measuring quadrats, used to map all intertidal/beach habitats and quantify the benthic habitats, biotopes and any potential "Annex 1" habitats. Photographs were collected of representative quadrats.

2.3 Environmental data gathering

In addition to the Offshore and Land based surveys described above, environmental data was gathered using an Acoustic Doppler Current Profiler (ADCP).

One ADCP was deployed along the route for a minimum of 28days in order to gather current and wave data for the site. This data is required to perform on-bottom stability assessment for the cable and therefore allowed a further detailed engineering assessment of the cable protection methods and quantities required along the route. At the time of preparing the Marine Licence Application these studies are ongoing.

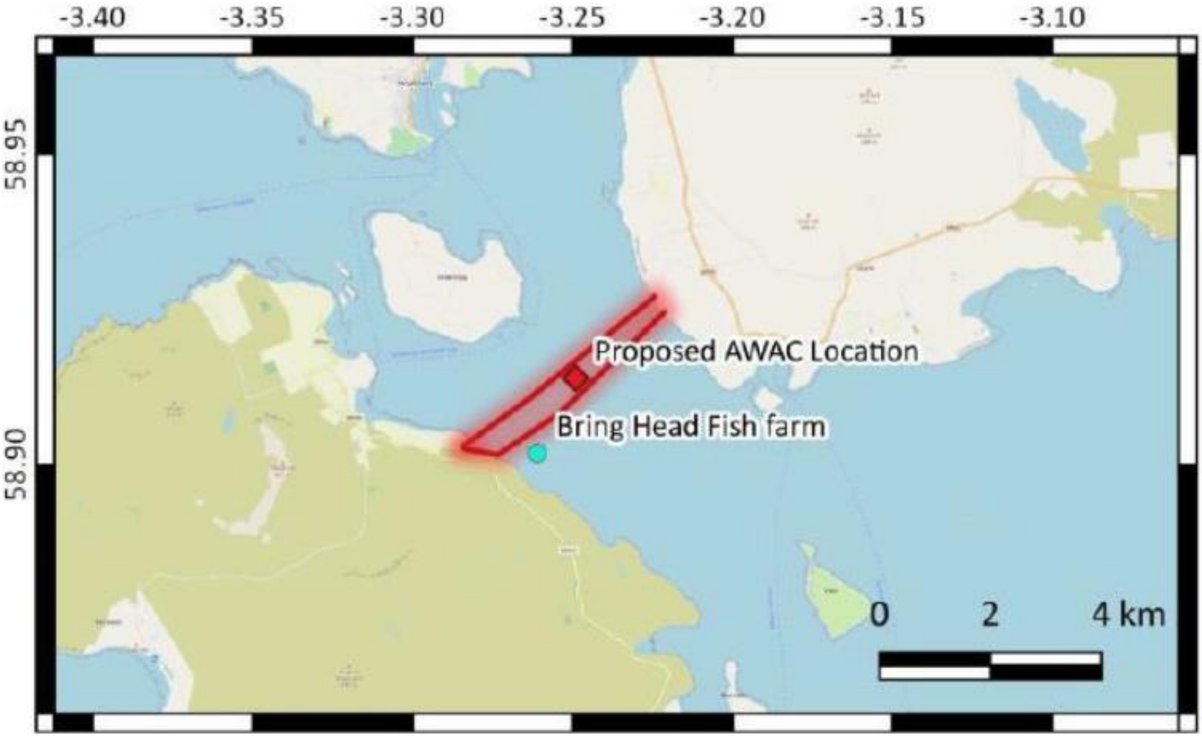


Figure 3: ADCP Deployment Location – Orkney – Hoy North & Centre combined

Figure 4: Example of ADCP deployed inside protection frame

3.0 Cable Information and Load Out

3.1 Cable Construction

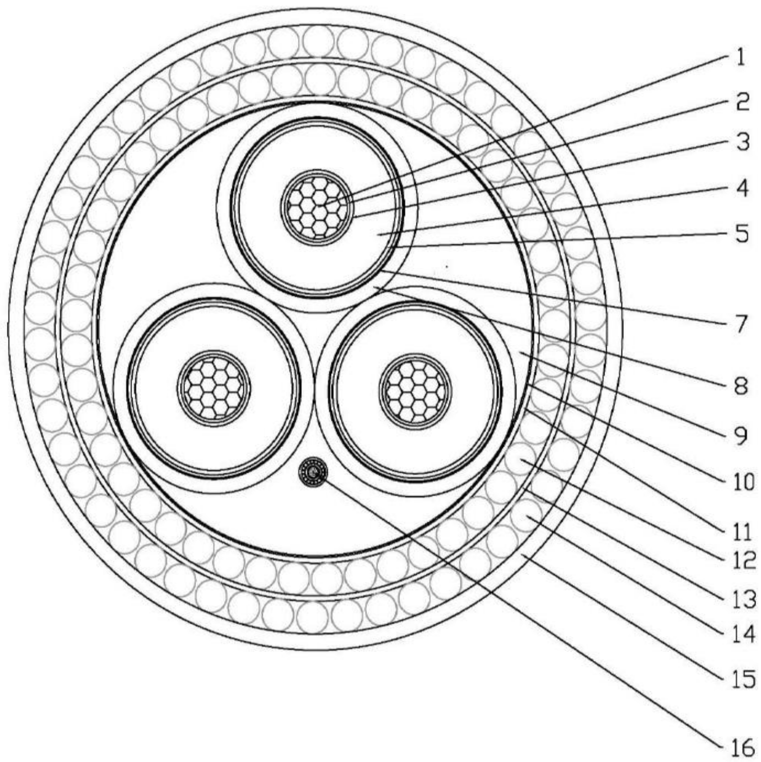
The cable to be installed will be a High Voltage Alternating Current (HVAC) submarine cable.

SHEPD will free-issue the cable conforming to the requirements in Table 3: Cable Specification.

TYPE	LENGTH (km)	DIAMETER (mm)	MBR (m)	Cable weight in air (kg/m)
3x185mm2 Cu DWA 33kV	5	127	2.5m (installation)	36.0

Table 3: Cable Specification

Cross section of the cable is provided in Figure 5: Cross Section Profile of 185mm2 Cu DWA 33kV below:



1 - Copper round stranded compacted class 2 according to BS EN 60228 of nominal cross-section equal to 185 sq.mm, longitudinally water sealed.

2 - Semi-conductive waterblocking tape applied helically with overlap.

3 - Conductor non-metallic extruded screen: Extruded semiconducting compound bonded to inner surface of insulation.

4 - Insulation: XLPE water-tree retardant type GP8 according to BS 6622 of 8.0 mm nominal thickness. 1,2

5 - Core non-metallic extruded screen: Extruded semiconducting compound firmly bonded to the insulation.

6 - Semi-conductive waterblocking tape applied with overlap.

7 - Metallic screen and radial watertightness: CU/PE laminated tape of 0.2 mm nominal thickness bonded to oversheath, longitudinally applied with overlap.

8 - Sheath: HDPE of 2.5 mm approximate thickness. Sheath colour: Black.

9 - Non-hygroscopic fillers at the interstices between cores in order to give the cable a circular cross-section.

10 - Binding tape helically applied with overlap.

11 - One layer of polypropylene yarns of approximate thickness of 1 mm.

12 - Inner layer of armour consisting of one layer of helically applied bitumen compound coated galvanized round steel wires of grade 34. class A. 6.0 mm nominal diameter according to EN 10257-2

13 – Separator layer consisting of a single layer of polypropylene yarns of 1 mm approximate thickness.

14 - Outer layer of armour consisting of one layer of helically applied bitumen compound coated galvanized round steel wires of grade 34. class A. 6.0 mm nominal diameter according to EN 10257-2

15 - Two layers of polypropylene yarns with total approximate thickness of 3 mm. Over the inner (first) layer bitumen is applied. Also, the outer (second) layer shall consist of black and yellow polypropylene yarns as to form a helical yellow stripe.

16 - Armoured Optical unit of 16 mm approximate diameter each one consists of a stainless steel tube (containing 48 optical single mode fibres), PE inner sheath, galvanized steel wire armour and PE oversheath.

Figure 5: Cross Section Profile of 185mm2 Cu DWA 33kV

4.0 Vessel and Equipment Specifications

Global Marine operates a fleet of vessels that are regulated under SOLAS and which are all required to comply with the ISM Code. Global Marine's Safety Management System ensures compliance with mandatory fleet rules and regulations and that applicable codes, guidelines and standards recommended by Administrations, Classification Societies and maritime industry organisations are met appropriately.

During the immediate lead-up to the project Global Marine will issue the Notice to Mariners and complete updates to the Kingfisher Fortnightly Bulletin.

4.1 Cable Lay Vessel (CLV)

The Global Symphony, or similar, will be the main Cable Lay Vessel (CLV) of this project.

Figure 6: Global Symphony

The vessel is equipped with a McGregor Hydramarine "Active Boost" 150T AHC knuckle-boom crane capable of subsea lifts at 150Te in single fall mode down to 3,000m as well as two FCV3000 Work Class ROVs located within ROV garages of the vessel superstructure.

