Scottish and Southern Electricity Networks (SSEN)

Aultbea to Ullapool Network Upgrade: Loch Broom Subsea Cable Installation

Project Description

ASSIGNMENT A303128-S02
DOCUMENT A-303128-S02-A-REPT-001

XODUS

Orkney

8 Garson Place
Stromness . Orkney
KW16 3EE . UK

T +44 (0)1856 851451
E eric.grieve@xodusgroup.com

www.xodusgroup.com

REVISIONS & APPROVALS

This report has been prepared by Xodus Group exclusively for the benefit and use of Scottish and Southern Energy plc. Xodus Group expressly disclaims any and all liability to third parties (parties or persons other than Scottish and Southern Energy plc) which may be based on this report.

The information contained in this report is strictly confidential and intended only for the use of Scottish and Southern Energy plc. This report shall not be reproduced, distributed, quoted or made available – in whole or in part – to any third party other than for the purpose for which it was originally produced without the prior written consent of Xodus Group.

The authenticity, completeness and accuracy of any information provided to Xodus Group in relation to this report has not been independently verified. No representation or warranty express or implied, is or will be made in relation to, and no responsibility or liability will be accepted by Xodus Group as to or in relation to, the accuracy or completeness of this report. Xodus Group expressly disclaims any and all liability which may be based on such information, errors therein or omissions therefrom.

A03	08/06/2022	Re-issued for Client Use	EC	EG	EG	-
A02	27/05/2022	Issued for Client Use	EC	EG	EG	-
A01	12/05/2022	Issued for Client Use	EC	JA	JA	-
R01	13/04/2022	Issued for Client Review	EC	EG	JA	-
REV	**DATE**	**DESCRIPTION**	**ISSUED**	**CHECKED**	**APPROVED**	**CLIENT**

CONTENTS

ABBREVIATIONS

ABBREVIATION	DEFINITION
ALARP	As Low as Reasonably Practicable
BMC	Briggs Marine Contractors
CBA	Cost Benefit Analysis
CLV	Cable Lay Vessel
DP	Dynamic Positioning
DSV	Dive Support Vessel
ft	Feet
HDPE	High Density Polyethylene
kg	Kilograms
kg/m	Kilograms per Metre
km	Kilometre
km/hr	Kilometre per Hour
kV	Kilovolts
LAT	Lowest Astronomical Tide
m	Metre
m^2	Metres Squared
m^3	Metres Cubed
MBES	Multi-Beam Echo-Sounder
MCA	Marine Coastguard Agency
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
mm	Millimetres
mm^2	Millimetres Squared
NATO	North Atlantic Treaty Organisation
PLGR	Pre-Lay Grapnel Run
PPY	Polypyrrole
ROV	Remotely Operated Vehicle
SBP	Sub-Bottom Profiler
SHEPD	Scottish Hydro Electric Power Distribution plc
SSEN	Scottish and Southern Electricity Networks
SSS	Side-Scan Sonar
TJP	Transition Joint Pit

ABBREVIATION	DEFINITION
UK	United Kingdom
UXO	Unexploded Ordnance
WWII	World War 2
XLPE	Cross-linked polyethylene

1 INTRODUCTION

1.1 Overview

Scottish Hydro Electric Power Distribution plc (SHEPD) holds a licence under the Electricity Act 1989 for the distribution of electricity in the north of Scotland including the Islands. It has a statutory duty to provide an economic and efficient system for the distribution of electricity and to ensure that its assets are maintained to ensure a safe, secure and reliable supply to customers. As such, there is a requirement to install a new 33 kV (kilovolts) subsea power cable approximately 1.9 km long, which will tie-in with the existing network on the Ullapool side and a proposed overhead line network on the southern side of Loch Broom at Altnaharrie. The location of the proposed cable route is shown in Figure 1-1.

This document presents information relating to the installation of the Aultbea-Ullapool cable at the Loch Broom subsea crossing. The installation of this cable is required to provide an additional link and improved resilience in the power distribution networks providing supply to communities in Wester Ross. The installation activities across Loch Broom are currently planned to be undertaken between September 2022 and January 2023.

This Project Description is designed to provide a consolidated point of reference for all proposed activities. The Project Description should be read in conjunction with the following documents:

- Marine Environmental Appraisal - Aultbea to Ullapool Cable Installation (A-303128-S02-A-ESIA-001);
- Marine Licence Application (A-303128-S02-A-TECH-001)
- Basking Shark Licence (A-303128-S02-A-TECH-002)
- EPS Licence (A-303128-S02-A-TECH-003)
- Construction Environmental Management Plan (CEMP) (A-303128-S02-A-TECH-001)
- Fisheries Liaison Mitigation Action Plan (FLMAP) – Aultbea - Ullapool;
- EPS and Protected Sites and Species Risk Assessment – Aultbea to Ullapool: (70079583);
- Operation, Inspection, Maintenance and Decommissioning Strategy; and
- Cost Benefit Analysis.

Figure 1-1 Overview of Aultbea – Ullapool Loch Broom Subsea Crossing Installation Corridor

1.2 Summary 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;
- Landfall re-instatement; and
- Post-installation surveys.

1.3 Project Need

The project extends from Aultbea to Ullapool with the aim of reinforcing the 33kV Aultbea – Ullapool network. This reinforcement will serve to make Ullapool P2 compliant[1] as well as greatly enhancing the security of supply to Aultbea for the 33 kV network. As part of the project, it has been proposed to install a subsea cable section that will connect the south side of Loch Broom (Altnaharrie) to the north side of Loch Broom (Ullapool). This £9.5 million project will benefit approximately 4,500 customers in the local area.

1.4 Consideration of Alternatives

As the proposed activities will involve installing a new cable within the region of Loch Broom, the main considerations made were the route this cable would take from Aultbea to Ullapool. The following options were considered:

Option 1: Do Nothing. This was discounted as a viable option due to the network requiring to be re-enforced.

Option 2: 33kV Interconnection between Lairg and Lochinver. This option has been discounted due to it not supporting the security of supply for the Aultbea network. In addition, the expenditure and technical difficulties associated with this scheme are anticipated to be considerably greater due to the long distance of new circuit that would require construction over mountainous and difficult terrain.

Option 3: 33kV Interconnection between Aultbea and Ullapool. This is the preferred option as it provides enhanced security of supply to both Aultbea and Ullapool. The layout of the existing network means the scheme may be delivered at a reduced cost and technical difficulty when compared to Option 2. A Feasibility Study was carried out for Horizontal Directional Drilling (HDD) but was deemed unsuitable. A subsea cable lay was deemed feasible for the crossing.

Option 4: 33kV interconnection Between Aultbea and Ullapool (land route only). This option was discounted due to the poor voltage losses expected when back feeding Aultbea or Ullapool circuits via the proposed 35 km land route necessary to bypass Loch Broom. Additionally, although the unit costs associated with this option are comparable to the subsea route, experience suggests the difficult terrain will amplify expenditure drastically.

SHEPD is progressing on the basis of Option 3 as it minimises potential environmental impacts, whilst remaining technically viable and will allow SHEPD to meet their statutory requirements as the Distribution Network Operator.

