

SCOTTISH HYDRO ELECTRIC POWER DISTRIBUTION PLC

Skye - Harris Subsea Cable Replacement

Project Description



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Intertek Energy & Water Consultancy Services

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Skve - Harris Subsea Cable Replacement

Project Description

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GLOSSARY

CBRA

Cable Burial Risk Assessment

CPSP

Cable Protection and Stabilisation Plan

CR

Client Representative

DP

Dynamic Positioning

DTS

Desktop Study

DWA

Double Wired Armour

FLMAP

Fisheries Liaison Mitigation Action Plan

FO

Fibre-Optic

HVAC

High Voltage Alternating Current

KP

Kilometre Point

MEA

Marine Environmental Appraisal

MHWS

Mean High Water Springs

MLWS

Mean Low Water Springs

NAVTEX

Navigational Telex

NTM

Notice to Mariners

OBS

On-Bottom Stability

PLGR

Pre-Lay Grapnel Run

ROV

Remotely Operated Vehicle

RPL

Route Position List

SEPA

Scottish Environment Protection Agency

SHEPD

Scottish Hydro Electric Power Distribution plc

SIMOPS

Simultaneous Operations

SSEN

Scottish and Southern Electricity Networks

Te

Tonnes

TJP

Transition Joint Pit

WD

Water Depth

WTN

Water Transfer Note

1. INTRODUCTION

1.1 Overview

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.

A single subsea electricity cable across the Minch connects Harris and Lewis to the Isle of Skye. On the 16 October 2020, a fault was identified on this circuit which has resulted in it being out of service since this date. Following a review of the options appraisal and survey information, SHEPD have identified that this cable needs to be replaced and is applying to Marine Scotland for a marine licence to carry out these works.

This project description sets out the installation methodology proposed to undertake the cable replacement works. Installation works are scheduled to take place over Summer 2021. The estimated time period for each installation activity is presented below in Table 1-1.

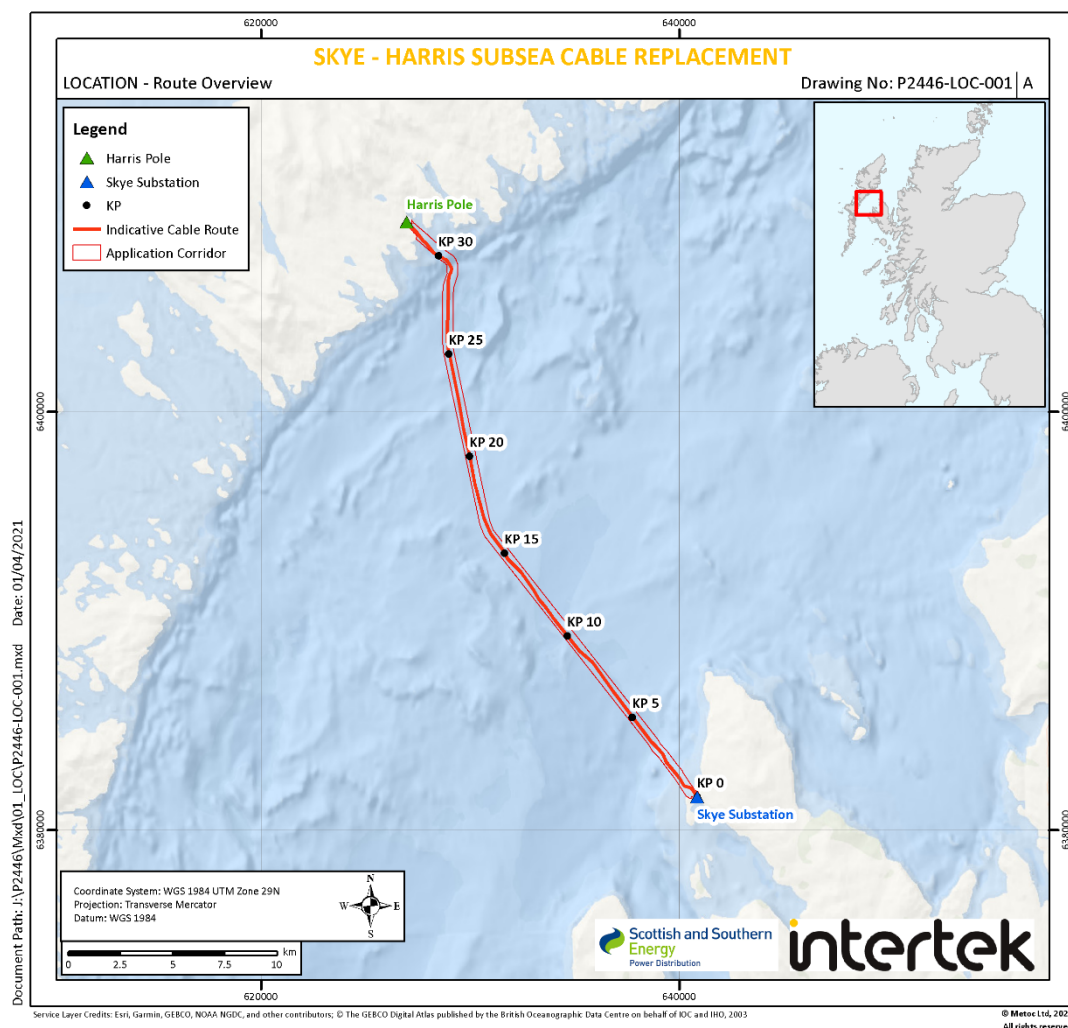
Table 1-1 Estimated Installation Schedule

Activity	Estimated time period
Seabed preparation (Cable cutting/ removal and PLGR)	3 days
Landfall route clearance	8 days
TJB construction	10 days
Landfall works	25 days
Pre-lay survey	2 days
Offshore cable lay and post-lay survey	10 days
Nearshore split pipe installation	13 days
Post-lay burial with trencher	6 days
Post burial survey	3 days
Rock bag and concrete mattress installation	9 days

1.2 Replacement cable route

The indicative cable route for the replacement cable is shown in red in Figure 1-1. The proposed Application Corridor within which the cable will be installed is 500m wide (250m either side of the route centre-line). It is this Application Corridor that is being applied for in this Marine Licence Application.

Figure 1-1 Indicative Replacement cable route within Application Corridor (Ref: P2446-LOC-001)



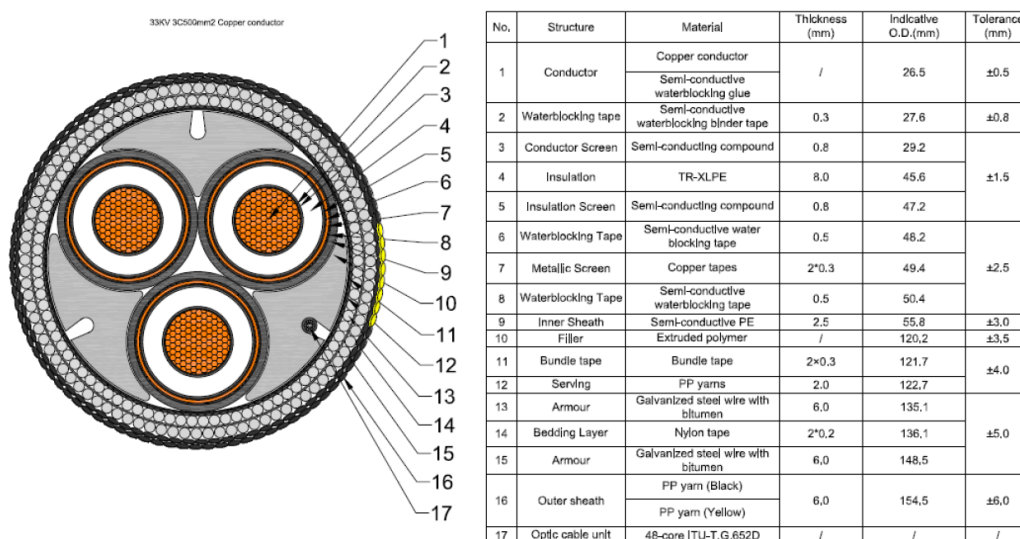
2. PROPOSED CABLE CONSTRUCTION

Electricity will be transmitted using High Voltage Alternating Current (HVAC) submarine cable technology. The typical cable 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: Ningbo Orient



The 33 kV subsea cable that is proposed for installation is a 500 mm² three core XLPE conductor with a fibre optic (FO) cable, 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 provided 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
59.4	150 +> Maximum Bend Radius (MBR) above 3mtrs	3	154.5	30	~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. PRE-INSTALLATION SURVEY WORKS

Pre-installation survey works were undertaken during February/March 2021 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 informed identification of the subsea cable installation corridor.