ITEM	DESCRIPTION
Type	DP Class 2
Gross Tonnage	11,324te
Dimension – Length (a/o)	130.2m
Dimension – Beam	24m
Draft	7.5m
PoB (Max.)	105

Table 4: Global Symphony Characteristics

Figure 7: Global Symphony Back Deck

4.2 FCV3000 Work Class ROV

The FCV3000 is a capable 3000msw rated modern work class ROV. The ROV will be used for Touch Down Monitoring (TDM) throughout cable lay operations as well as any subsea intervention works and post lay survey.

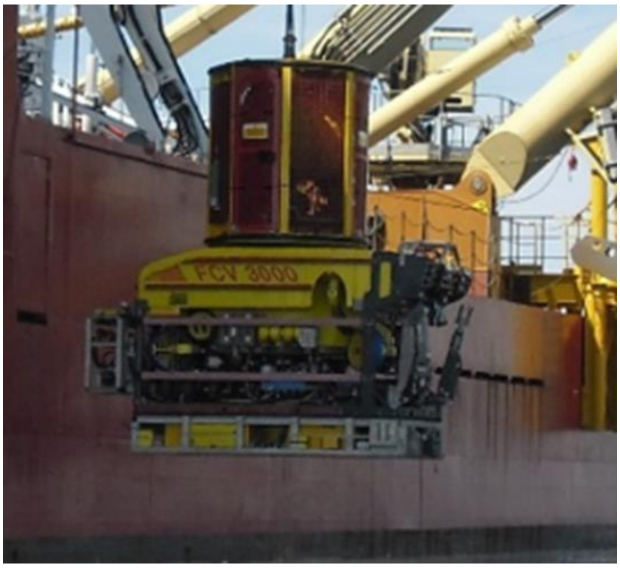


Figure 8: FCV3000 Deployment

ITEM	DESCRIPTION
Type	FCV3000 (150HP)
Length	3.3m
Height	1.7m (exc. TMS)
Width	1.7m (exc. TMS)

Weight	4.1te (inc. 400kg payload)

Table 5: FCV3000 Specifications

4.3 Cable Protection and Stabilisation Installation Vessel

Upon completion of the cable installation campaign, there may be a requirement to install some cable protection. This may include a combination of concrete mattresses and rock bags. Details of these methods are described in Section 5.1 and Section 6.4.6 below. The final quantity of protection and stabilisation to install will dictate the type of vessel that may be used.

It is likely that the bulk of the installation will take place form a DP Class 2 vessel. Specifications of this vessel would be comparable to that of the Global Symphony as described in Section 4.1 above.

For locations where a DP Class 2 vessel cannot access due to water depth restrictions, a Multicat vessel would be used. Details of such a vessel can be found in Section 4.11 below.

4.4 Onshore installation and Excavation

The excavation works at the TJP and landfall will be carried out with the aid of a 13Te LGP tracked excavator.

Figure 9: Example 13te LGP Excavator

4.5 Tracked Winch

Pull-Ins will be performed using a tracked 10Te constant tension capstan winch which has an electronic cable recording device which can be downloaded as evidence of the cable pull tensions. The winch will self-tracked into place to ensure the allowable over pull is considered. The winch will be anchored back using certified anchor chains and pinned anchor blocks.

Figure 10: Tracked 10Te Bull Wheel Winch

4.6 Quadrant and Beach Rollers

Various cable quadrants will be used on the beach along with pipe cradle lifters to securely handle the cable to shore and into the excavated trench.

Figure 11: Example of the Beach Quadrant Layout during pull-in

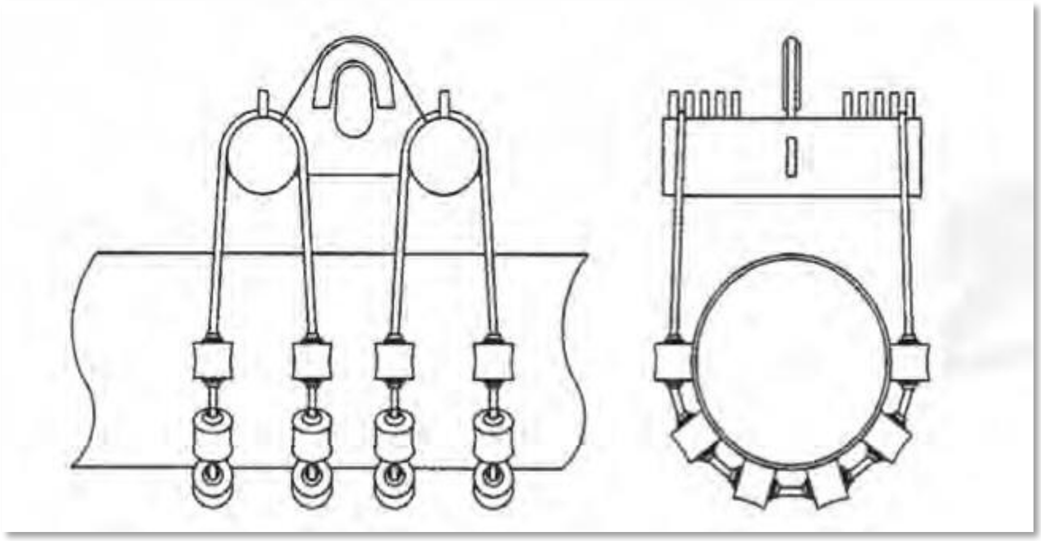


Figure 12: Pipe Cradle Lifter

4.7 Cable Bollard

A survey team will accurately mark out the onshore cable pull-in route and positions of the cable handling equipment such as bollards, excavator, rollers, quadrants and skid steer winch.

The Bollard Roller shall be positioned on the RPL at the Landfall and will ensure that pull-in alignment is maintained.

An excavator with sheave block shall be in position adjacent to the Bollard Roller to ensure a smooth cable transition from floating to shore/ onshore roller. Divers shall also remove cable buoyancy from the cable prior to the cable reaching the Bollard Roller.

Figure 13: Bollard Roller

4.8 Survey / ROV and Safety Boats

Safety Boats such as the ‘Delta 9151’ would be used to transfer the pull-in wire from the MLV to shore or from shore to MLV, where applicable.

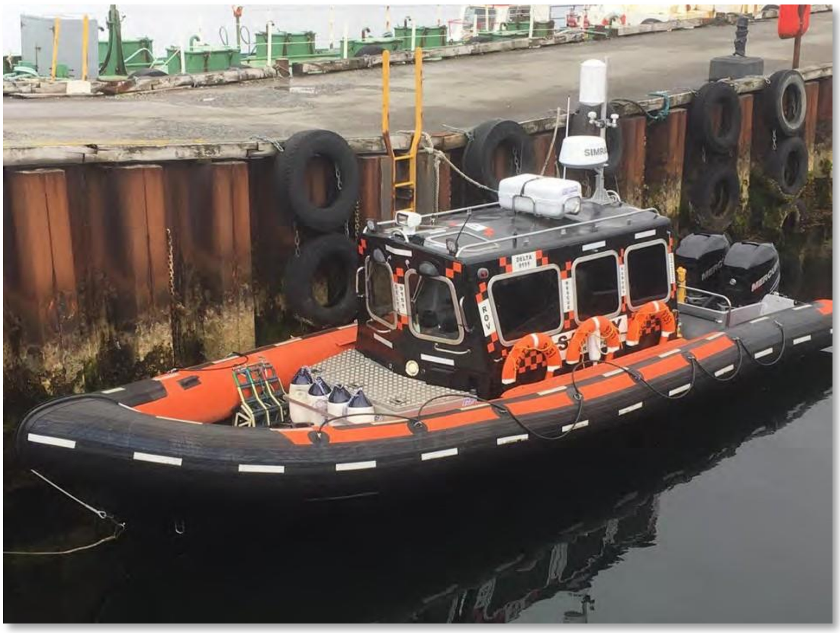


Figure 14: Delta 9151 Safety Boat

ITEM	DESCRIPTION
Type	RHIB
Category	MCA Cat 3 (20 miles)
Dimension – Length (a/o)	9.151m
Dimension – Beam	2.75m
Draft	0.5m
Top Speed	50 knts
PoB (Max.)	2 crew + 6 pax.

Table 6: General Specification of Delta 9151 Safety Boat

4.9 Work Boat – Speedbird One

Work Boat 'Speedbird One' or a similar vessel would be used to perform Safety Boat, Diver and project and cable support works.