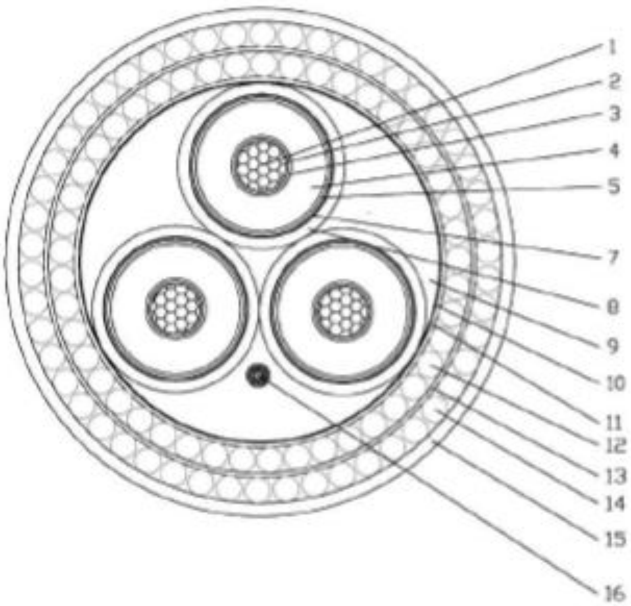
2 PROPOSED CABLE INFRASTRUCTURE

The purpose of this section is to provide a description and drawings of the proposed 33 kV submarine power cable.

[1] P2 compliant relates to the distribution network planning standard whereby it sets out the minimum levels of security of supply that distribution licensees must achieve on UK distribution networks under DCRP/18/03 – Revision of Engineering Recommendation (EREC) P2 – Security of Supply (Ofgem, 2019).

The proposed submarine cable consists of a three-core design with copper round compacted stranded conductors, XLPE insulation and copper polyethylene laminated tape, polyethylene sheath, polypyrrole (PPY), double galvanized and steel wire armour. It will also feature an integrated Fibre Optic (FO) cable consisting of a bundle of optic fibres, polyethylene sheaths, and steel armouring. The cable is rated at 33 kV with an outer diameter of approximately 133 mm and weight of approximately 30 kg/m in water. The proposed cable construction cross section is shown in Figure 2-1.

Figure 2-1 Proposed Cross Section of the XLPE Submarine Cable



1 - Copper round stranded compacted class 2 according to BS EN 60228 of nominal cross-section equal to 185 sq.mm, longitudinally water sealed. Water-blocking compound (Solarite KM-4565) is applied between the strands.

2 - Semiconductive water-blocking 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 mm nominal thickness.

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

6 - Semiconductive water-blocking tape applied with overlap.

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

8 - Sheath: High Density Polyethylene (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 two helical yellow stripes.

16 – Armoured Optical unit of 13 mm approximate diameter each one consists of a stainless steel tube (containing 48 optical single mode fibres), scPE inner sheath, galvanized steel wire armour and scPE over-sheath.

3 PREVIOUS SURVEY WORKS

SHEPD appointed a Contractor to conduct marine surveys which involved undertaking geophysical, drop-down video and benthic grab works on Loch Broom between Ullapool and Aultbea. The main objectives of the marine survey were to:

- Assess potential risks to the cable from local seabed influences including boulders, crossings, debris, freespans, trawl scars, etc; and
- Provide data that forms the basis for preliminary route engineering for the proposed cable.

These surveys were undertaken over a corridor of approximately 500m wide, within a 1.5 km buffer (to allow for survey vessel turning) as shown Figure 3-1.

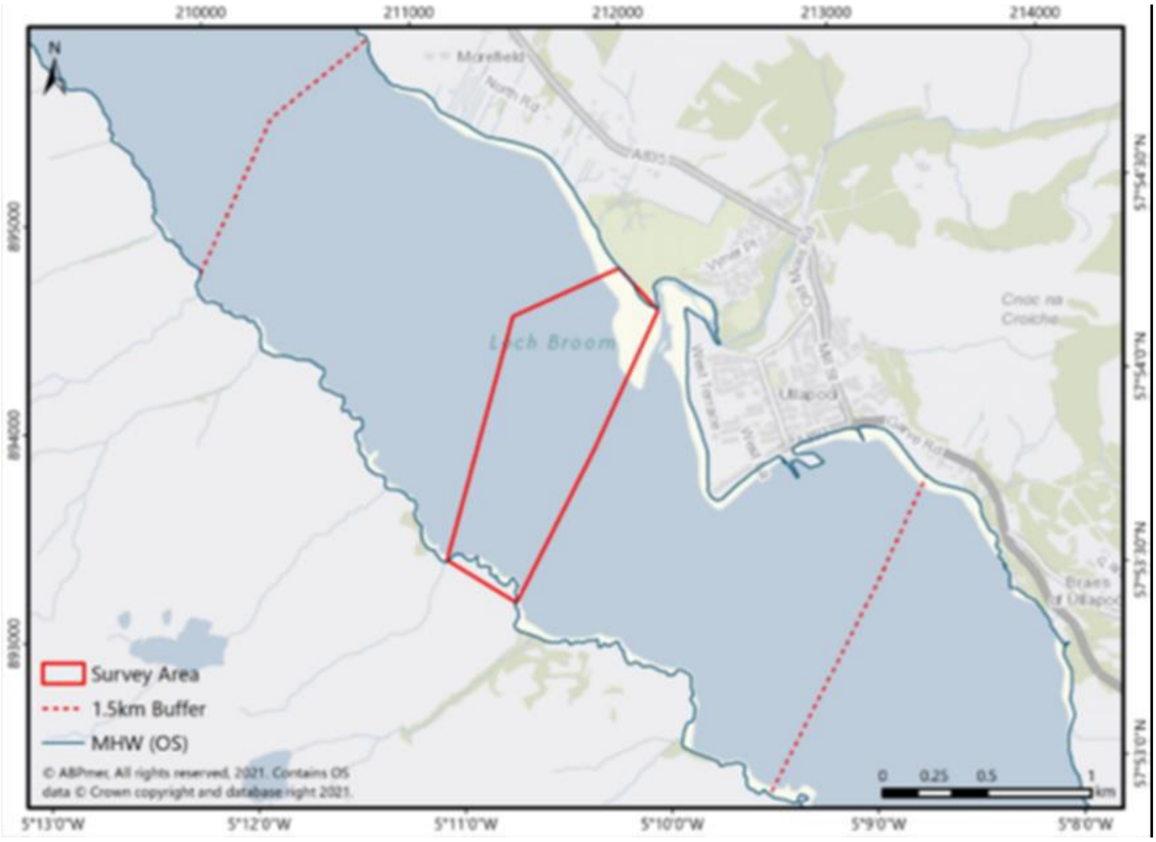


Figure 3-1 Location of Survey Area

4 PROJECT OVERVIEW

4.1 The Proposed Cable Installation Corridor

The length for the proposed cable will be approximately 1.9 km between the two transition joints, which are located inshore from the Mean High Water Spring (MHWS) limit between both landfalls. This cable length allows for obstacle avoidance during the cable lay and tolerances with the cable lay operations. Debris or obstructions will be cleared as discussed in Section 4.3.1, however, if debris/obstructions cannot be removed from the planned route, the cable will be micro-routed around them. At all times the works and final cable placement will stay within the licensed installation corridor.

The proposed cable installation corridor is shown in Figure 1-1, with landfalls located at Altnaharrie and Ullapool. The selection of the installation corridor was based on the avoidance of environmental constraints, whilst ensuring it will be technically feasible to install a cable within it, considering cable seabed stability. An assessment for seabed stability in the cable installation corridor was carried out as part of the detailed route engineering report. Seabed stability was assessed by reviewing the Side-Scan Sonar (SSS), Sub-Bottom Profiler (SBP) and Multi-Beam Echo-Sounder (MBES) survey data. The cable landing at Ullapool was heavily influenced by the practicalities of the cable installation vessel MV Elektron and where the vessel can hold station on Dynamic Positioning (DP). The proposed corridor was moved slightly north to avoid an area of cobbles and boulders identified during the survey and to maintain an agreed clearance from the navigation buoy.