The survey works have also informed the environmental assessment provided in the supporting Marine Environmental Appraisal (MEA).

4. CABLE PROTECTION AND STABILISATION

4.1 Overview

A Cable Protection and Stabilisation Plan (CPSP) has been developed as part of the Marine Licence application, see Table 4-1 below. This CPSP has been based on preliminary survey data acquired from the nearshore and offshore survey vessels.

The CPSP conservatively outlines the type and number of seabed deposits required as part of the marine licence and is the basis of the assessment made in the MEA.

Engineering studies are ongoing which may alter the final quantity of deposits required and the information provided in the CPSP is therefore based upon worst-case scenarios.

Table 4-1 Cable Protection and Stabilisation Plan

Location Description	Kilometre Point (KP) Range	Installation Type	Length of Cable (m)	Area of rock berm (m ²)	Volume of rock berm (m ³)	Length of articulated pipe	Number of rock bags*	Number of grout bags*	Number of concrete mattresses*
Skye substation to Transition Joint Bay	0.000-0.025	Buried by land-based excavator in field	25	0	0	0	0	0	0
Transition Joint Bay to Mean High Water Springs (MHWS)	0.025-0.067	Buried by land-based excavator in field. Cable in articulated pipe	42	0	0	42	0	0	0
MHWS to Landing Point (Mean Low Water Springs (MLWS))	0.067-0.152	Buried by land-based excavator in field. Cable in articulated pipe	85	0	0	85	0	0	0
Landing point (MLWS) to end of articulated pipe	0.152-0.280	Surface laid. Cable in articulated pipe	128	0	0	128	0	0	0
End of articulated pipe to Direct Shore End vessel setup position	0.280-0.330	Cable buried by trenching ROV or diver assisted jetting sled	50	0	0	0	0	0	0
Seabed	0.330-1.610	Cable buried by trenching ROV	1280	0	0	0	0	0	0
Surface laid through till/rock	1.610-2.835	Surface laid. Possible rock berm required as indications of seasonal scallop fishing to KP 5.	1225	15,925	8575	0	0	0	0

Location Description	Kilometre Point (KP) Range	Installation Type	Length of Cable (m)	Area of rock berm (m ²)	Volume of rock berm (m ³)	Length of articulated pipe	Number of rock bags*	Number of grout bags*	Number of concrete mattresses*
Surface laid through till/rock with steep slope >15°	2.835-2.950	Surface laid. Possible rock berm required as indications of seasonal scallop fishing to KP 5	115	1,495	805	0	0	0	0
Seabed with boulder fields	2.950-5.000	Surface laid. Possible rock berm required as indications of seasonal scallop fishing to KP 5	2050	26,650	14,350	0	0	0	0
Seabed	5.000-8.235	Cable buried by trenching ROV	3235	0	0	0	0	0	0
Seabed with boulder fields	8.235-15.000	Surface laid Cable route avoids as many boulders as possible through boulder fields. Some selected clearance may be required within +/- 5m of Route Position List (RPL). Possible rock berm required from KP 12.7 as high levels of trawling indicated between here and to KP26.1.	6765	29,900 (2300*13)	16,100 (2300*7)	0	88 (2 bags every 100m KP 8.235-12.700)	0	0
Seabed	15.000-16.960	Cable buried by trenching ROV	1960	0	0	0	0	0	0

Location Description	Kilometre Point (KP) Range	Installation Type	Length of Cable (m)	Area of rock berm (m ²)	Volume of rock berm (m ³)	Length of articulated pipe	Number of rock bags*	Number of grout bags*	Number of concrete mattresses*
Seabed with fishing trawl scars	16.960-24.500	Cable buried by trenching ROV	7540	0	0	0	0	0	0
Seabed	24.500-26.700	Cable buried by trenching ROV	2200	0	0	0	0	0	0
Seabed with boulder fields	26.700-29.150	Boulder Clearance by picking. May need ~2km rock placement around KP 27 as anecdotal evidence of scallop dredging noted	2450	26,000 (2000*13)	14,000 (2km*7)	0	0	0	0
Steep Sloped Seabed with boulder fields	29.150-29.325	Surface laid. Selected boulder clearance by picking within +/-5m of RPL	175	0	0	0	0	0	0
Seabed leading to Direct Shore End vessel setup position	29.325-31.800	Cable buried by trenching ROV	2475	0	0	0	0	0	0
Direct Shore End vessel setup position - End of articulated pipe	31.800-31.968	Cable buried by trenching ROV or diver assisted jetting sled	168	0	0	0	0	0	0
End of articulated pipe to landing point (MLWS)	31.968-32.108	Surface laid. Cable in articulated pipe	140	0	0	140	0	0	0

Location Description	Kilometre Point (KP) Range	Installation Type	Length of Cable (m)	Area of rock berm (m ²)	Volume of rock berm (m ³)	Length of articulated pipe	Number of rock bags*	Number of grout bags*	Number of concrete mattresses*
Landing point (MLWS) to MHWS	32.108 - 32.173	Buried by land-based excavator. Cable in articulated pipe	65	0	0	65	0	0	0
MHWS to start of articulated pipe	32.173 – 32.185	Buried by land-based excavator. Cable in articulated pipe	12	0	0	12	0	0	0
Start of articulated pipe to Transition Joint Bay	32.185-32.209	Buried by land-based excavator in field	24	0	0	0	0	0	0
Transition Joint Bay to Pole	32.209-32.256	Buried by land-based excavator in field	47	0	0	0	0	0	0
Deposit totals (including potential deposits)			32.256km (With contingency = 33km)	99,970m ²	53,830m ³ (50% contingency = 26,915m ³) Total = 80,745m ³	472m (184 pipe sections) (20% contingency = 37) Total = 567m (221 pipe sections)	88 (20% contingency = 18) Total = 106	20 (20% contingency = 4) Total = 24	8 (20% contingency = 2) Total = 10

* Exact KP location not known at this stage, indicative total provided for whole route.

4.2 Cable Protection and Stabilisation

Initial route engineering indicates that the cable is likely to be buried for approximately 64% of the land and marine route however the cable route runs through several boulder fields and it is likely that the cable may be surface laid in these areas.

The cable will be laid in articulated pipe at the both the landing areas. At Skye, articulated pipe is approximately 255m long, with around 217m at Harris.

The cable will be surface laid for approximately 12.1km of the route, predominantly in areas where the seabed is dominated with boulder fields, although the cable route has been engineered to avoid as many boulders as possible. There is indication that the area between KP 0.110 and KP 5 is used for fishing activities and therefore rock placement may be used to protect the cable where surface laid in these areas (approximately 3.4km long section). It is estimated that 4m³ of rock will be used per metre of cable for this activity.