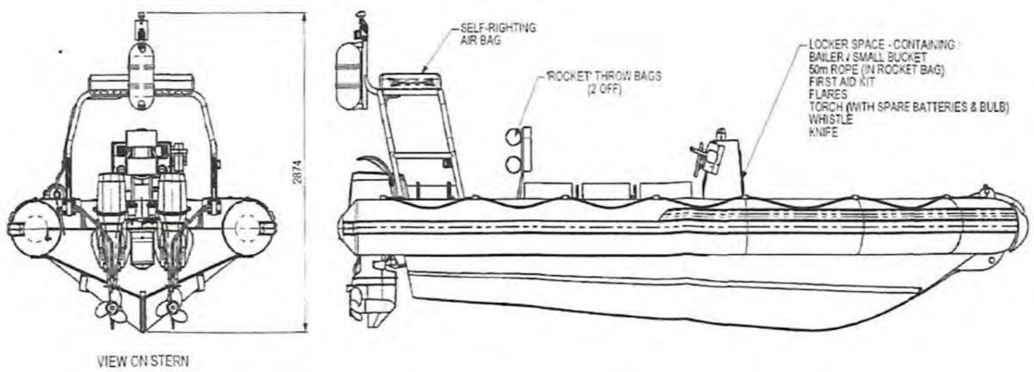


Figure 15: Speedbird One Workboat

ITEM	DESCRIPTION
Type	RHIB
Category	MCA Cat 3 (20 miles)
Dimension – Length (a/o)	8.6m
Dimension – Beam	2.13m
Draft	0.5m
Top Speed	25/30 knts

Table 7: General Specification of Speedbird One Workboat

4.10 Work Boat – UR 101

Work Boat '101' would be used to perform Safety Boat, Diver and project and cable support works.

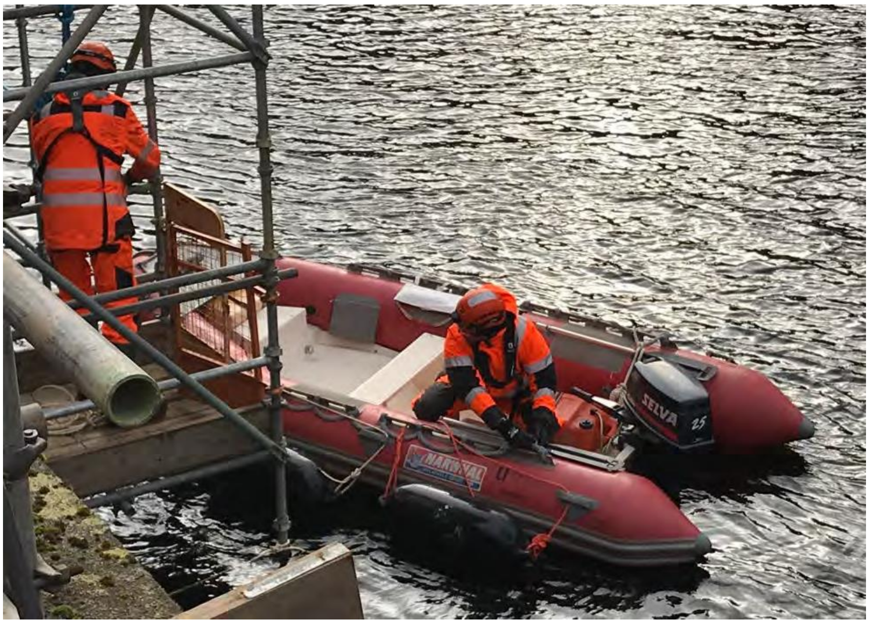


Figure 16: UR 101 Workboat

ITEM	DESCRIPTION
Type	RHIB
Dimension – Length (a/o)	4.0m
Dimension – Beam	1.0m
Draft	0.4m
Weight (Fully Equipped)	0.5te
Top Speed	25 knts

Table 8: General Specification of UR 101 Workboat

4.11 Multicat

A Multicat similar to the 'C-Odyssey' below shall be used as the Dive Support Vessel for the nearshore cable installation and lowering works at each landfall site. Cable stabilisation and protection measures may also be installed from this vessel.

Figure 17: Example Multicat

ITEM	DESCRIPTION
Type	Multiworker Twenty6
Built	2011
Category	MCA Cat 1 (150 miles)
Dimension – Length (a/o)	26m
Dimension – Beam	10.5m
Draft	2.5m
Free Deck Space	120m2
Passenger	12 (plus crew)
Gross Tonnage	150 GT

Table 9: General Specification of Multicat

4.12 Landing Craft – MV Challenge

A landing craft, similar to the below example, may be used to transfer plant and equipment from one work location to another. This would take place in regions where availability of local public transport and services fall short of project requirement.

In tandem with the appropriate tide cycle, the shallow water landing craft shall be sailed to shore and conduct beach landings allowing subcontractors plant and equipment to be loaded onboard. With the next favourable tide in place, the Shallow Water Landing Craft shall re-float float and shall make sail to the next work location.

Figure 18:Landing Craft

ITEM	DESCRIPTION
Type	Landing Craft
Category	MCA Cat 3 (20 miles)
Dimension – Length (a/o)	14.4m
Dimension – Beam	4.26m
Draft	1.44m
Deck Area	10m x 4.2m
Deck Cargo	10te
Passenger	2 (plus 6 crew)
Gross Tonnage	15 GT

Table 10: General Description of Landing Craft

5.0 Cable Protection and Stabilisation Plan

5.1 Overview

Offshore and Onshore surveys have been completed as per Section 2.0. Additional onsite environmental data was also gathered in late Q1 2021 using an Acoustic Doppler Current Profiler (ADCP) system. This, coupled with metocean data, allows for a further detailed assessment of the Cable protection methods to be deployed.

A Cable Protection and Stabilisation Plan (CPSP) has been developed as detailed below in Table 11. The CPSP outlines the deposits required based on route engineering studies undertaken to date and on this basis represents the most likely scenario. The supporting Marine Environmental Appraisal has assessed, and the Marine Licence application seeks consent for, a greater number of deposits than stated here.

KP From	KP To	Dist. (m)	Description	Burial Status	Cable Protection Details
0.000	0.050	0.050	Hoy TJB to end of bank above beach	Buried	Buried by land based excavator in field
0.050	0.267	0.217	End of grass bank to end of rock outcrop offshore	Surface Laid	Articulated Pipe (217m) cable to MLW buried by excavator
0.267	0.272	0.005	Seabed	Surface Laid	1 x 2 RB at ~15m LAT
0.272	0.407	0.135	Seabed	Surface Laid	8 x 2 RB at 15m spacing
0.407	0.514	0.107	Seabed	Surface Laid	6 x 2 concrete mattresses at 21m spacing
0.514	1.121	0.607	Boulder Field	Surface Laid	29 x 2 concrete mattresses at 21m spacing
1.121	2.300	0.179	Seabed	Surface Laid	1 x 2 concrete mattresses at 500m spacing 1 x 2 RB at 500m spacing
2.300	2.700	0.400	Seabed	Surface Laid	1 x 2 RB at 150m spacing 2 x 2 concrete mattresses at 500m spacing 1 x 2 RB at 150m spacing
2.700	3.600	0.900	Seabed	Surface Laid	1 x 2 RB
3.600	3.665	0.065	Seabed	Surface Laid	
3.665	3.700	0.035	Boulder Field	Surface Laid	1 x 2 RB
3.700	4.345	0.645	Boulder Field	Surface Laid	
4.345	4.550	0.205	Edge of rock outcrop to edge of farmers field	Surface Laid	Articulated Pipe (205m) cable from MLW buried by excavator
4.550	4.648	0.098	Edge of farmers field to Orkney TJB	Buried	Buried by land based excavator in field

Table 11: Cable Protection and Stabilisation Plan

	Rock Bags		Articulated Pipe		Uraduct Protection		Concrete Mattress	
	28	bags	422	m	422	m	76	mats
+20% contingency	**34**	**bags**	**507**	**m**	**507**	**m**	**92**	**mats**