The conclusions of the study based on a number of simulations suggested that sand is the most favourable for on-bottom stability and rock is the least favourable. Penetration into the sand even by a few centimetres is enough to significantly reduce lateral movement. In general, sediment cover within the corridor was found to be shallow and surficial in nature. The patches of cobbles and boulders are more significant and largely unavoidable although the corridor has been optimised as much as possible.

4.2 Vessels

4.2.1 Cable Lay Vessel (CLV)

The MV Elektron (shown in Figure 4-1) or a similar vessel will be the main CLV for this project. MV Elektron is a specialist CLV that was built in 2008. She is a DP2 class vessel so is able to hold station using her thrusters, without the need for anchoring. The specifications for this vessel are detailed in Table 4-1.

Figure 4-1 Image of the MV Elektron

Table 4-1 MV Elektron - Key Information

ITEM	DESCRIPTION
Gross Tonnage	3,438
Dimension – Length	87 m
Dimension – Beam	18 m

4.2.2 Dive Support Vessel (DSV)

The Forth Warrior (shown in Figure 4-2) or a similar vessel will be used as the DSV for this project and will help in conducting Pre-Lay Grapnel Run (PLGR) if there is a requirement for PLGR. Forth Warrior is a general utility vessel which is sailing under the flag of the United Kingdom (UK). The specifications for this vessel are detailed in Table 4-2.

Figure 4-2 Image of the Forth Warrior

Table 4-2 Forth Warrior - Key Information

ITEM	DESCRIPTION
Gross Tonnage	296
Dimension – Length	27
Dimension – Beam	12

Station Keeping

If the Forth Warrior is used, this vessel may be able stay on location using DP, although not during diving operations where she will use her spud legs. Similar vessels such as the Forth Jouster and/or Forth Drummer do not have DP capabilities, and as such, spud legs are proposed to be utilised for these particular vessels if they are required. It is most likely that the DSV will be one of Forth Drummer, Forth Jouster or Forth Warrior, however, included below in Table 4-3 are some spud leg dimensions of some larger vessel in the instance that these are required instead of the vessel described above.

Due to the differing length of the spud legs and the approximate 5 m tidal range at Ullapool, depth limits for each vessel in flat calm conditions are also noted in Table 4-3.

The exact number of spud placements on the seabed is hard to calculate for the following reasons:

- Weather may interrupt a period of work, so multiple days of spudding may be required for a single task;
- Vessel may not achieve good seabed hold on first attempt so may need to repeat spudding down; and

- Once in position, vessel may need to change heading, therefore would require to-lift and lower at least one spud.

The number of spud cans expected to be used will be two, with the requirement of deployments dependant on various factors including weather, tidal conditions and heading changes. Therefore, the total number of deployments is unable to be predicted. However, it is proposed that the spud cans will only be deployed within two designated spud legs 'boxes' as shown in Figure 4-3. The area of the Altnaharrie cable works spud area is approximately 0.0254 km^2 and the Ullapool cable works spud area will be 0.0361 km^2. It is key to noted that the overall area covered by these boxes will not be impacted by the spud legs, rather only a relatively small fraction of these area will be disturbed by the deployment of the spud legs.

Table 4-3 Spud Leg Parameters and Working Limits

VESSEL	SPUD DIAMETER	DEPTH LIMIT (LAT)
Forth Warrior	610 mm with spiked tip	<13 m
Forth Jouster	610 mm with spiked tip	<13 m
Forth Drummer	508 mm with spiked tip	<10 m
Forth Guardsman	914 mm with spiked tip	<12 m
Harry McGill	914 mm with spiked tip	<14 m
Forth Atlas	914 mm with spiked tip	<15 m

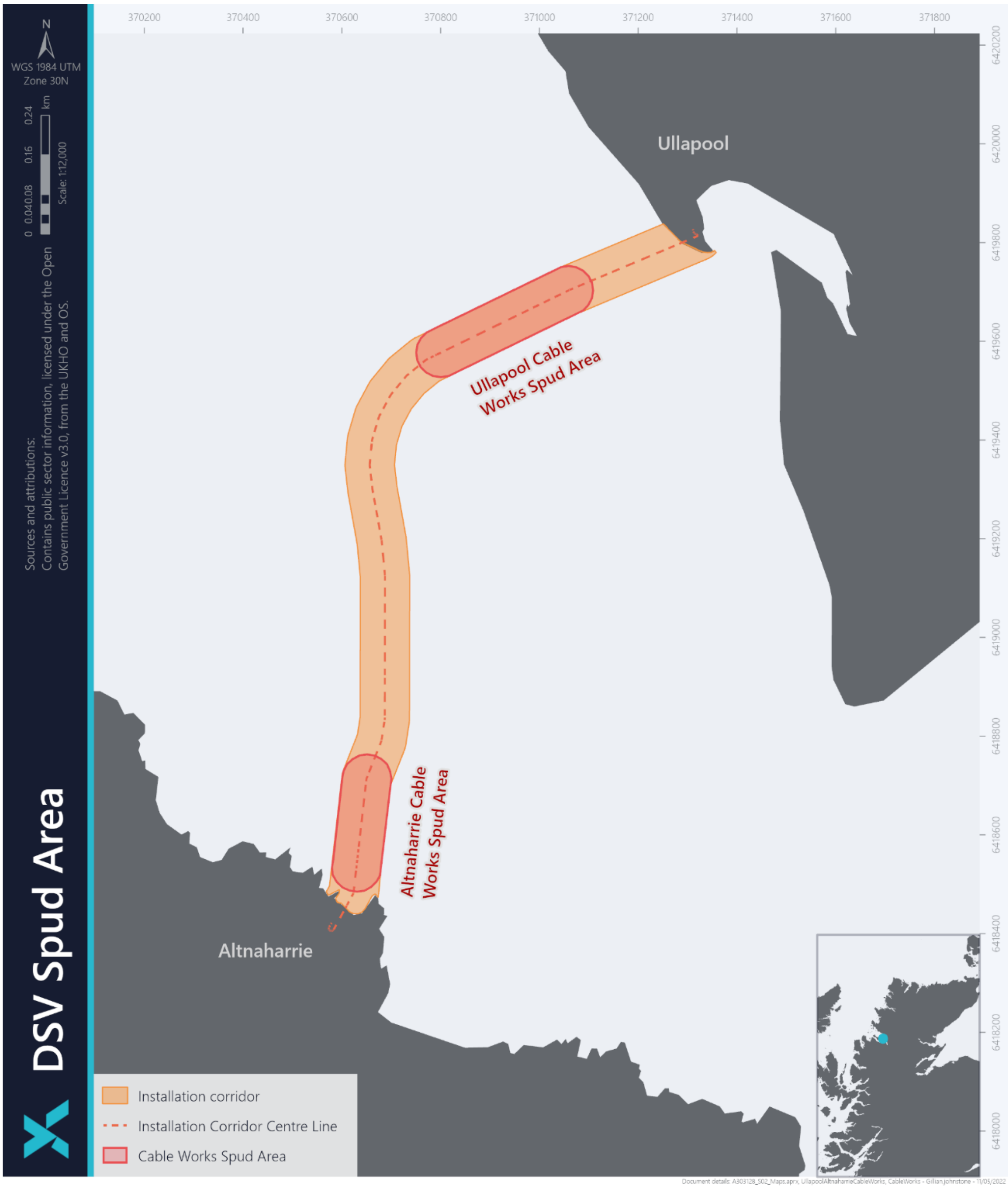


Figure 4-3 Spud Leg Placements Locations within the Installation Corridor

4.2.3 Other Support Vessels

The Celtic Guardian Figure 4-4 or a similar vessel will be used in order to provide general support the installation activities. Celtic Guardian is a general purpose inshore vessel and is sailing under the flag of the UK. The specifications for the Celtic Guardian vessel are detailed in Table 4-4.