The seabed is also dominated by boulder fields between KP 8.2 and KP 15 and the cable may be surface laid in this area also. There is also indication that there are high levels of trawling between KP12.7 and KP26.13. In addition, trawl scars were noted on the side scan sonar data between KP16.9 and KP24.5, therefore rock placement may be used to protect the cable where surface laid in this area also (approximately 2.3km section). The cable is likely to be protected by burial along the majority of the remainder of this fishing zone, however as the cable approaches Harris the seabed is once again dominated by boulder fields from KP25.75 and therefore some rock placement may be required between here and KP26.13 to protect the cable from fishing activity.

There is also indication of limited scallop dredging around KP27. There is no further indication of the area used for scallop dredging in this area and trawl scars are not evident in the preliminary side scan sonar data however there may be a need for rock placement in this area to protect the cable for such fishing activities. An initial estimate totalling 2km of rock placement around KP27 has been made for this protection at this stage.

The cable will also be surface laid along a steep sloped seabed with boulder fields which is evident in the seabed profile between KP29.03 and KP29.34. Burial will commence from the top of this slope to KP31.965 where the cable is surface laid in articulated pipe once again at the Harris landing.

It should be noted that to allow for potential micro-routing to be undertaken along the replacement cable route, a cable length of 33km will be applied for in the accompanying Marine Licence Application. Other contingency figures for the remaining deposits are detailed in Table 4-1 above.

5. PROJECT DESCRIPTION

5.1 Proposed Route

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 MEA Report and fisheries considerations outlined as part of the FLMAP.

During the Desk Top Study phase of the project, it was identified that the landfall site on Skye could be moved to a bay to the east of where the existing faulted cable comes into land. Moving to the eastern bay allows for a shorter route overland to the substation and the avoidance of the live Skye-South Uist power cable. Post-survey environmental considerations, such as avoidance of sensitive habitat were also taken into account in selecting the final optimised route for the cable route within the cable corridor.

The position of the replacement cable route in relation to existing infrastructure is shown in the chart provided in Appendix A.

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

5.1.1 Route Decision Making Process

Table 5-1 Key Route Engineering Timeline

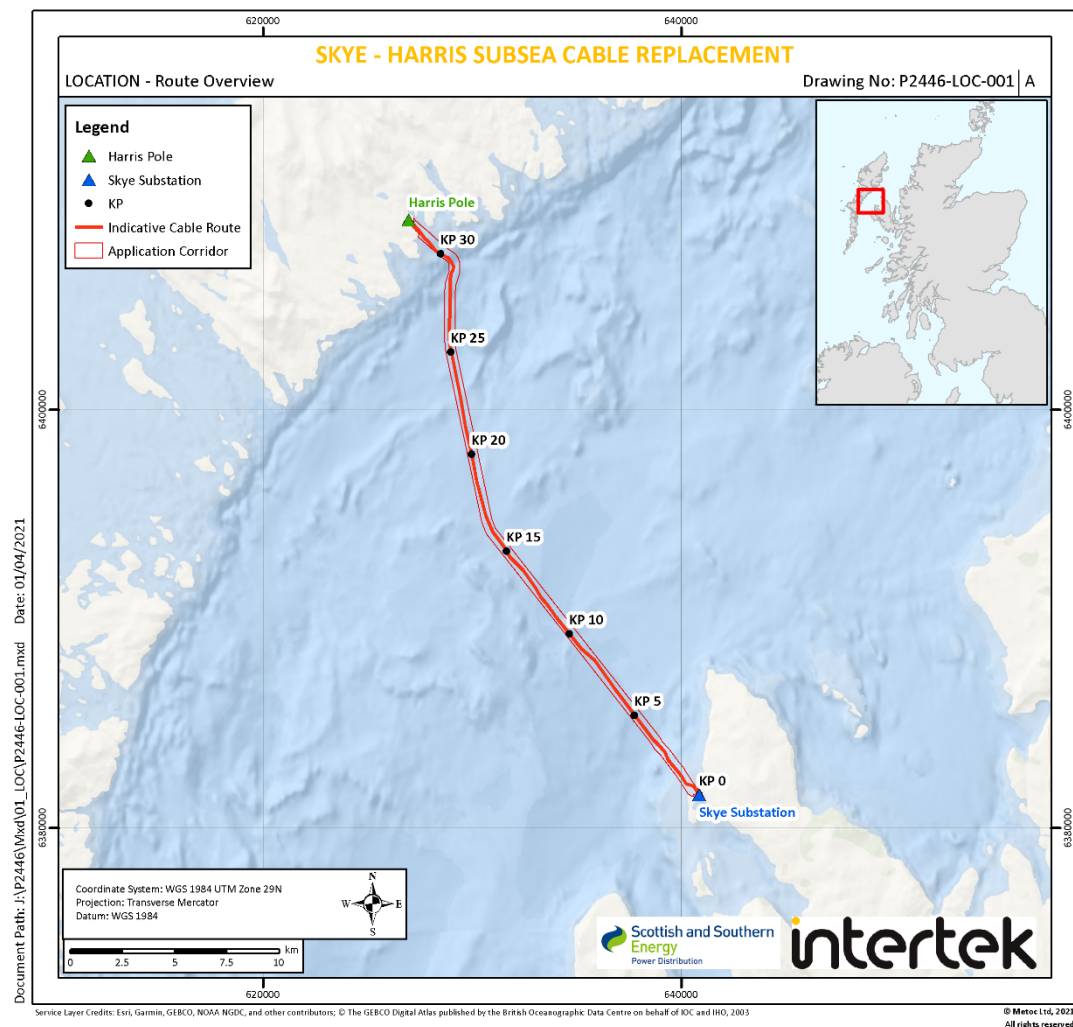
Stage	Date	Description
Pre-survey	2 nd December 2020	Preliminary RPL based on existing cable
Pre-survey	20 th January 2021	Preliminary RPL moved 200m offset from existing cable to expand useable corridor
In-field selected route	22 nd March 2021	Updated infield selected route from preliminary vessel deliverables
Post survey and route engineering works	TBC	RPL for cable installation generated from geophysical and geotechnical survey data and cable burial risk assessment

5.1.2 Route Description

The proposed cable route lies between Skye and Harris as indicated in Figure 5-1. The cable route commences at Ardmore on the island of Skye and runs across the Little Minch to Beacravik on the island of Harris.

The survey corridor for the replacement cable was centred 200m south of the existing cable as illustrated in Figures 5-3 - 5-6. The survey corridor was selected taking into account avoidance of key seabed features as well to maximise the amount of survey data available to inform route engineering decisions.

Figure 5-1 Proposed Cable Route (Ref: P2446_LOC_001)



A bathymetric overview of this portion of the Little Minch is presented in Figure 5-2. Where possible the cable route has been optimised to allow for improved burial, efficient installation and least disruption to the seabed.

On leaving the Skye landing point, the seabed is initially dominated by an area of outcropping rock and associated boulders however the seabed comprises sandy sediments from around KP0.23 (see Figure 5-3). The cable route heads north-west through an area of seabed with anticipated harder outcrops and numerous boulders before a steep cliff is noted around KP2.8. The cable route continues at the base of this cliff through a significant boulder field, the approximate location of which is shown as an orange line on Figure 5-2. An example of the density of sonar contacts within this area of boulder field is shown in Figure 5-4.

Boulders are noted until around KP15 where a number of trawl scars are visible on the sonar data indicating the presence of trawling. There is also indication of the presence of heavy trawling between KP12.7 and KP26.1 in these softer clays also. The route continues towards the north-northwest through this fishing ground before a second boulder field is encountered on the offshore approaches to Harris (see second orange line on Figure 5-2).