Table 12: Cable Protection Quantity Summary

	Surface Laid (km)	Buried (km)
Length	4.500	0.148
% of Route	0.97	0.03

Table 13: Cable Burial Summary

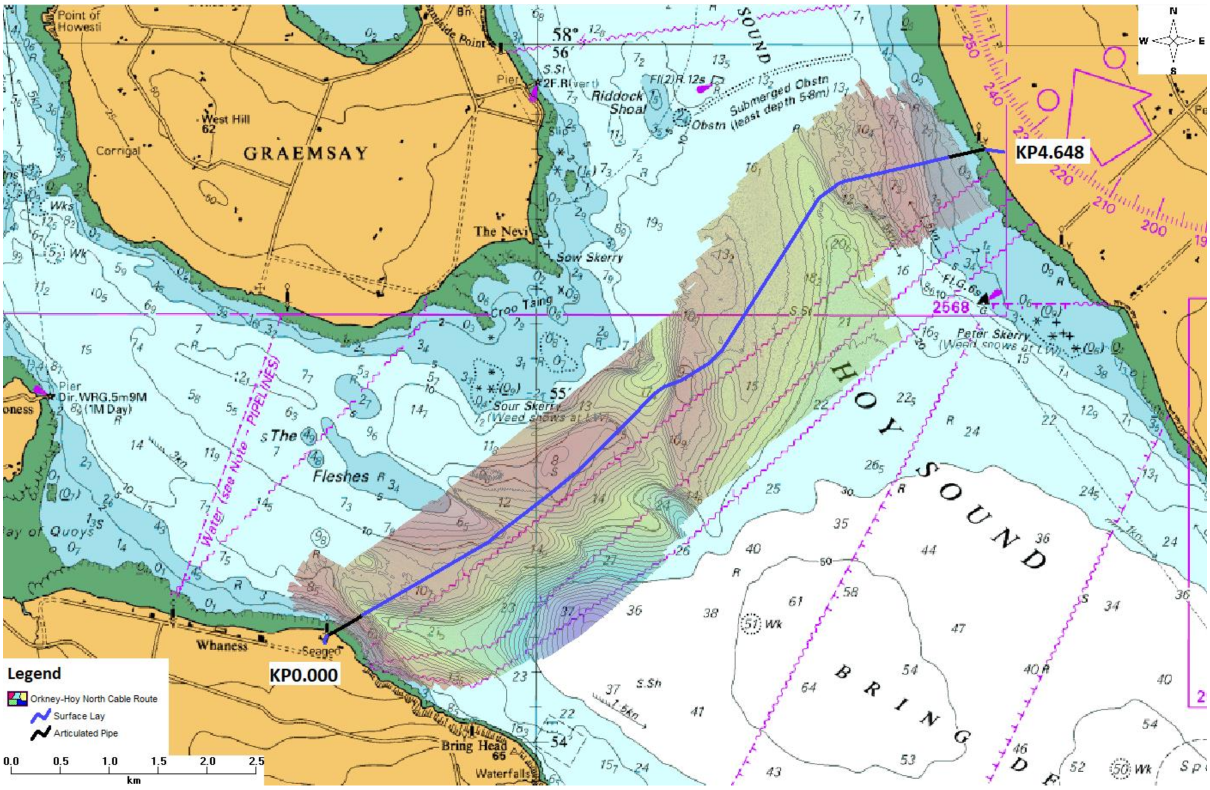


Figure 19: Cable Burial Graphic

5.2 Cable Protection and Stabilisation – Cost Benefit Analysis

Please refer to the supporting Cost Benefit Analysis and summary document.

6.0 Project Description

6.1 Proposed Route

6.1.1 Routing Decision Making Process

The priority for routeing the Hoy-Orkney North cable was to avoid the very shallow regions along the route, namely Fleshes Bank and the skerries to the southeast of Graemsay, whilst also maintaining a minimum 50m separation from the northernmost existing cable. This was to ensure that the route was installable with a cable ship, as the vessel will need sufficient clearance from the seabed and when using an ROV.

The Landing Point (LP) at Hoy was chosen as a suitable location as it provides separation from the existing cables to the south, without extending cable distance excessively by landing further west along the coast of Hoy. Aside from proximity issues, the LP for the existing cables is more challenging due to small cliffs and a rocky foreshore. The location of the proposed LP also provides sufficient space for two TJPs for both this cable and the Mainland Orkney to Hoy Centre cable which is also being replaced.

The LPs at Orkney were selected again to allow the avoidance of the existing cables, which land just to the south of the proposed cables. The chosen LPs have been selected with the CLV offshore position identified as close to shore as possible, and within water depth limitations, therefore minimising the length of floated cable bight. The proposed Centre cable crosses back over the existing north cable so that it can share the LP with the north proposed cable, and to avoid an onshore crossing with the link between the existing north and centre cables. There is sufficient space onshore where the cables land for two TJPs, whilst still being in close proximity to tie into the existing infrastructure.

6.1.2 Route Description

The northern cable route starts near the settlement of Quoyness on Hoy, with the TJP. The cable proceeds from the TJP position at a bearing of 59.743°, heading northeast in a straight segment to the vessel setup position for a pull-in from KP0.243. The cable continues on the same bearing for another 741m, remaining at around 12m water depth as it passes south of Fleshes Bank. The first alter course starts at KP0.983, and has a radius of 600m. The turn allows the cable to maintain a minimum 50m separation from the existing north cable, whilst also maintaining sufficient depth to allow for CLV operation.

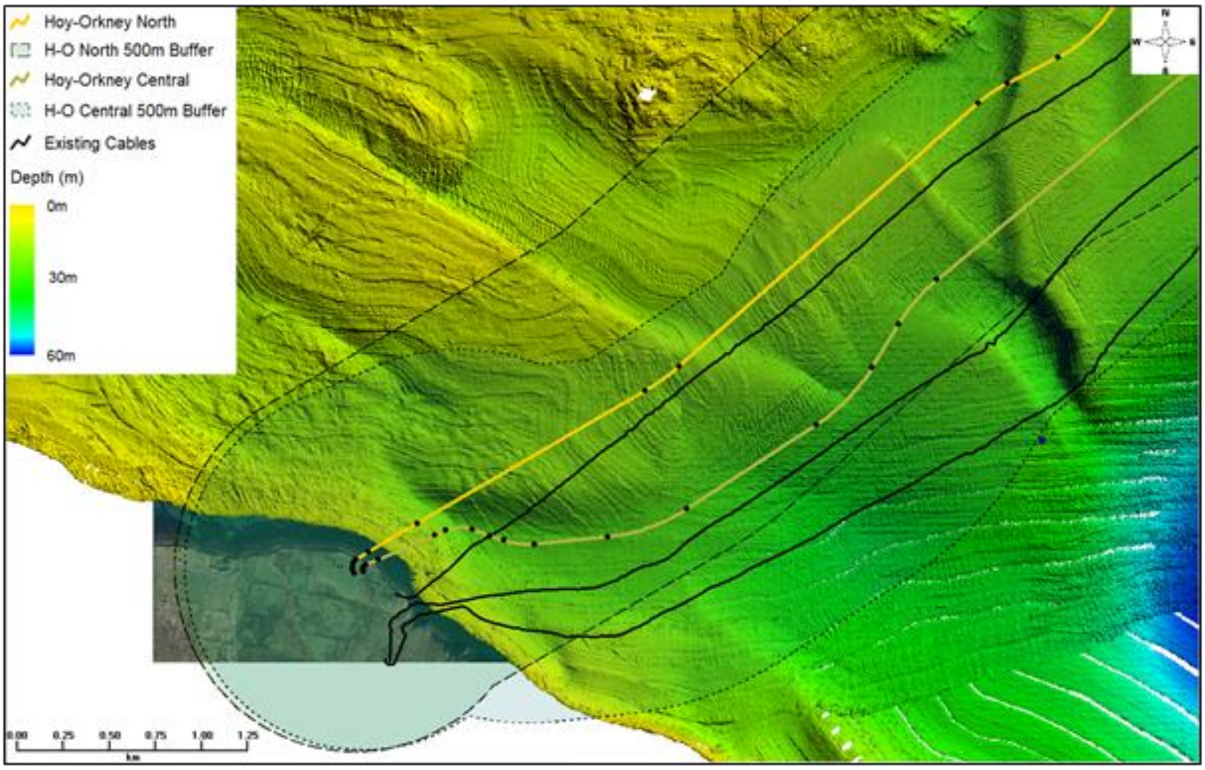


Figure 20: Hoy to Orkney North cable route between KP0.000 and KP1.910, showing aerial imagery at the Hoy LP (approximately georeferenced)

The cable continues northeast across the channel on a bearing of 48.653°, entering some more shallow areas which reach as little as 10m LAT water depth. The cable takes a second turn 400m in radius at KP2.217 to climb a small slope at a closer to perpendicular angle. The slope ascends 2m back to 10m depth, as the cable takes another turn to the northwest with a radius of 400m to cross the mouth of the channel separating the island of Graemsay and Orkney. After the end of the turn, the cable proceeds northeast straight for 831m at a bearing of 45.792°. At KP3.593 the cable begins a 50m radius turn to align for its final approach to shore. The vessel set up position for a pull-in lies at KP3.963. from vessel position to LP is 579m long, ending at the LP on mainland Orkney at KP4.542. The cable makes an onshore altercourse to align for the TJP.