Table 4-4 Celtic Guardian - Key Information

ITEM	DESCRIPTION
Dimension – Length	14
Dimension – Beam	4

4.3 Pre-Installation Activities

4.3.1 Pre-Installation Survey

Before cable installation commences, a pre-installation survey will be conducted using a Remotely Operated Vehicle (ROV) to assess seabed conditions and the presence of debris. Survey operations will likely be conducted from a small vessel, such as the Celtic Guardian before the CLV arrives. The objectives of the survey will be to:

- Identify and investigate possible debris; and
- Identify any obstructions within the installation corridor.

During installation a similar survey spread may also be utilised to monitor the installation process. Alternatively, an ROV may be deployed from the CLV or other support vessel and operate touchdown monitoring and ROV surveys from this platform. The below ROV and survey equipment are examples of the type of equipment that will be used-exact models may vary, however, all equipment used will fall within the requirements set out within the EPS/BS Licenses provided by SSEN. Table 4-5 also summarises details of other survey equipment which may be used in the proposed cable installation activities.

Figure 4-4 shows an example of an ROV survey vessel which could be used.

Figure 4-4 (1) Example of Possible Survey Vessel and (2) Example ROV

Table 4-5 Examples of Proposed Survey Equipment

SYSTEM / SURVEY EQUIPMENT	DESCRIPTION
Geophysical Survey	
Ultra-Short Baseline (USBL)	USBL systems are used to determine the position of subsea survey items, including ROVs, towed devices, grab samplers, etc. This involves the emission of sound from a vessel-mounted transducer to a subsea transponder, thereby introducing sound into the marine environment. A USBL system consists of a transducer, which is mounted on the vessel and a transponder attached to the ROV. The transducer transmits acoustics through the water and the transponder sends a response which is detected by the transducer. The USBL calculates the bearing and time taken for the transmissions to be completed and thus the position of the subsea equipment is determined. These systems can either be used continuously or intermittently through the operation they are supporting.
Multi-beam echosounder (MBES)	Multi-beam echo-sounders are used to obtain detailed 3-dimensional (3D) maps of the seafloor which show water depths. They measure water depth by recording the two-way travel time of a high frequency pulse emitted by a transducer. The beams produce a fanned arc composed of individual beams (also known as a swathe). Multi-beam echo-sounders can, typically, carry out 200 or more simultaneous measurements.
Sidescan Sonar (SSS)	Side-scan sonar is used to generate an accurate image of the seabed, which may include 3D imagery. An acoustic beam is used to obtain an accurate image of a narrow area of seabed to either side of the instrument by measuring the amplitude of back-scattered return signals. The instrument can either be towed behind a ship at a specified depth or mounted on to a ROV. The frequencies used by side-scan sonar are generally very high and outside of the main hearing range of all marine species (NOAA, 2018). The higher frequency systems provide higher resolution but shorter-range measurements.
Seabed Imagery	
Hi-Resolution Camera	An ROV mounted camera will be utilised to acquire imagery of the cable and adjacent seabed.

4.3.2 Pre-Lay Debris Removal

Any obstructions or debris identified during the surveys which cannot be avoided will be removed, if possible. This will be achieved by conducting a PLGR in order to remove debris from the proposed installation corridor.

The PLGR will aid to clear the installation corridor of debris such as cables, chains, wires, ropes, and fishing gear. It should be noted that there are no in or out of service cables within the installation corridor. Therefore, it is expected that this activity will be completed shortly in advance of the cable installation activities to ensure that the installation corridor remains free of debris prior to installation.

When on site, the vessel will manoeuvre into the start position and overboard the appropriate grapnels for the reported seabed conditions. When in position, the vessel will proceed along the designated cable route at a speed of 1 km/hr. Tow tensions will be monitored during the PLGR, if a steady increase in tow tension is observed, the vessel will be brought to a stop, and the grapnels recovered to deck. Debris will be cleared from the grapnels and stored onboard the vessel, before redeploying and resuming the PLGR. All recovered debris will be taken ashore and sent for appropriate recycling or disposal at a licenced waste handling facility. Typical grapnel trains are shown below in Figure 4-5 and Figure 4-6.

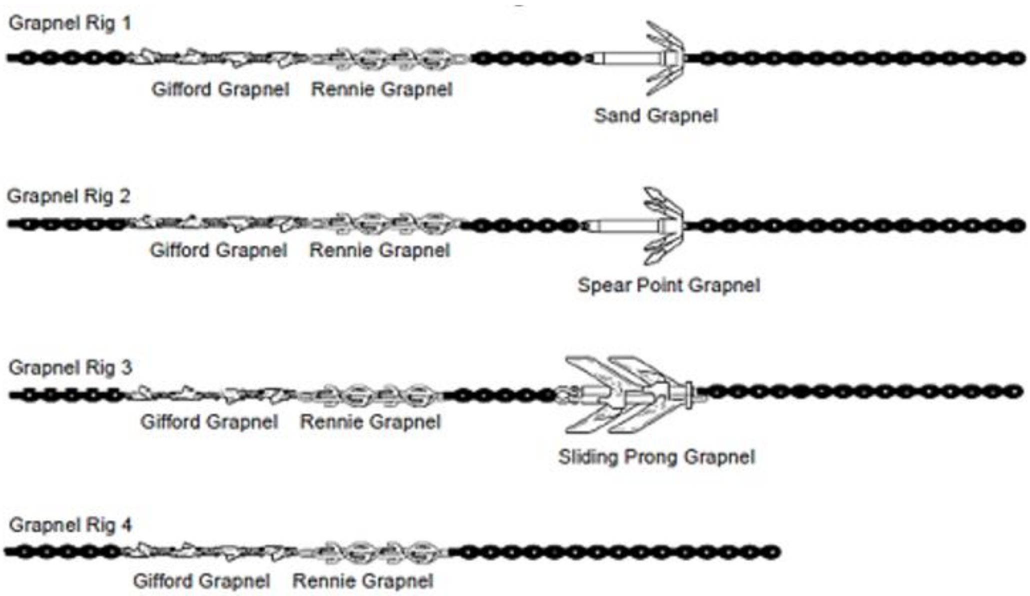


Figure 4-5 Typical Grapnel Trains

Figure 4-6 Grapnels and Chain at Stern Roller of Vessel

If required in the intertidal areas, debris removal is likely to be conducted at low water, when the area is exposed, either by hand or using mechanic plant depending on the size and nature of the debris. It is possible that a diver may be required to remove debris if tidal working from shore is not possible.

4.4 Installation Methods – Intertidal

4.4.1 Open Cut trench (OCT)

In the intertidal areas, the cable will be buried at both landfalls using an OCT method, from MHWS down to the MLWS (refer to Figure 4-7 as an example of this method). This will be conducted using conventional land-based excavators working tidally, e.g. when the intertidal area is exposed, avoiding works below the waterline. Temporary shoring, such as trench boxes, may be required to prevent the collapse of trench walls. The excavated material will be placed to one side of the trench and stored for later reinstatement. An outline of the location for the general working area at the Ullapool landfall is provided in Figure 4-8 and Altnaharrie landfall in Figure 4-9.

The width of the trench is expected to be approximately 1 m, however this may be increased depending on the stability of the soils. The target depth will be to the top of the cable at approximately 800 mm below ground level, depending on sub surface sediment makeup. A rock pecker may be utilised to achieve burial depth where the sub-surface is rocky. Alternatively, additional split pipe may be utilised on sections where burial depth cannot be practicably achieved.