The seabed rises rapidly up a steep cliff face with areas of exposed bedrock from around KP28.5 before levelling off around KP29.5 on the nearshore approaches to the Harris landing point. Seabed sediments in this area generally comprise sands and gravels however the beach at the landing point

comprises cobbles and boulders, becoming grassy landwards of the landing point. The nearshore area at Harris is illustrated in Figure 5-5.

Figure 5-2 Cable Route and Bathymetry of Little Minch

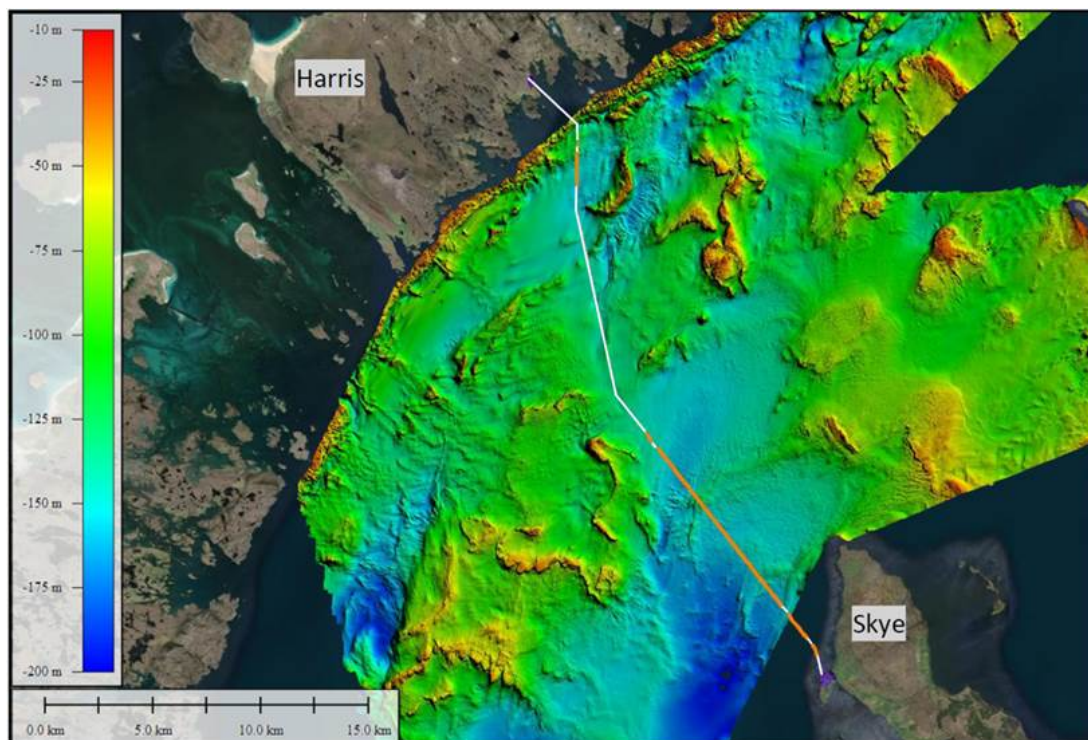


Figure 5-3 Skye Nearshore Area

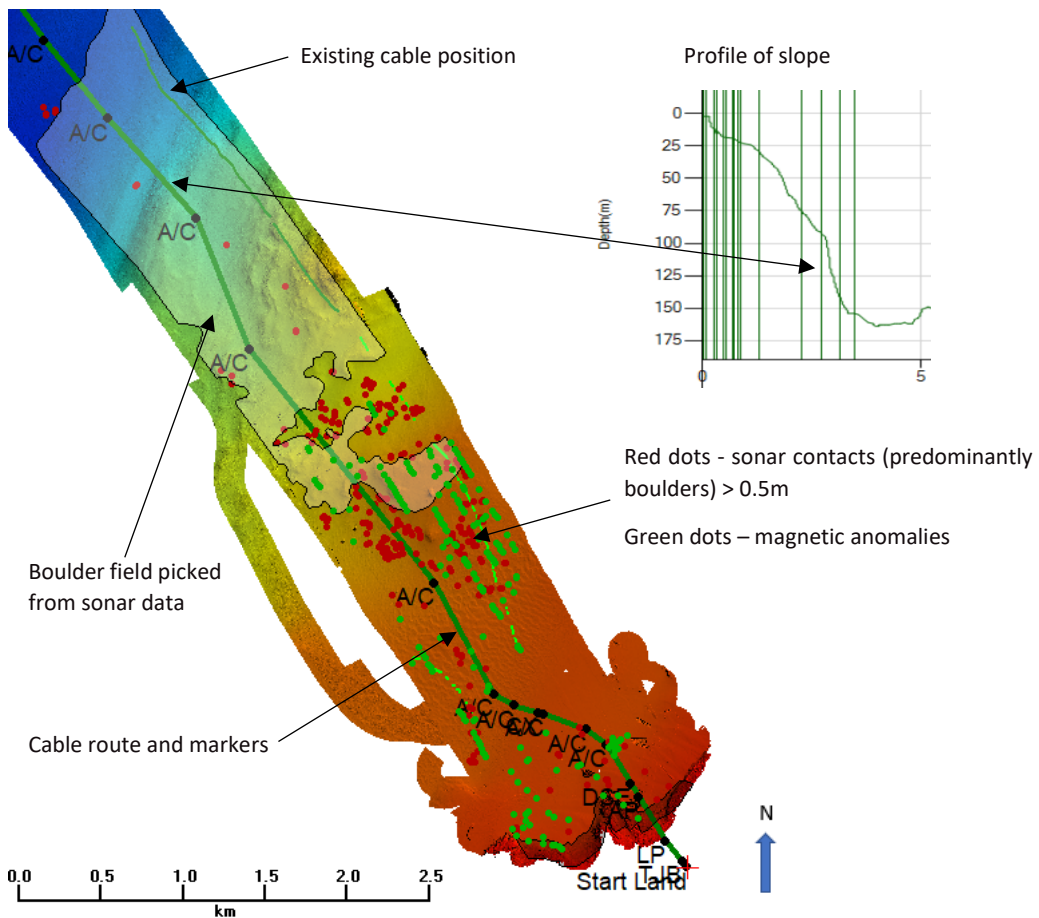


Figure 5-4 Example of Boulder Field

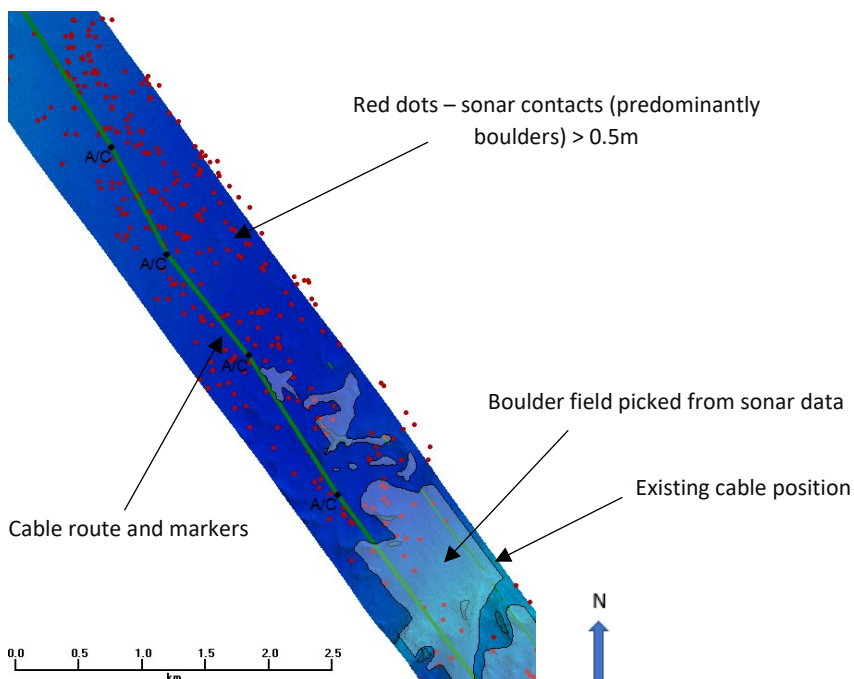
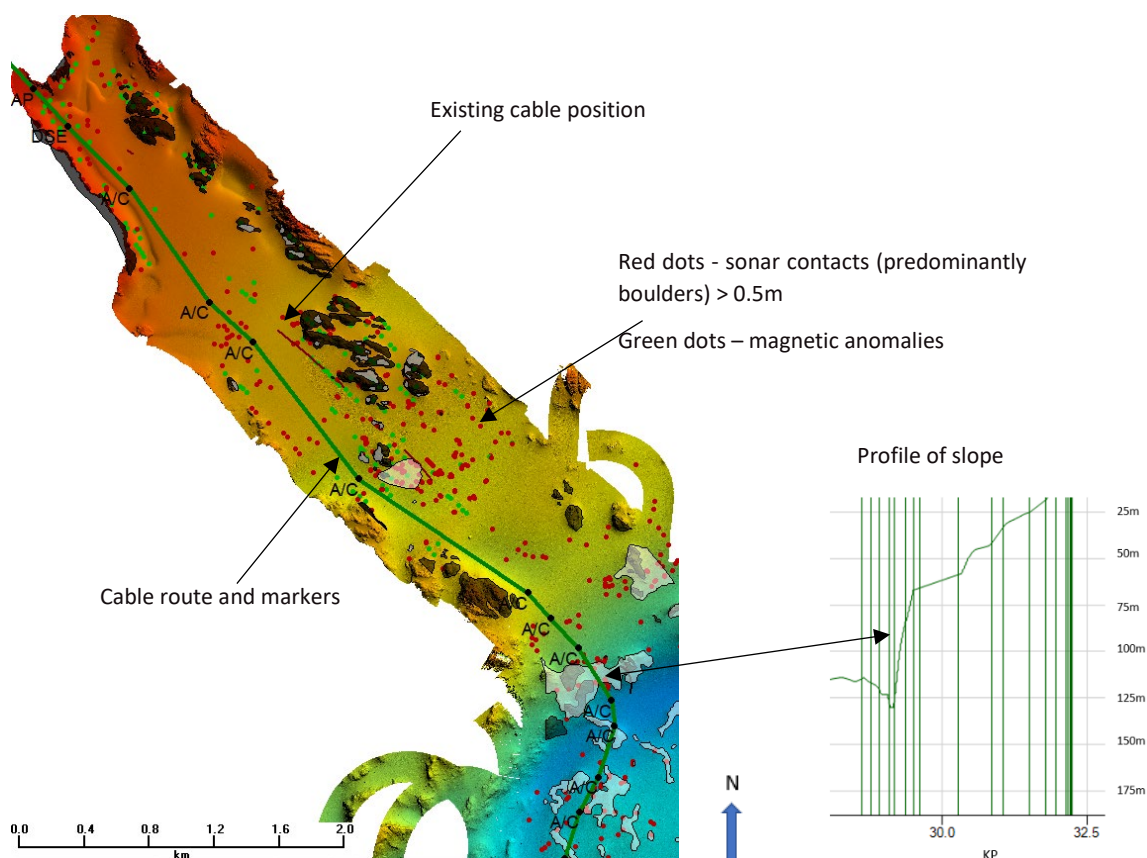


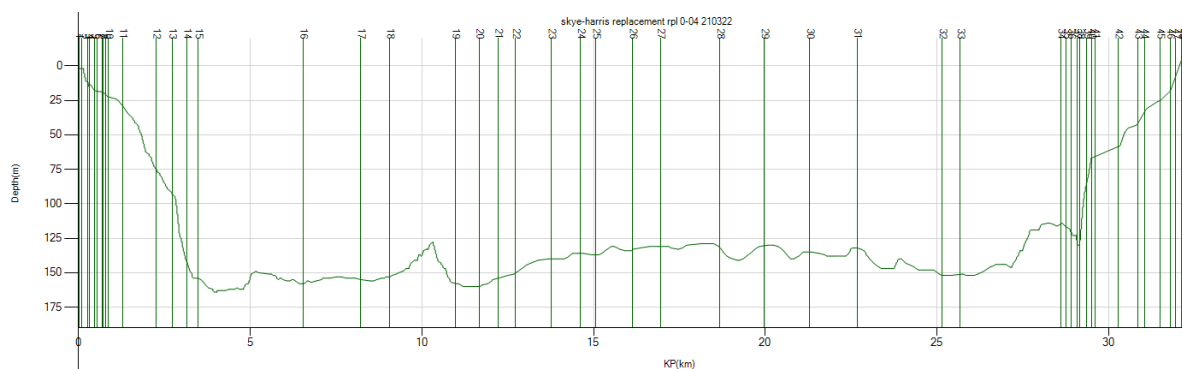
Figure 5-5 Harris Nearshore Area



5.1.3 Route Profile