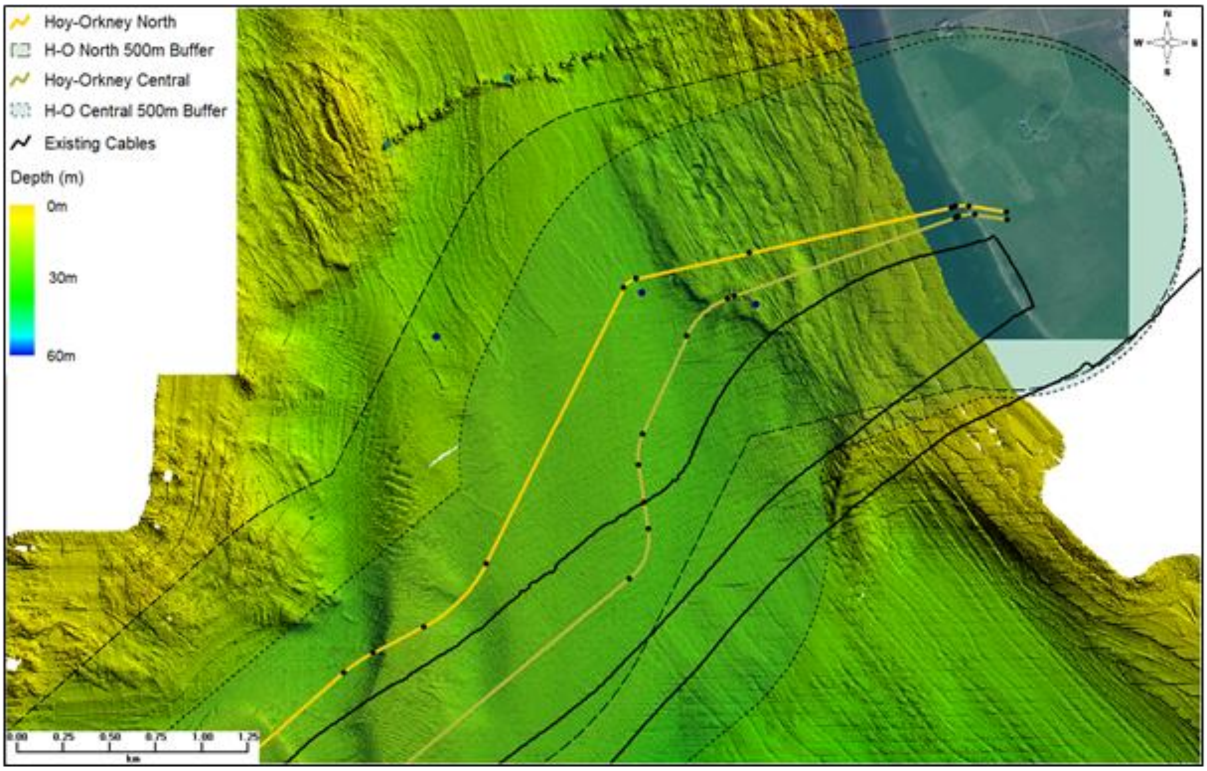


Figure 21: Hoy to Orkney North cable route between KP1.910 and KP4.510

6.1.3 Route Profile

The below Figure 22: Bathymetry profile of proposed Mainland Orkney-Hoy (North) route illustrates the route profile for the replacement cable route.

At its deepest, the route reaches c.18m.

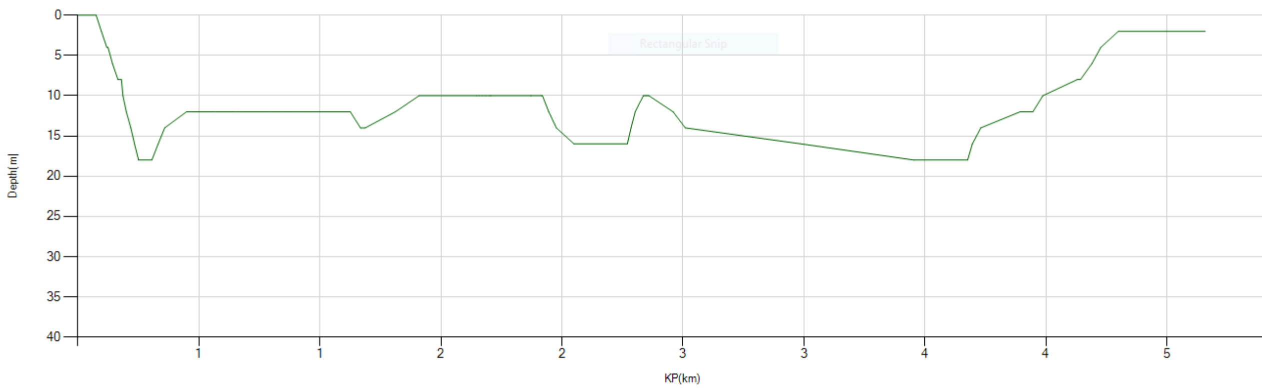


Figure 22: Bathymetry profile of proposed Mainland Orkney-Hoy (North) route

6.2 Landfall Preparations

The landfall areas 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

6.2.1 Access to Site

Access to the TJP will be via public roads and paths. Where access via public routes are not possible, permissions from landowners have been agreed and will be used throughout the temporary engineering works. All land will be re-instated after completion of the engineering works.

6.2.2 Site Compound

For the onshore engineering works a base will be established which will also act as a local site management office for the works. It shall comprise of, but is not limited to, the following:

- Suitable office accommodation, including space for: site briefing/training, electrical supply internet and telephone connectivity (where applicable and signal is available);
- Lay-down areas designed to take the biggest loads likely to be delivered to site;
- Secure storage areas for all required materials, with segregation of flammable materials;
- Compound lighting where work is required to be undertaken in low light levels;
- An area designated for waste and waste recycling skips, with clear signs to indicate the waste segregation requirements of each container or skip.

The site shall have a traffic management plan in order to maintain safety of traffic entering and exiting the compound. It should be noted that traffic at the local site compounds shall be light and minimal throughout, with the heaviest traffic during set up and tear down of the compound.

The site compound will be secured from the public by means of Heras fencing where applicable and or pedestrian walkways, all relevant site signage and warning signs will be posted where necessary to ensure site safety and public safety.

All responsible methods will be employed to mitigate environmental damage and in particular spill kits (120L bins) and machine nappy pads to catch leaks and drips on site.

The compound shall comply with the environmental requirements for all activities impacting protected or sensitive habitat or species.

120 Liter Spill Kits at each site

Machine Nappies to protect from leaks

Figure 23: 120L Spill Kits and Machine Nappy Trays

6.2.3 Transition Joint Pit (TJP)

The TJP will be the location where the subsea cable is split out into its individual cores and terminated to a land cable.

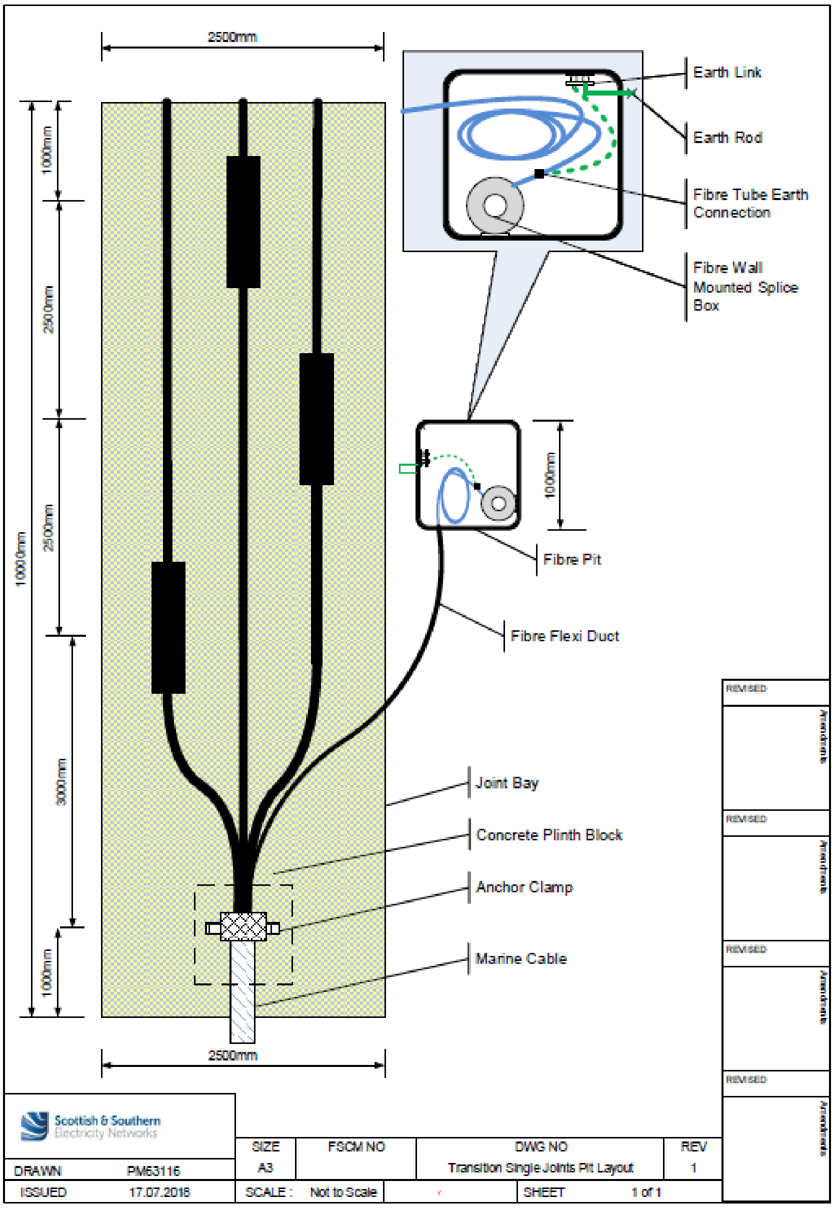


Figure 24: SSEN provided TJP plan

Figure 25: TJP final layout (example)

6.3 Earthing Protection

A Sea Earth may be installed in order to provide protection from surges and lightning strikes to the electrical circuit provided by the newly installed Mainland Orkney-Hoy (North) cable.

A sea earth could be installed at the either landfall. The Sea Earth would consist of up to two bare copper earth wires (c.1kg/m) at each landfall, typically 95mm², and be installed around the TJB perimeter and connected to the outer marine cable armour wire which has been terminated on the anchor clamp within the TJB. It would also be connected to the metallic elements of the FO cable package within the joint housing.