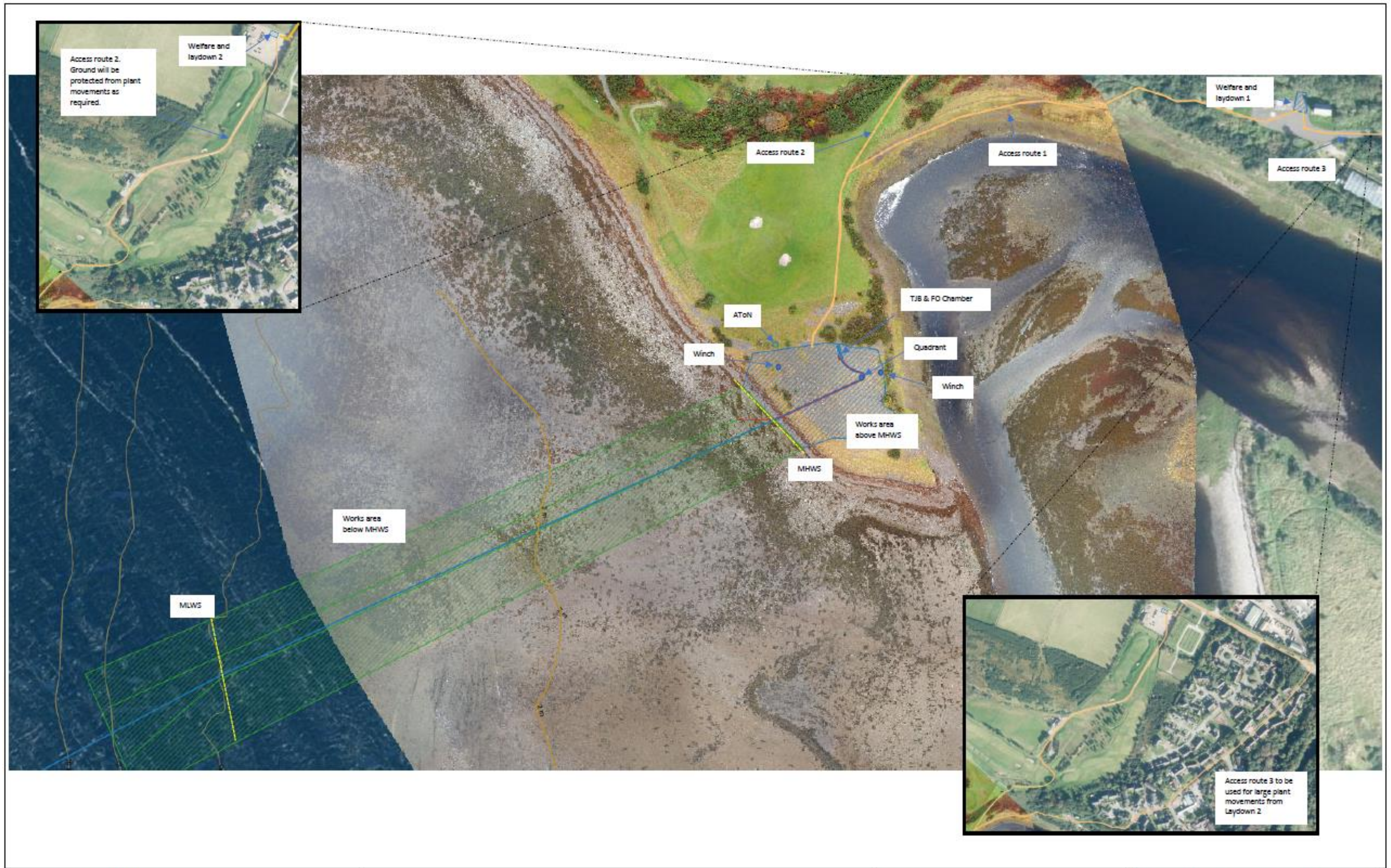
Two trenches will be required at each landfall: one for the subsea cable and the armour earth, another for the fibre optic earth. It is anticipated that a 20 m wide working corridor will be required for each trench, accounting for the footprint of the excavator and the temporary storage of excavated material. Table 4-6 details the requirements for the trenching activities.

On completion of OCT activities and installation of the cables, the trenches will be backfilled using the original excavated materials to reinstate the intertidal area.

Table 4-6 OCT Trench Requirements

LOCATION	TRENCH PURPOSE	WORST-CASE BURIAL LENGTH REQUIRED UP TO 50 M PAST MHWS (M)*	TARGET DEPTH, TOP OF CABLE (MM)
Working corridor for all OCT is 20 m Wide			
Ullapool MHWS to 50 m past MLWS	Cable + earth	333	800
	FO earth	333	600
Altnaharrie MHWS to 50 m past MLWS	Cable + earth	90	800
	FO earth	90	600
TOTAL		846	N/A
*A 10% contingency has been applied to these values to represent the worst-case			

Figure 4-7 Example of OCT Cable Burial



Title	Ullapool Landfall	
Drawing No	CB0218-DWG007	Revision 4
Project	CB0218 Ullapool Aultbea	

Briggs

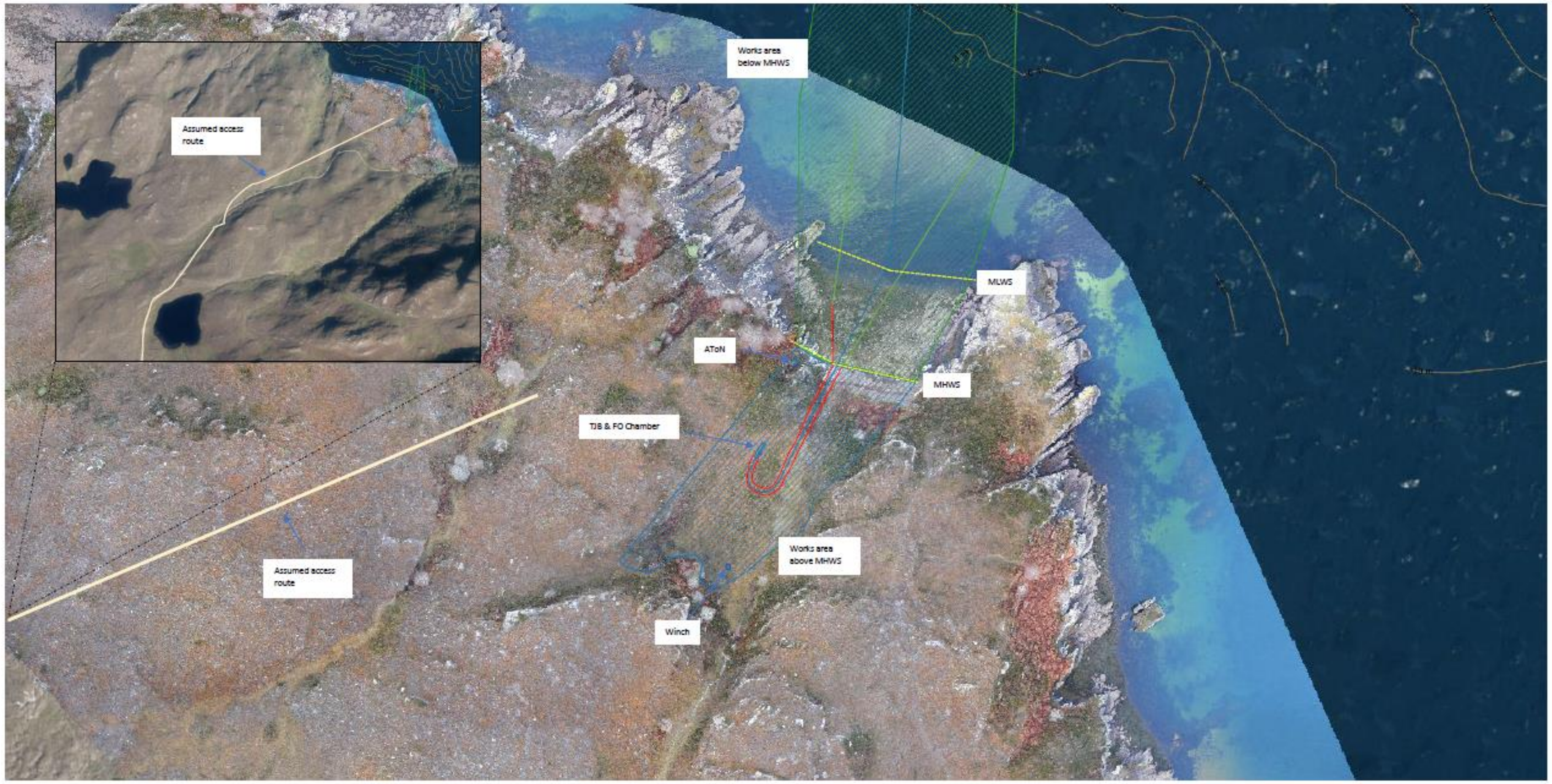
Scottish & Southern Electricity Networks