A profile of the topography and seabed along the cable route is presented in Figure 5-6 below:

Figure 5-6 Topographic and Seabed Profile Along the Skye to Harris Cable



5.1.4 Proposed Skye Landing Site

The Skye landing site (Figure 5-7) was selected to provide a route which allows good vessel and shore access. Consideration was also given to the effects of coastal erosion and the route of the live Skye-South Uist cable which makes landfall to the west of the proposed Skye-Harris landfall.

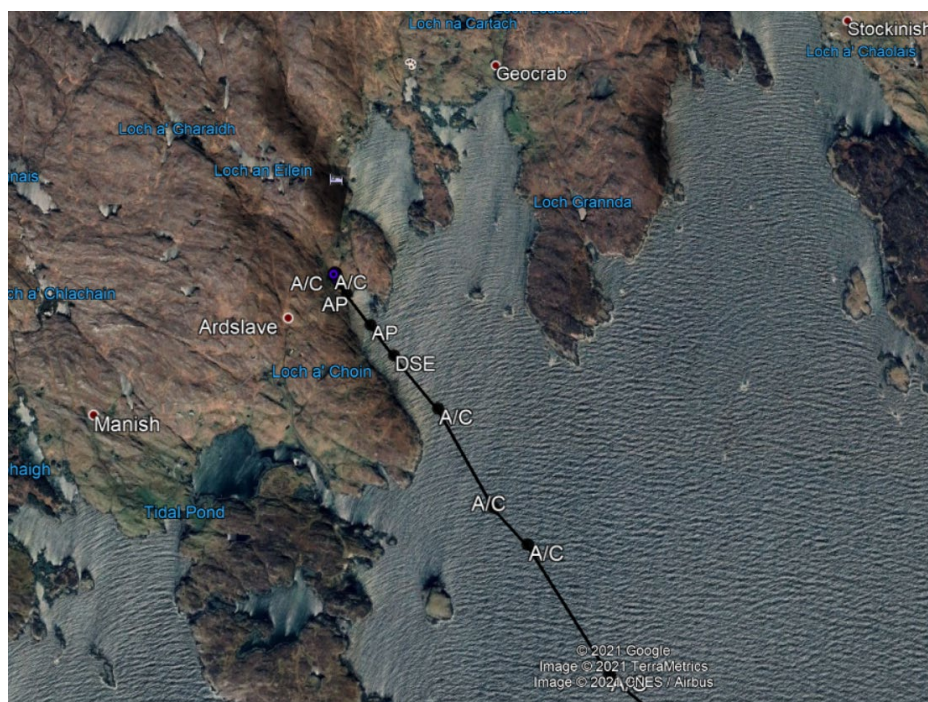
Figure 5-7 Photographs of Skye Landing Site



5.1.5 Proposed Harris Landing Site

The existing cable lands in a small enclosed bay (Figure 5-8) before reaching the termination point higher up the hillside as shown in the images below. The replacement cable route will follow a similar route as much as possible.