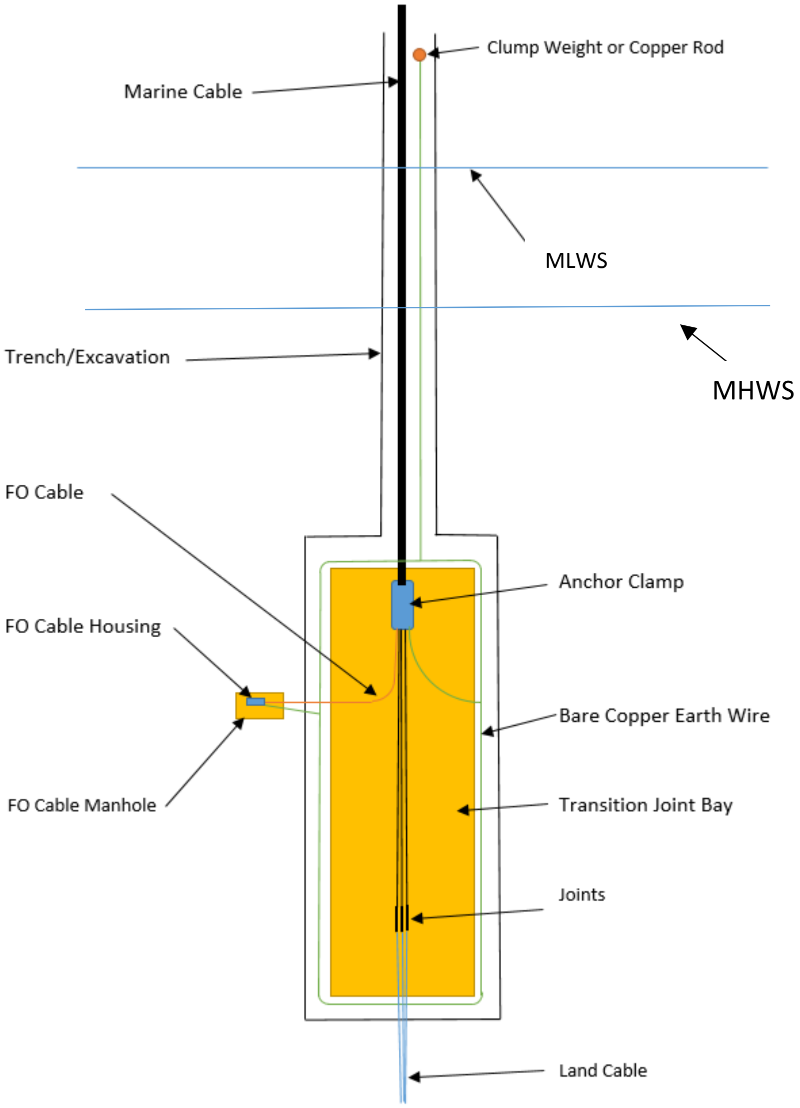


Figure 26: Sea Earth Schematic

The earth wire is typically installed into the same trench as the marine cable (although some cable manufacturers may stipulate a separate trench) with a minimum separation of approx. 200mm. Should a separate trench be required, the trench would remain within the consented +/- 50m cable corridor. The sea earth would be trenched to a maximin depth of approximately 1.5m and a width of approximately 1m. Up to two trenches may be required at each landfall site, one containing the earth for the submarine cable and one for the fibre optic cable earth.

Figure 27: Bare Earth wire being installed in Subsea cable Trench

The length of the earth wires will vary between sites and the locations of the TJB but will have to be installed 30-50m beyond MLWS or deep enough to ensure the earth wire is always in sea water. At the Mainland Orkney landfall this is anticipated to be approximately 240m per trench from the TJB and at Hoy this is anticipated to be approximately 200m per trench from the TJB.

Depending on the landfall materials, either a clump weight or a copper rod will have the earth wire connected by either welding or crimping and will then be installed into the seabed below the surface. The copper rod would be approximately 12mm in diameter and up to 5m in length. The rod would be driven into the seabed and covered for protection. Where a copper rod cannot be used as an anchor to the earthing wire, a concrete clump weight with a pre-installed padeye may be used to anchor the earth wire. The concrete clump weight would have a footprint of approximately 1.0m diameter x 0.5m high and would be placed on the seabed.

	Bare Copper Wire		Concrete Clump Weight		Copper Earth Anchor	
Orkney (North)	**240m x 2 = 480m**	**95mm^2 wire @ 1kg/m = 480kg**	**1 per earth = 2**	**Up to 300kg each**	**5m length per earth = 10m**	**15kg / rod = 30kg**
Hoy (North)	**200m x 2 = 400m**	**95mm^2 wire @ 1kg/m = 400kg**	**1 per earth = 2**	**Up to 300kg each**	**5m length per earth = 10m**	**15kg / rod = 30kg**

Table 14: Sea Earth Deposits

6.4 Proposed Marine Cable Installation Method

This section outlines the envelope of all potential marine cable installation activities for which consent is being requested. 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 installation of the Marine Cable.

6.4.1 Pre-Lay Debris Removal

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

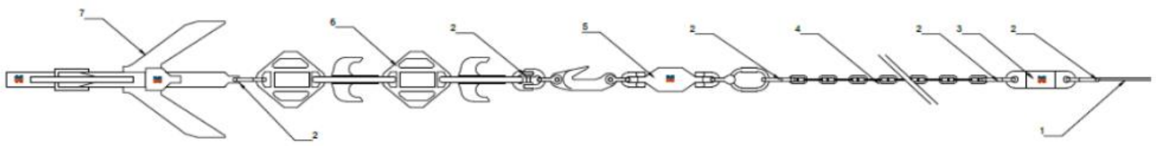
- Identify and investigate possible debris;
- Identify any obstructions on the proposed route

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. 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.

6.4.2 Pre-Lay Grapnel Run (PLGR)

A PLGR may be required to prepare the route where deemed appropriate. A typical grapnel train is shown below in Figure 28: Typical Grapnel Train. Multiple pre-lay grapnel runs both end to end and perpendicular to the route may be required within the licensed installation corridor as part of any route preparation activities, where appropriate.



	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 28: Typical Grapnel Train

6.4.3 First End Pull-In

Onshore preparation for the TJP and pull-in site shall be completed ahead of the CLV arriving to location, this will include beach quadrants, rollers, cable handling equipment and personnel. Equipment shall be accurately orientated and positioned via the use of handheld DGPS positioning devices.

Onshore pulling equipment will be set up and winch wire pulled though the TJP and winch wire flaked out on the beach to ensure there is enough available slack to hand over to the CLV.

The beach pull-in contractor shall use support craft to take the winch wire end towards the 'Hand Over Zone' located approximately 200m from the CLV stern. The wire between the beach and support craft will be fitted with clamped floats to reduce the weight of the wire whilst in the water. A second support craft will receive a messenger line from the CLV stern and transport it to the 'Hand Over Zone'. Here the connection between the main pull-in winch and messenger line is made.

Figure 29: Example Cable Support Vessel

Next, the support crafts shall move to a safe distance, clear of the messenger line and winch wire. The CLV shall then pick up in order to pull the main winch wire onto its back deck. The onshore team shall pay slave to the CLV during winch wire transfer. Once the winch wire in on the deck of the CLV, the messenger line is to be removed from the system and the winch wire connected to the cable pulling head with a suitably rated swivel between them. The onshore team will then be asked to take up any remaining slack in the system by picking up on the main pull-in winch.

All parties involved in the operation will be advised of the intention to commence the pull-in and confirm their readiness to commence. The CLV shall be master throughout the operations, with the onshore team acting as slave. The CLV will install pillow floats, and any pipe shells or any other cable protection that may be required, onto the cable as it is deployed over the vessel stern. The pillow floats will reduce the weight of the cable in the water and therefore reduce the required pull-in tensions. The floats will be removed by support craft / divers support teams as the cable settles onto the cable rollers positioned on the beach. The floats will be collected and stored on the beach for re-use and will not be discarded locally.