Do not scale.
Dimensions as labelled.
Not to scale.

All intellectual property rights in this drawing are property of Briggs Marine Contractors Ltd. No copy is to be made without the written permission of Briggs Marine Contractors Ltd. Any patent applications and/or design applications, registered design or copyright arising from or contained in this drawing and its designs are the property of Briggs Marine Contractors and all information must be held in the strictest confidence.

Rev.	Description	Date	Drawn	Check
1	First revision	15/02/22	MB	SG
2	SSEN comments	11/03/22	MB	SG
3	Added access route 3	21/03/22	MB	SG
4	RPL Update	08/04/22	MB	SG

Figure 4-8 Landfall General Working Area at Ullapool



Notes:

Where road access required, BMC will utilise infrastructure installed by SSEN Region.

BMC welfare and laydown will be contained within "work area above MHWS".

Title	Altnaharrie Landfall	
Drawing No	CB0218-DWG008	Revision: 2
Project	CB0218 Ullapool Aultbea	

Do not scale.
Dimensions as labelled.
Not to scale.

All intellectual property rights in this drawing are property of Briggs Marine Contractors Ltd. No copy is to be made without the written permission of Briggs Marine Contractors Ltd. Any patent applications and/or design applications, registered design or copyright arising from or contained in this drawing and its designs are the property of Briggs Marine Contractors and all information must be held in the strictest confidence.

Rev.	Description	Date	Drawn	Check
1	First revision	15/02/22	MB	SG
2	SSEN comments	11/03/22	MB	SG

Figure 4-9 Landfall General Working Area at Altnaharrie

4.4.2 Cable Pull-In

Winches will be mobilised to the landfall areas in order to facilitate pulling the cables ashore. These winches will be located onshore above the MHWS. A combination of rollers (Figure 4-10) and quadrants (Figure 4-11) are used to ensure the cable isn't damaged and follows the correct alignment during the pull-in process through the intertidal area. Rollers support the cable and reduce friction, while quadrants are used to facilitate changes in direction. They can either be held in position using land plate anchors or anchored on an excavator. The rollers and quadrants are temporary aids to installation, and will be removed entirely following the completion of the pull-ins.

Figure 4-10 Example Images of Rollers

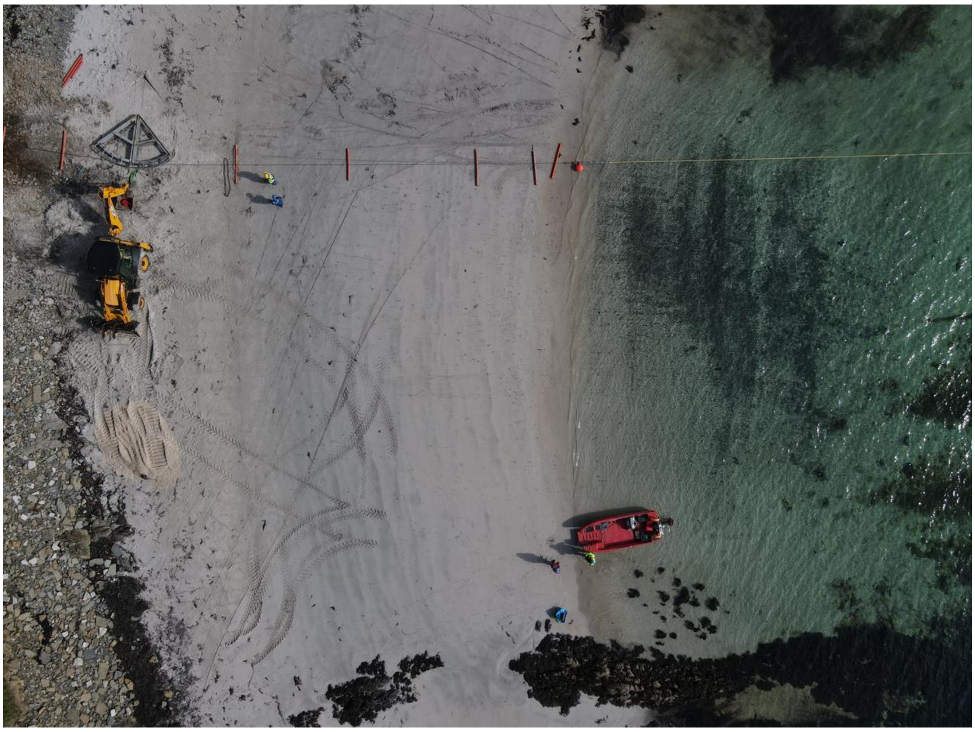


Figure 4-11 Example Image of Rollers and Quadrants

The first end (Ullapool) cable pull in will be conducted on a rising tide due to the long length of the intertidal area. A messenger wire will be taken ashore from the cable lay vessel by small craft and connected to the shore winch wire at low water. The mooring line and winch wire will be pulled back to CLV and connected to the cable end. The shore winch will then pull the cable ashore with floats being attached to the cable on CLV and removed as the cable reaches low water. The cable will then travel through the intertidal area, through the rollers and quadrants until it reaches the TJP where it is secured. At this point, any remaining cable floats can be removed from shore towards the CLV, completing the pull-in operation.

At the second end (Altnaharrie) the pull-in will be achieved using a floating bight of cable. On approach to the second end, floats will be connected to the cable while support craft ensure the cable is held securely within its design limits until CLV has paid out enough floating cable to reach the TJP, such that the cable can be cut and sealed. Once this is done, a messenger wire will be sent ashore from the CLV and connected to the shore winch wire. As with the first end, this will be pulled back to CLV and connected to the cable end. Once connected, the shore winch will pull the cable end towards shore. During this phase, support craft will manipulate the floating cable bight, within its limits, to ensure that the cable end pulls directly to shore and the cable is pulled straight. Once the cable end reaches the shore winch, the initial pull is completed. Now floats are removed from CLV towards shore, with the shore winch pulling in any slack that is created to complete the installation.

4.5 Installation Methods – Subtidal

4.5.1 Cable Laying

The cable will be surface laid along the entire length of the subtidal section of the installation corridor (MLWS-MLWS), this will be achieved by using a CLV. Smaller support vessels may also be used in the shallower shore locations.