Figure 5-8 Photographs of Harris Landing Site



5.2 Proposed Installation Method

An indicative installation methodology is outlined below. 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. This indicative methodology has been used to inform the environmental assessment provided in MEA, so that the worst-case impact scenarios of the installation have been considered.

Vessels and equipment proposed to be utilised during the installation process are summarised in Section 5.5.

5.2.1 Pre-Lay Survey, Boulder-Picking and Out-of-Service 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 including the presence of boulders which may impede the safe installation of the cable; and
- Identify the location of the short sections of the Out-of-Service (OOS) cable to be removed to facilitate installation of the new cable and to confirm the location and position of the existing Skye to South Uist cable in the proximity of the Skye landfall for the proposed route.

Any obstructions or debris will be removed, if possible. A work class Remotely Operated Vehicle (ROV) or Pre-Lay Grapple Run (PLGR) will be undertaken to remove debris from the proposed route. Boulders may be removed using a “grab” tool deployed from a support vessel with suitable crane, as shown below in Figure 5-9.

Figure 5-9 Boulder removing ‘grab’ tool



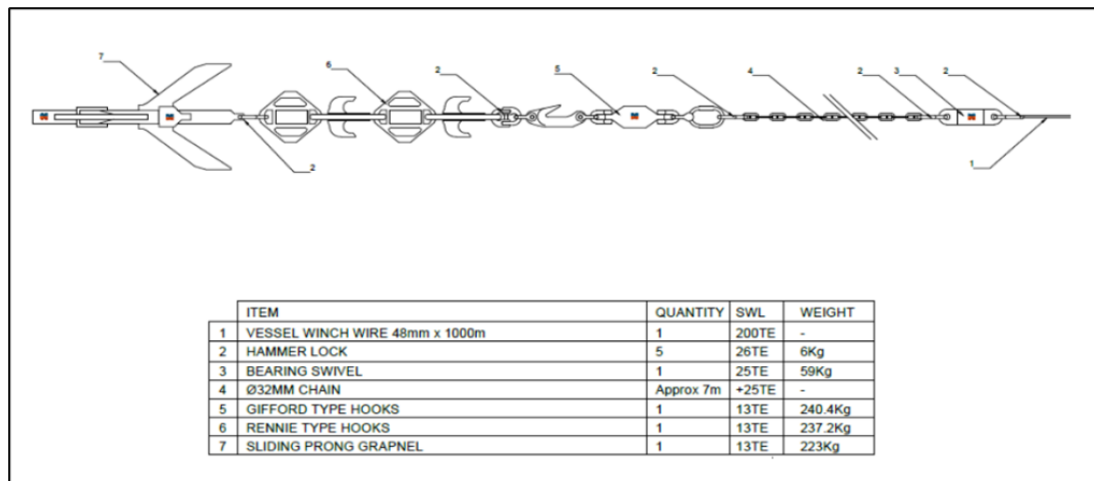
If debris or an obstruction cannot be removed from the planned route, the offshore surveyors will micro-route around the debris/obstruction in consultation with the onboard Client Representative (CR) – at all times staying within the licenced installation corridor.

Debris identified and removed along the route will be disposed of as outlined in the offshore CEMP (Document Reference: P2446_R5282_Rev0).

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 this is deemed appropriate. A typical grapnel train is shown below in Figure 5-10. Multiple PLGR's both end to end or perpendicular to the route may be required within the licenced installation corridor to remove OOS cables and as part of pre-burial activity, where appropriate.

Figure 5-10 Grapnel Train (Typical Example)



5.3 Landfall Preparation

The landfall areas will be prepared with the following tasks undertaken:

- Site setup, including fencing, signage, welfare units etc;
- Landfall drone survey and site walk-over;
- 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

5.3.1 Access to Site

Access to the Transition Joint Pit (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.

5.3.2 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.

Figure 5-11 120L Spill Kits and Machine Nappy Trays



120 Liter Spill Kits at each site



Machine Nappies to protect from

5.3.3 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. The TJP at each landfall will be located above MHWS. As the marine licence Application Corridor only covers up to MHWS details on the TJP are only included in this report to provide further information on the Project.

Figure 5-12 SSN provided TJP plan

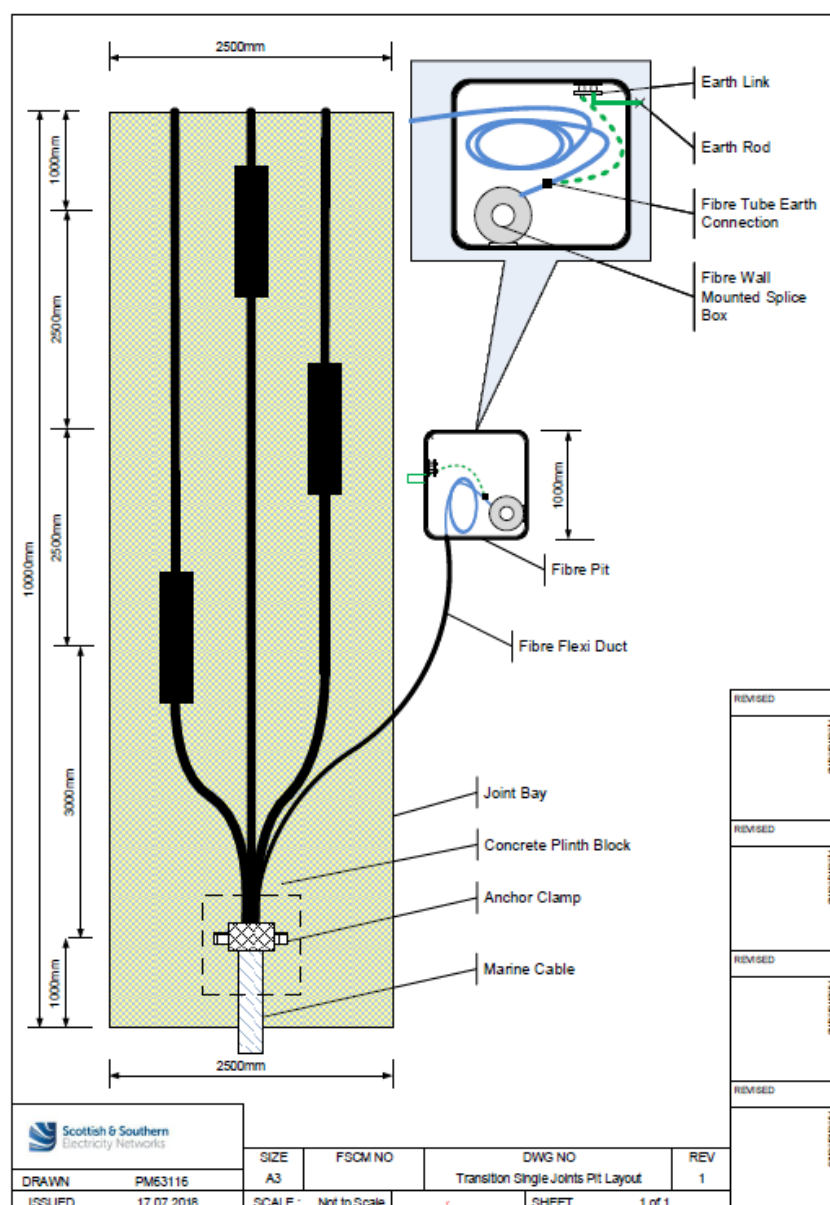


Figure 5-13 TJP Final Layout (Example)



5.4 Marine Cable Installation

5.4.1 First End Pull-In

The Cable Lay Vessel (CLV) will position at the first end pull-in site at Skye, generally stationed at the 13m water depth (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. An example CLV is displayed in Figure 5-14 below.