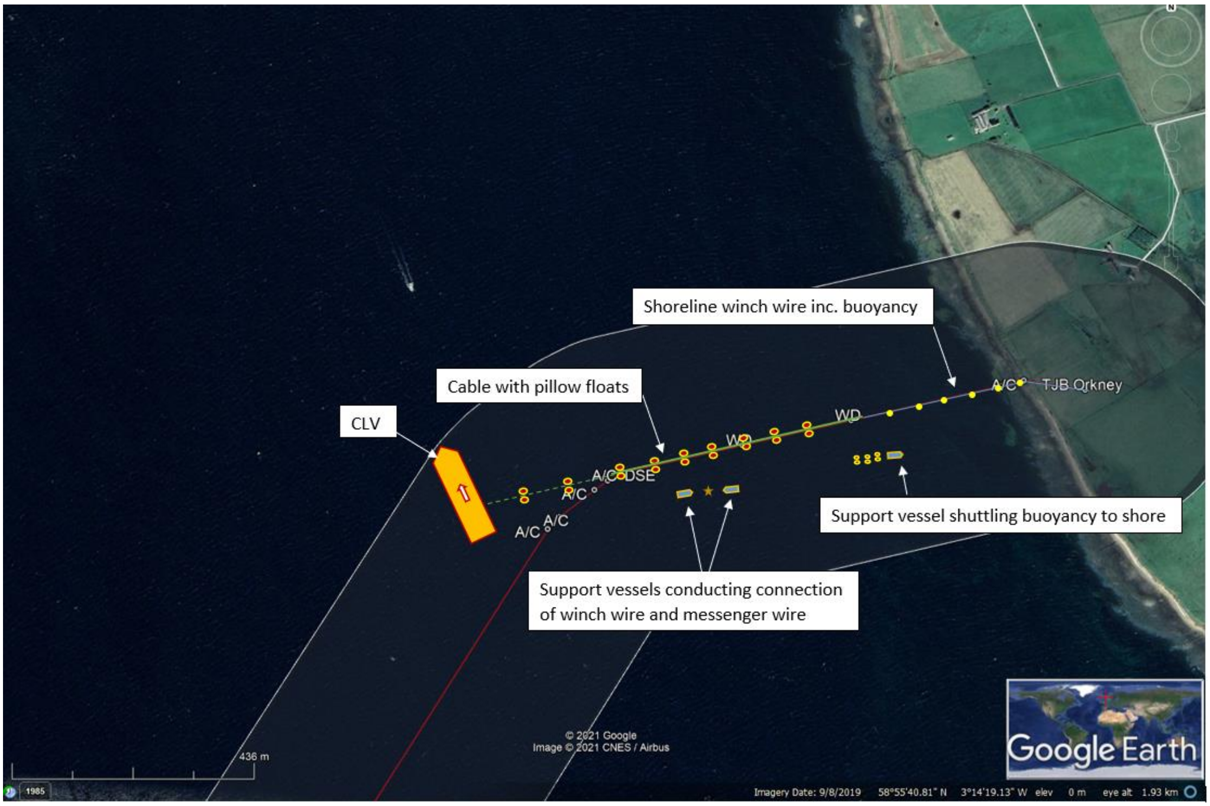


Figure 30: 1st End Pull-In Overview

An excavator will be used at the beach location to support the cable end into any quadrant handling equipment at TJP entry as required. The cable end will be visually monitored throughout the pull-in operations as it reaches the TJP and beyond. The cable will be pulled passed the TJP to an agreed point approximately 20m beyond the TJP. The cable tension will then be relaxed and secured into the TJP to avoid any uncontrolled cable movements. The pull-in contractor dive team will then remove any remaining pillow floats and sink the cable onto the RPL.

With the cable in position, an offshore survey will take place from MHWS and the onshore survey at MLWS using a handheld DGPS. This will create an overlap in data to stitch together.

It should be noted that that the cable pull-in may take place close to an in-service 33kV subsea cable. The newly installed cable will be positioned a safe distance from the existing cable in line with SSEN requirements.

6.4.4 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.

6.4.5 Second End Pull-In

The site for the 2nd end pull-in will be prepared ahead of the arrival of the CLV to that location. This will require there to be separate pull-in equipment sets for each landfall site to avoid any delays due to repositioning them for the CLV when arriving on site from the cable lay works.

Once the cable has been installed along the main RPL towards 2nd end, the CLV will stand off at a suitable position offshore and hold position at the agreed water depth. The cable support vessels will then approach and assist with the cable offload into an omega shape and act as a Hold Back support vessel in order to manage the cable at this location as the omega is laid on the water surface. Cable floats will be attached to the cable by the CLV deck crew and lowered into the water column and the omega loop laid.

Figure 31: Typical Pull In Floats

As the omega is created, the bight shall be managed by the support vessels. A support vessel shall also transfer a messenger line from the CLV to the onshore main winch wire and connect at the Hand Over Zone in the same manner as performed for the 1st end. The CLV shall pick up on its messenger line and receive the onshore winch wire on board. The main winch wire will be connected to the cable pull-in head via a suitably rated swivel and prepared for pull in.

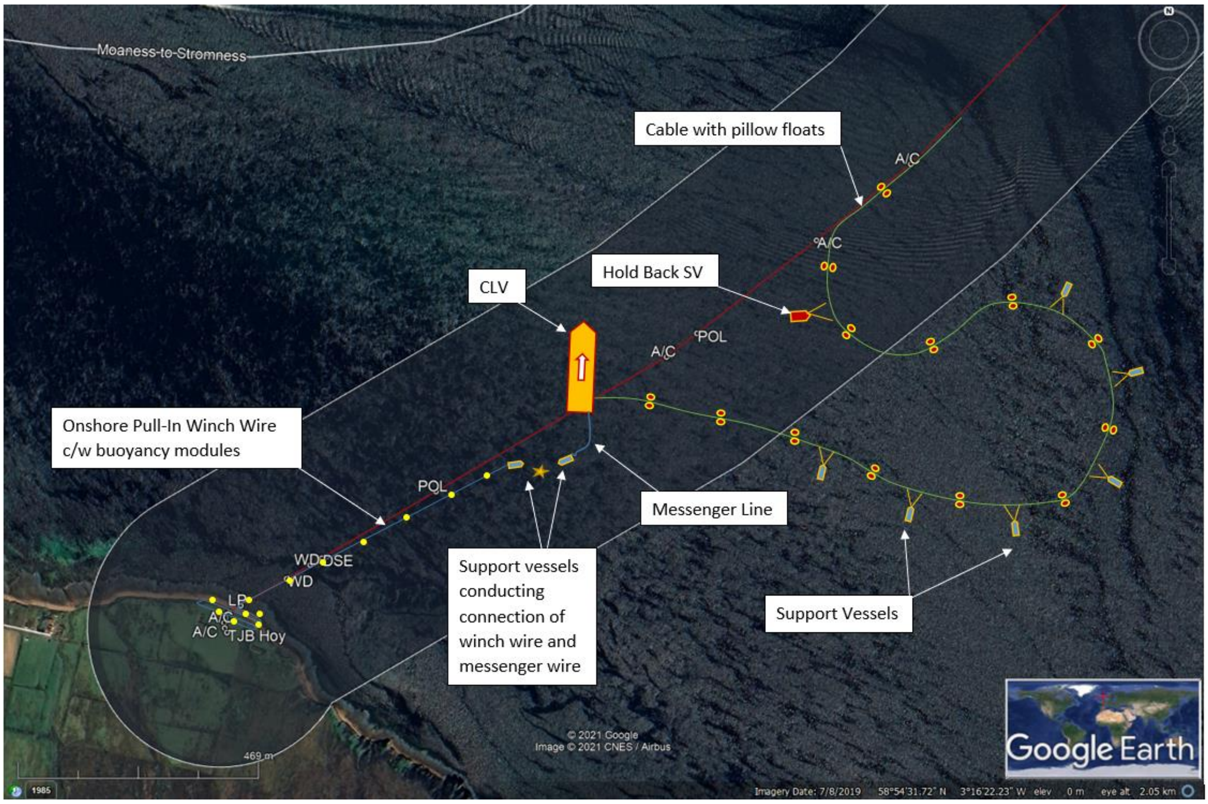


Figure 32: 2nd End Pull In Overview

The cable will be received by support craft that will manage the cable bight on the surface of the water ensuring the MBR of the cable is not compromised. The CLV crane may be used to support the offloading of the cable end from the CLV. Pillow floats will be installed along the length of the cable to prevent the cable from sinking and therefore reducing the pull in tension. This will also make it easier for the support vessels to manage the omega bight on the surface. The pace of operations shall be dictated by the crew on the CLV managing the speeds on the lay system but the positioning and the control of the cable bight and support vessel shall be managed by the Beach Master ensuring that the cable MBR is not compromised.

It should be noted that that the cable pull-in may take place close to an in-service 33kV subsea cable. The newly installed cable will be positioned a safe distance from the existing cable in line with SSEN requirements.