There will also be a DSV that may utilise spud legs to hold station in the nearshore area (refer to Section 4.2), and a guard vessel may be required during the cable lay operations in order to ensure other vessels remain outside the area of operations to reduce collision risk.

The reason for surface laying the proposed cable is that the proposed installation corridor does not have good burial potential along majority of its length, and an area of rock needs to be crossed during the cable installation. Furthermore, there is an intertidal area at the Ullapool landfall that stretches out to 250 m. In areas where there is unavoidable rock or limited burial potential, further cable protection will be required as discussed in Section 4.5.2.

For pull-in operations, the DSV and CLV will be positioned at the first end work site. The CLV will then prepare for cable operations, remaining stationary on DP while laying out the cable. The cable will float towards land, with the shore team maintaining tension on the pull-in wire. As the cable comes ashore, cable floats are removed before the cable passes through a series of quadrants and rollers towards the TJP. Shore pull will continue until the cable end reaches the TJP. Once the pull in is complete, the CLV is set up and catenary established to the sunken cable, the cable lay can commence. The vessel shall then proceed to lay the cable as it moves away from the landfall. An example of a cable being pulled to shore in shown in Figure 4-12. Touchdown monitoring will be conducted using an ROV deployed from the CLV or other support vessel and will monitor the lay parameters during the installation.

Once the CLV reaches the other landfall, a similar process is conducted to pull the cable ashore and complete the cable laying operations, further detail is provided in Section 4.4.2.

Figure 4-12 Example of Cable being Pulled to Shore

4.5.2 Diver Dredging

SHEPD propose to bury the cable from TJP to MLWS using open cut trench by excavator after the installation of the cable has been completed. At the Ullapool landfall, trenching and burial will take place to MLWS and split pipe is planned for 50 m above and 50 m below MLWS. At the Altnaharrie landfall, split pipe and trenching will take place in the intertidal zone with no burial below MLWS.

There is the potential that a limited section of the cable at the Ullapool landfall is buried below MLWS. If required, this would be conducted using a diver operated dredge pump, as depicted in Figure 4-13. This system allows targeted removal of sediment from below the installed cable. As sediment is removed, the cable will gradually lower into the narrow trench that has been excavated below.

Due to the steep seabed beyond MLWS at Ullapool, it is not expected that more than 250 m of burial could be achieved by divers as the DSV would need to be on spud legs, which will likely be limited to approximately 10 m Lowest Astronomical Tide (LAT).

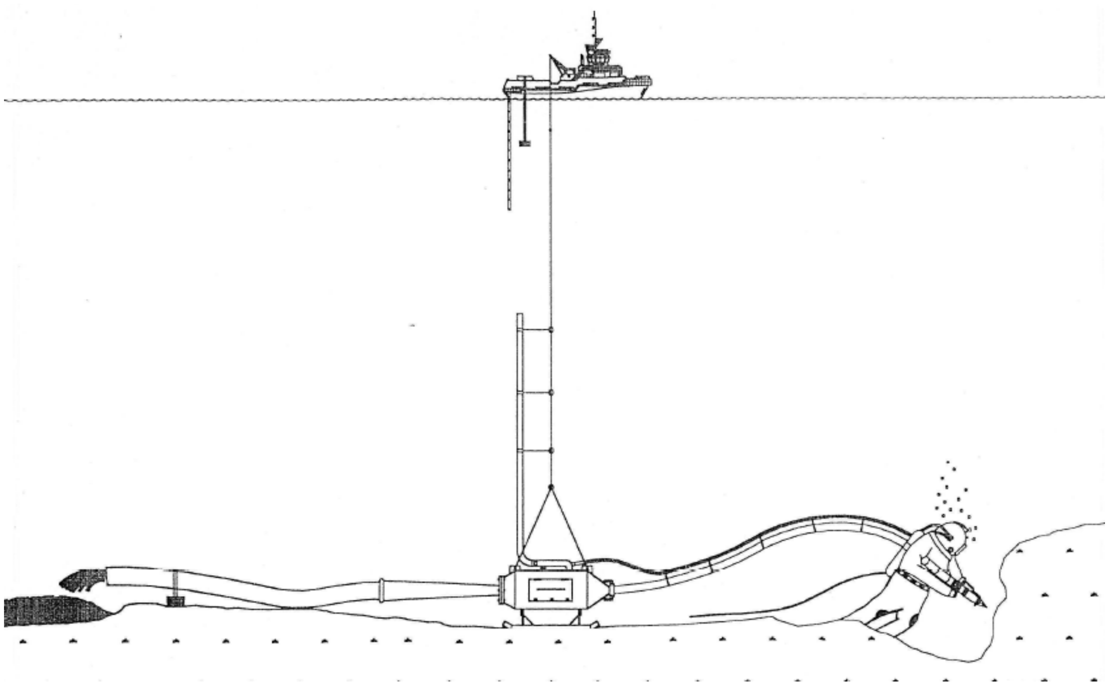


Figure 4-13 Diver Dredge In-Use

4.6 Cable Protection Methods

The proposed operations will involve the protection methods of split pipe and sea earths. Section 4.6.1 through to 4.6.3 provides further details on these proposed cable protection methods.

4.6.1 Split Pipe

Articulated pipe (also referred to as split pipe) is commonly used on cable shore ends and beach landings. It consists of a series of approximately 0.5 m long half pipe sections of iron which clamp around the cable and also interlock, providing mechanical protection, a flexible connection and bend restriction. Various types of split pipe are available, but most typically have an external diameter of approximately 260 mm.

Split pipe can be applied during the installation of a shore end, being fitted on the CLV whilst the cable is being paid out or retrofitted at low tide or by divers subsea. In this instance, it is likely that the articulated pipe will be retrofitted. Additional protection afforded by articulated split pipe has been incorporated into the route engineering with respect to the Altnaharrie landfall and out to include the area rocky outcrops.

On either shore above the MLWS limit, where sufficient cable burial cannot be achieved, split pipe will be fitted around the cable for additional protection in the event of exposure.

An example of a split pipe diagram is shown in Figure 4-14 and installation method in Figure 4-15.

Figure 4-14 Split Pipe Example

Figure 4-15 Example Split Pipe Installation

The split pipe will be installed in the following areas by the methods outlined below, with a summary provided in Table 4-7:

- Ullapool MHWS – MLWS: the base case is to install 100 m of split pipe, extending 50 m above and below MLWS, however there is the potential that it may be required to extend from 50 m below MLWS to MHWS. It is likely that the split pipe will be installed retrospectively by personnel on foot/wading at low tide in the intertidal area, with divers being required from the DSV to install subtidal split pipe. However, consideration is being given to installing the split pipe on the CLV in advance during the pull-in operation.
- Altnaharrie MHWS - MLWS – the base case is to install 31 m of split pipe which is most likely to be installed by personnel on foot/wadding at low tide after the cable has been installed.
- Altnaharrie MLWS to offshore end of rocky seabed – the base case is to install 74 m of split pipe which will be installed by divers after the second end has been floated ashore. The purpose of this section of split pipe is to protect the cable in an area of wave action on hard seabed and to provide provision of extra weight to the cable, thus making it more stable across the hard seabed.

Table 4-7 Split Pipe Requirements

SITE LOCATION	TIDAL LOCATION	BASE CASE (M)	WORST-CASE UP TO MHWS (M)
Ullapool	MLWS +/- 50 m	100	302
Altnaharrie	MHWS to MLWS	31	31
Altnaharrie	MLWS to offshore end of rocky seabed	74	74
	TOTAL	205	407
	TOTAL (+ 10% Contingency)	226	448

4.6.2 Sea Earths

Sea Earths will also be installed in order to provide protection from surges and lightning strikes to the electrical circuit. It is expected that two earthing cables will be required at each shore end using stainless steel cables with a cross sectional diameter of 95 mm^2. One cable will earth the armour of the HVAC cable system, while the other provides an earth for the fibre optic armour (integral to the HVAC cable system (refer to Figure 2-1).