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 5-15 shows typical first end pull-in operations.

Figure 5-14 Typical Cable Lay Vessel



Figure 5-15 First End Pull-In



5.4.2 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 Fisheries Liaison Mitigation Action Plan (FLMAP).

5.4.3 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 at Harris.

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 5-16.

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 MEA references 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 5-16 Second End Pull-In



5.4.4 Earthing operations

5.4.4.1 Skye

One off trench will be excavated (depth between 600 and 750mm) from the TJP to the MLWS. Inside the trench, a copper conductor will be run from one side of the trench to the other. At the MLWS end of the trench, another pit will be excavated with a multiple rods being driven into the pit (rods quantity to be determined after completion of round resistivity survey). The copper conductor will be connected to the rods array at the MLWS side and at the TJP earth hub. All trenches and pits will be covered with a layer fine material and then filled with the excavated soil up to the mean ground level.

5.4.4.2 Harris

Two off trenches will be excavated (depth between 600 and 750mm). One of these trenches will run from the OTH pole to MLWS and the second trench from the TJP to MLWS. Inside each trench a copper conductor will be run from one side of the trench to the other. At the MLWS end of each trench, another pit will be excavated with multiple rods will be driven into each pit (rods quantity to be determined after completion of round resistivity survey). The copper conductors will be connected to the rods array at the MLWS side, and at the OTH pole earth clamp or at the TJP earth hub, depending on the trench. All trenches and pits will be covered with a layer fine material and then filled with the excavated soil up to the mean ground level.

5.5 Cable Protection Methods

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

Upon completion of the desktop study (DTS) and On Bottom Stability Assessment for the Skye-Harris route it will be possible to better identify the quantities of cable protection and stabilisation to be employed along the route.

5.5.1 Mattress Installation

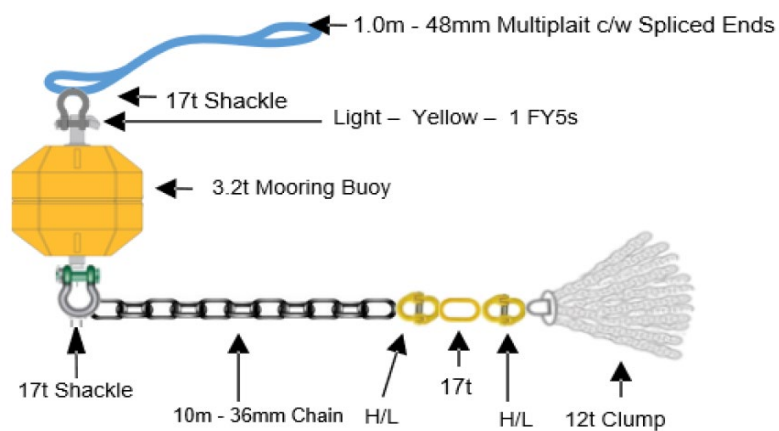
If shallow water mattress installation is required, a Multicat type vessel will carry out the installation in shallow water. During the installation in shallow water, the Multicat may need to hold position by means of clump weights. An overview of the likely clump weight arrangement is shown Figure 5-18.

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.

Figure 5-17 Concrete Mattress Deployment



Figure 5-18 Example Clump Weight Configuration



5.5.2 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 5-19). The vessel's ROV monitors the installation and detaches the crane wire from the Rock Bag once in position.

Figure 5-19 Rock Bag Lifted from Vessel (Left) and In Subsea Position (Right)



Details of a 4 tonne (Te) and 2 Te rock bag dimensions are provided in Table 5-2.

Table 5-2 Rock Bag Dimensions

Rock Bag Mass in Air (Te)	Diameter (m)	Height (m)	Area occupied on seabed (m ²)	Volume (m ³)
4	2.4	0.6	4.5	2.5
2	1.8	0.5	2.5	1.75

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.

5.5.3 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 in a similar manner to the Rock bags as described in Section 5.5.2 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.

5.5.4 Rock Placement

Rock Placement provides a means of protecting the cable from potential damage due for example, to over-trawling by fishing vessels. This method of cable protection would require graded rock to be deposited on top of the cable using a dynamic positioning (DP) vessel loaded with rock (Figure 5-20). The vessel would be equipped with a fall-pipe that would accurately deposit the required quantities of rock over sections of the cable that are unsuitable for other means of cable protection as outlined above (see Figure 5-21 below). The rock placement design profile is typically a 13.0m wide spread (6m either side of the cable centreline) with a minimum 1m depth of cover at the centreline, tapering to each side. As such the berm will be have a slope of 1:6, with allowance being made for settlement of

the rock into the seabed. Volume is approximately 7m^3 of rock per metre of cable. A typical rock berm profile is shown below in Figure 5-22 below.

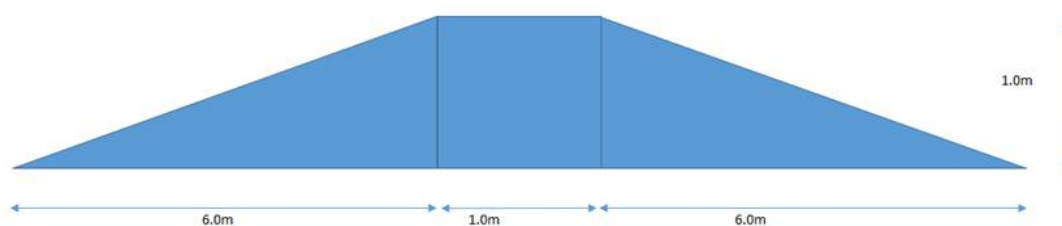
Figure 5-20 Typical Fall-pipe Vessel with hoppers



Figure 5-21 Rock placement installation



Figure 5-22 Typical rock berm profile



5.5.5 Articulated Pipe Installation

The cable protection strategy includes the installation of cast-iron articulated pipe. Generally, this is installed following the cable pull-in operations by divers or from the CLV, or by a combination of both methods. This protects the cable in the nearshore and intertidal section of the cable route.

See the cable protection and stabilisation plan detailed in Table 4-1 for the length of anticipated articulated pipe installation. An example articulated pipe installation is shown in Figure 5-23, with Table 5-3 detailing the technical specifications of the split pipe to be used.

Figure 5-23 Example Articulated Pipe Installation



Table 5-3 Articulated pipe dimensions

Total length per unit	Maximum outer diameter	Weight per metre	Worst-case total length
390mm	263mm	59.8kg/m	567m (With 20% contingency)

5.6 Post-Lay Trenching

The cable protection strategy includes 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), see Table 5-3 for an overview of burial tool specifications. During burial operations, the environmental conditions (wind, wave, current etc.) will be monitored by the crew on board the Trenching vessel. It is anticipated that the Q1400 Trenching ROV will be utilised for trenching operations. An overview of the hybrid cutting tool is shown in Figures 5-24, 25 and 26.