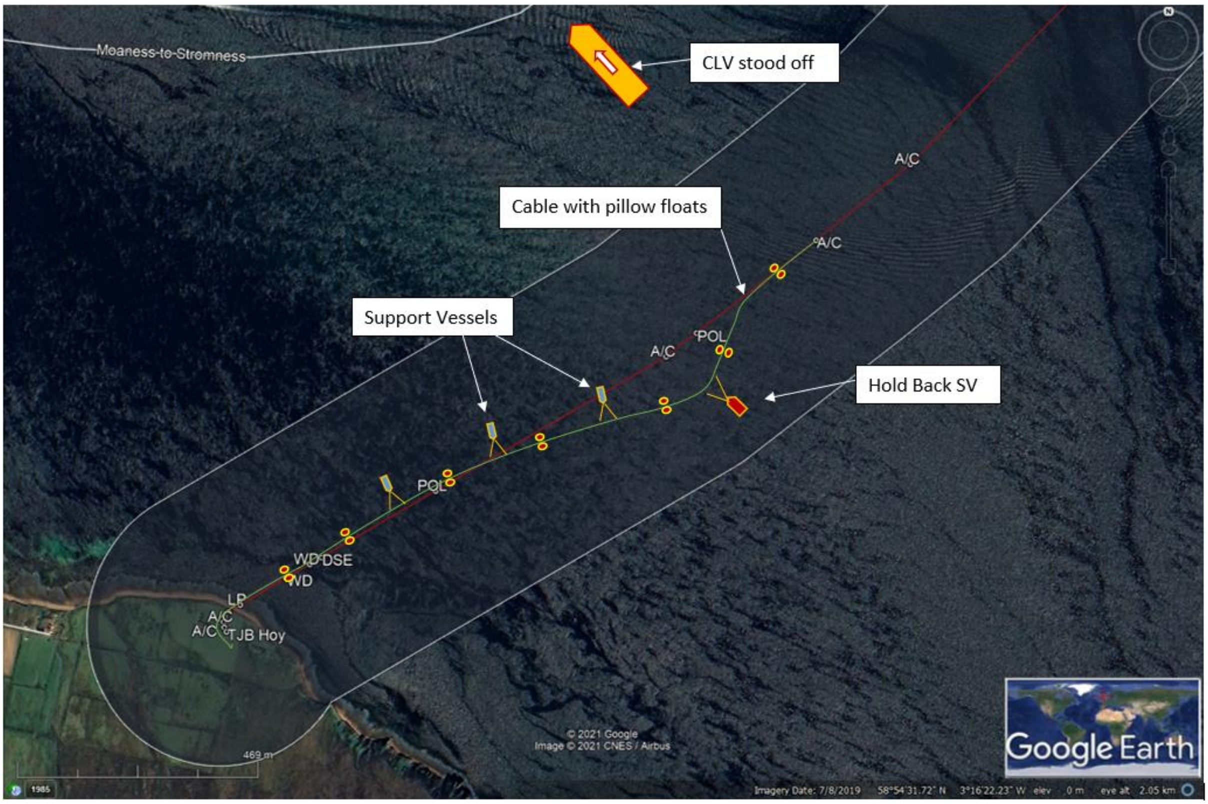


Figure 33: 2nd End Pull In Overview

Once the full length of cable has been laid out on the water surface, the CLV will relocate to a safe distance from the omega bight and support vessels. Under direction from the Beach Master, the pull in shall take place with support vessels assisting the cable pull in works. The pull-in shall continue until the cable end is received onshore. The support vessels and divers will manage the floating cable and excavators may be used on the beach to support the cable end. The pull in shall be complete when the agreed overpull from the TJP has been achieved.

Once the final pull in has been achieved the cable floats will be released in a systematic way (offshore to nearshore) and the cable settled onto the RPL. Offshore survey will take place at MHWS and the onshore survey at MLWS using a handheld DGPS. This will create an overlap in data to stitch together.

Figure 34: Second End Pull In Example

6.4.6 Cable Protection Methods

This section outlines the envelope of all potential marine cable stabilisation and protection methods for which consent is being sought.

6.4.6.1 Mattress Installation

If mattress installation is required, a Multicat type vessel will carry out the installation in shallow water. During the installation, the Mulitcat may need to hold position by means of clump weights. An overview of the likely clump weight arrangement is shown in Figure 276: Example Clump Weight Configuration, note that the clump weights are designed to be non-penetrative and rely on the self-weight of the arrangement to provide stability to the vessel.

Details of a concrete mattress can be seen in Table 15: Concrete Mattress Dimensions below

Concrete Mattress Mass in Air (Te)	Length (m)	Breadth (b)	Height (m)
10	6.0	3.0	0.3

Table 15: Concrete Mattress Dimensions

Figure 265: Concrete Mattress Deployment

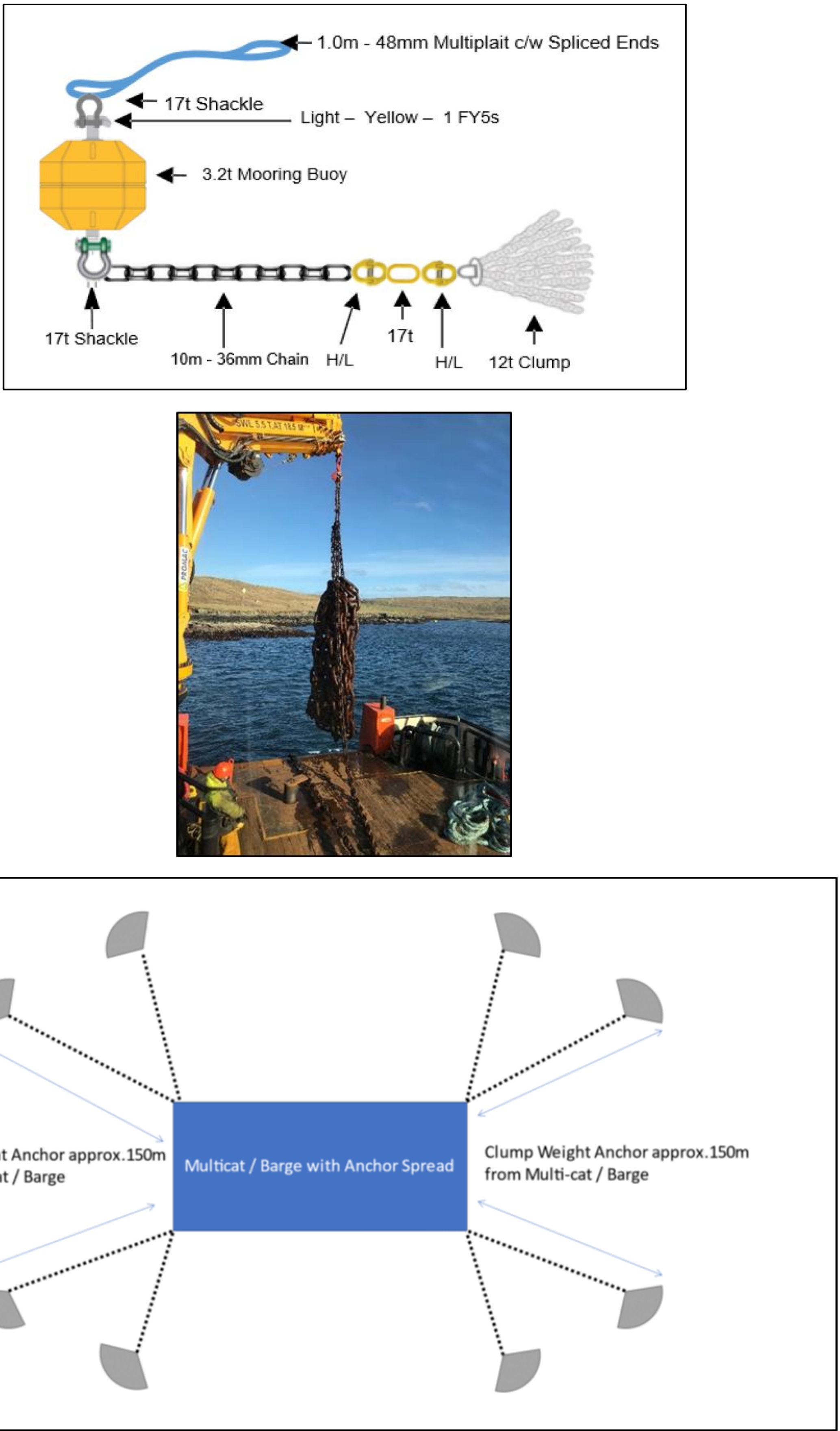


Figure 276: Example Clump Weight Configuration

6.4.6.2 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 Figure 287 and Figure 298). The vessel's ROV monitors the installation and detaches the crane wire from the Rock Bag once in position.

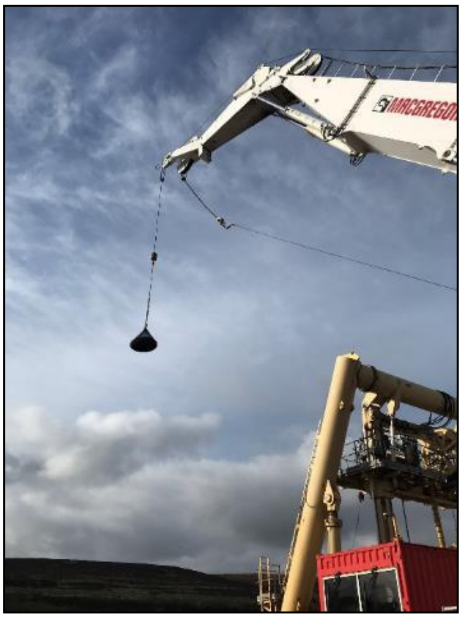


Figure 287: Rock Bag Being Lifted off the Vessel

Figure 298: Rock Bag in Position Subsea

Details of a 4te rock back can be seen in Table 146: Rock Bag Dimensions below:

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

Table 146: Rock Bag Dimensions

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.

6.4.6.3 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. If these are required, then this can be installed from the CLV using its 150te subsea crane in a similar manner to the Rock bags as described in Section 6.4.6.2 above. 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.

6.4.6.4 Split Pipe / 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. The total maximum installed length of Split Pipe and Uraduct combined would be 507m.

See Section 5.1 for details of anticipated Split Pipe or Uraduct installation. An example Split Pipe installation is shown in Figure 41: Example Split Pipe Installation. In locations where Split Pipe is to be employed as cable protection, this will be installed onto the cable from the CLV and deployed over the cable chute as part of the cable lay.

Figure 41: Example Split Pipe Installation

6.5 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.).