Table 5-4 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 5-24 Hybrid Cutting Boom Side View

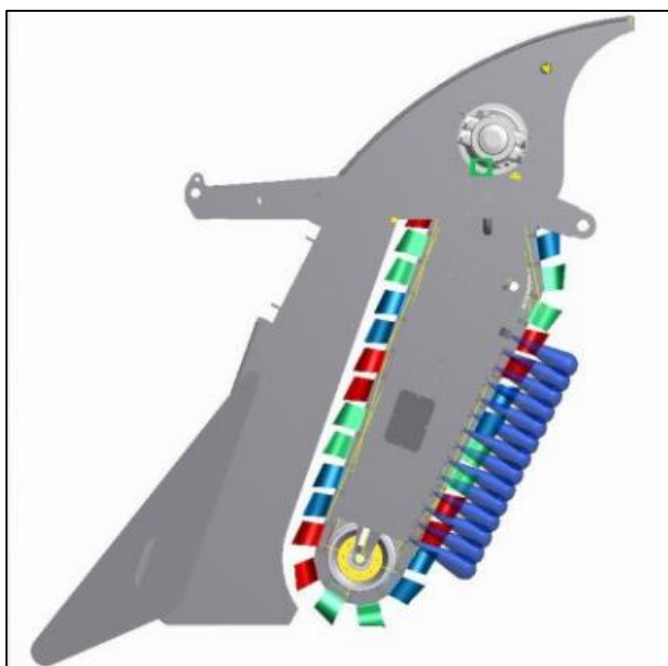


Figure 5-25 Hybrid Cutting Boom Front View

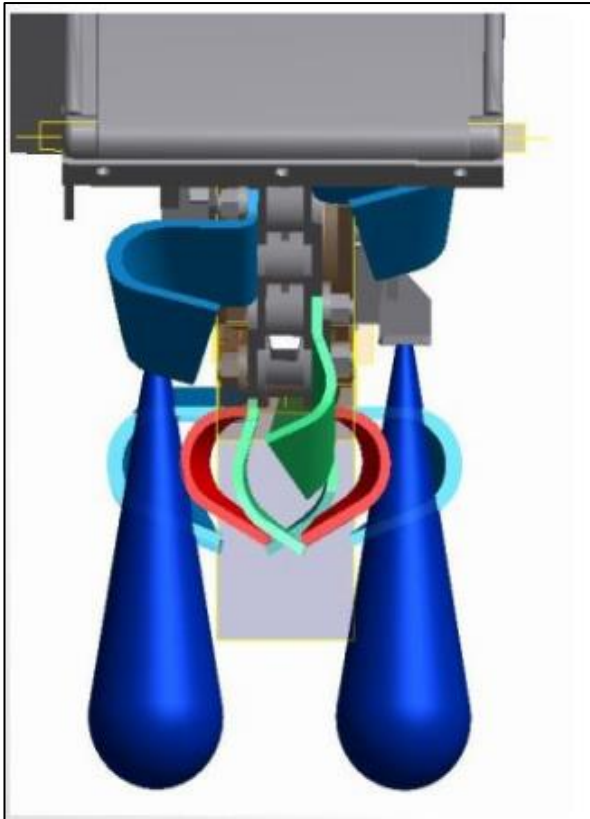
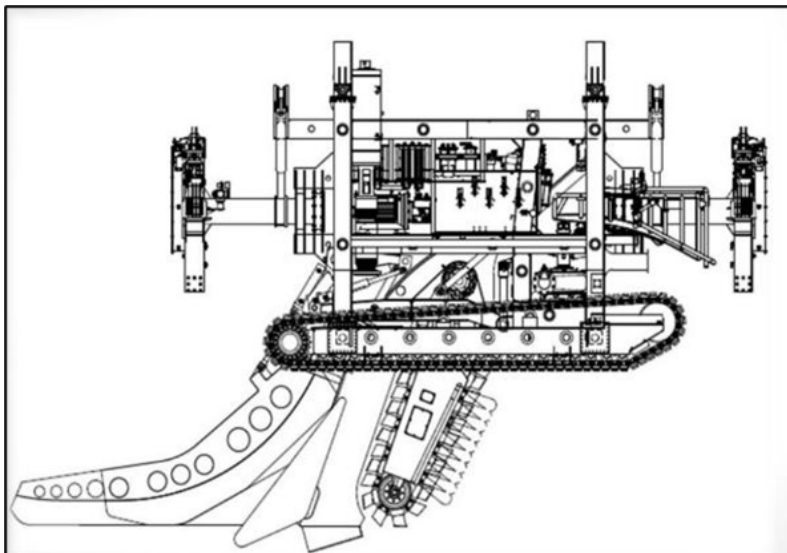


Figure 5-26 Hybrid Cutting Skid Assembly



5.7 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, articulated pipe etc.).

5.8 Decommissioning

5.8.1 Removal of OoS cable at Harris

The existing Out of Service (OoS) marine and land cable sections will be identified and marked with flags or other suitable means down to MLWS. An excavator will be used to remove the soil covering the cable, until the cable is fully exposed. The section of cable in the intertidal area will be accessed during low tide. Once the cable is exposed, the cut location will be agreed, and the cable cut with the aid of a stihl saw and/or Halmotro cutting tool. These tools will also then be used to cut both the marine and land cable in short sections so that it can be removed from the trench. The cut sections of cable will be bundled together for ease of handling and so that they can be moved into temporary storage and later removed from site. A Waste Transfer Note (WTN) will be raised to remove materials from site and they will be disposed of according to the regulations set out by the Scottish Environment Protection Agency (SEPA). Split pipe sections will be either secured to the cable or removed and stored separately, always ensuring they do not constitute a hazard for the workforce during handling of cable sections. The old trench profile may be used to facilitate the new cable installation following an onsite assessment.

5.8.2 Removal of OoS cable at Skye

A new marine cable landing point is proposed at Skye which is separate to the landing point for the existing OoS cable. The existing land section of the cable extends for over 350m from the landing point to the substation following the tidal line. It is proposed that in the final section (approaching the substation) that replacement cable will re-use the existing cable trench. Note the marine licence application only covers the section of the replacement cable below MHWS. For most of the length, the existing OoS cable is located close to the in service and energised Skye-South Uist cable. For this reason, the majority of the OoS land cable will be left in place and only the section of the cable from MLWS to the TJP and the section of land cable closest to the substation boundaries will be removed. Removal methodology will be similar to that outlined for the Harris cable in Section 5.8.1, with the difference that the excavation in the locations closest to the in-service cable will be carried out to a maximum of 6m proximity to avoid any risk of damage to the energised cable and any risk of harm to personnel. The OoS cable will be de-buried and cut into sections for temporary storage and later removal.

APPENDIX A

Route Overview Chart

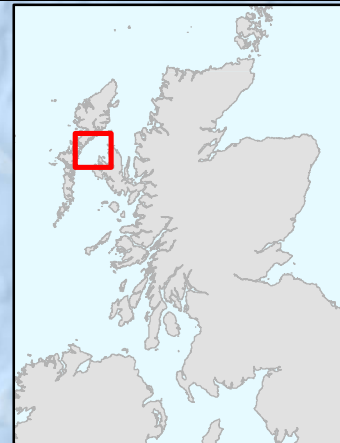
SKYE - HARRIS SUBSEA CABLE REPLACEMENT

LOCATION - Route Overview

Drawing No: P2446-LOC-001 | A

Legend

- ▲ Harris Pole
- ▲ Skye Substation
- KP
- Indicative Cable Route
- Application Corridor



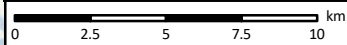
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Projection: Transverse Mercator
Datum: WGS 1984



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