Below MHWS, the earth wire will be installed in a separate trench with a minimum separation of 10 m. The working corridor will be 20 m either side of each trench (10 m either side of the cable). This will still be inside the consented corridor as defined by SSEN. By utilising an excavator, the trench will be excavated using the same method employed for the subsea cable, as detailed in Section 4.4.1.

Clump Weights

Concrete clump weights may be used to anchor the sea earths at intervals/at their termination subsea. It is most likely that these would be used more on the Ullapool landfall than Altnaharrie due to the sediment types. If used intertidally, they would be completely buried along with the sea earth. In the subsea section (max 50 m beyond LAT), the earth would be on the seabed surface while the clump weight would be buried to provide best anchoring.

Rock Anchors

Rock anchors for the subsea earth are more likely to be used on the Altnaharrie landfall, in lieu of clump weights, as it is understood to be a harder seabed with less sediment cover. In instances where rock anchors are required, a diver would drill a hole in the rock (max 20 mm diameter, 200 mm depth) and insert a small volume of marine grade resin and a stainless steel anchor.

4.6.3 Rock Bag and Mattress Requirements

Rock bags and concrete mattresses are not expected to be required; however, they have been included as contingency in case they are required to increase cable stability on the seabed.

Rock Bags

If rock bags were to be used, they would be installed below 8 m LAT and within 3 m either side of the installed cable. The 8 m below LAT is derived by ensuring that the navigable water depth has not been reduced by >5%; the rock bags are 400 mm tall when installed. Should there be a potential requirement to install rock bags in < 8 m LAT then consultation would be undertaken with the Marine Coastguard Agency (MCA) and other navigation interests to obtain their approval. An example image of 2 tonnes rock bags is provided in Figure 4-16.

The rock bags used will be 2 tonnes, with the associated dimensions of these deposits having a diameter of 2.2 m. Rock bags would potentially be positioned on top of the cable and/or on either side of it. The potential numbers required in the event of contingency is 60 rock bags which equates to a total of 120 tonnes collectively. The formation of rock bag installation would typically be 1 either side and 1 on top (3 total) at required intervals to maintain cable on-bottom stability.

Installation of rocks bags would either be from the CLV deck, a separate large construction vessel with ROV, or multicat vessel. Trips to a port to re-fill the deck with rock bags may be required in instances where rock bags are deemed necessary.

Figure 4-16 Example Image of 2 Tonne Rock Bags

Mattresses

If concrete mattresses were to be used, then they would most likely be installed below 6 m LAT and within 3.5 m either side of the installed cable. The 6 m LAT is derived by ensuring that the navigable water depth has not been reduced by >5%; the mattresses are 300 mm high when installed. Should there be a potential requirement to install mattresses in less than 6 m LAT then consultation would be undertaken with the MCA and other navigation interests to obtain their approval.

The 300 mm thick concrete mattresses are nominally 6 m long by 3 m wide and weigh 8.52 tonnes. The formation of mattress installation would typically be on top or on either side of the installed cable. Potential numbers required in the event of contingency is 33 concrete mattresses which equates to 282 tonnes collectively.

Installation of mattresses would either be from the CLV, a large construction vessel with ROV or multi-cat vessel. Trips to a port to re-fill the deck with mattresses may be required in instances where mattresses are deemed necessary.

4.7 Post-Installation Survey

Following completion of the cable installation, a survey of the installed infrastructure will be conducted to confirm its as-built position, and to ensure that the design requirements have been met. This will utilise a similar survey spread to that described in Section 4.3.1. Details of the as-built locations of the cable and associated protection measures will be provided to the UK Hydrographic Office and the Kingfisher Information Service for inclusion on Admiralty Charts, and Offshore Renewable and Cable Awareness Charts respectively.

4.8 Schedule of Deposits

Table 4-8 summarises the deposits required below MHWS.

Table 4-8 Deposits Below MHWS

DEPOSIT BELOW MHWS	MATERIAL	LENGTH REQUIRED (WORST-CASE) (M)	PIECES REQUIRED (PAIRS OF HALF SHELLS)	WEIGHT PER METRE (KG) IN AIR	TOTAL WEIGHT (KG) IN AIR	WEIGHT PER METRE (KG) IN WATER	TOTAL WEIGHT (KG) IN WATER
Cable	Copper Steel XLPE	1900	-	-	-	26.9	51,110
Split Pipe	Cast iron	448	1,221	59.8	26,790	51.3	22,982
Ullapool armour earth	Stainless steel wire e.g., 11 mm diameter	333	-	0.591	197	-	-
Ullapool FO earth	Stainless steel wire e.g., 11 mm diameter	333	-	0.591	197	-	-

Altnaharrie armour earth	Stainless steel wire e.g., 11 mm diameter	90	-	0.591	53	-	-
Altnaharrie FO earth	Stainless steel wire e.g., 11 mm diameter	90	-	0.591	53	-	-
Clump weights for earths	Concrete structures	Up to 10 no.	-	60 each	600	-	-
Rock anchors for earths	300 mm Stainless steel threaded rod, plus bolt fixing and marine grade resin	Up to 20 no.	-	2 each	40	-	-
Rock bags	Rock bags made of individual rock within mesh	Up to 60 no.	-	2,000 each	120,000	-	-
Mattresses	Mattresses made of concrete	Up to 33 no.	-	8,520 each	281,160	-	-

5 PROPOSED DELIVERY PROGRAMME

Table 5-1 summarises the indicative schedule of durations for works relating to the proposed cable installation activities. The below is the expected duration of each activity, however it should be noted that some may take longer or less days depending on different variables such as weather and/or operational delays. Therefore, the below should be taken as the best estimate.

Table 5-1 Key Dates for Operation Activities

SPLIT	DURATION (days)
Onshore Works	16
Offshore Works	19
Nearshore Works	8
Cable Pull-In	2
TOTAL	45

6 UXO STRATEGY

Unexploded Ordnance (UXO) are explosive weapons (bombs, shells, grenades, land mines, naval mines, cluster munition, and other munitions) that did not explode when they were employed and still pose a risk of detonation, sometimes many decades after they were used or discarded. UXO exist worldwide and poses a potentially lethal threat in any area in which they are present. The inherent dangers associated with UXO can largely be attributed to the deterioration of the detonator and main charge, which makes these already volatile components more sensitive to disturbance such as heat, shock and/or friction. Therefore, as part of the route engineering process, 6 Alpha (a UXO consultancy) was enlisted to provide a UXO threat and risk assessment within the area.

Background UXO threats may have been generated by nearby modern military training activities, as well as due to historic aerial bombing in the wider area, though such prospective threats are purely precautionary posing only a residual background level of UXO threat. 6 Alpha has confirmed that the primary source of potential UXO contamination threat is driven by post-World War 2 (WWII) naval training, with the proposed installation works area situated within the boundaries of a large submarine exercise area. This submarine exercise area has been used by the UK and North Atlantic Treaty Organisation (NATO) forces to undertake torpedo firing and mine hunting exercises previously, although these are likely to have occurred in open areas of water as opposed to within Loch Broom and near to commercial fishing operations operating from Ullapool harbour.

6Alpha have concluded that the nature and scope of the UXO risks are categorised consistently as 'low' at the installation works area, based upon a source-pathway-receptor review, as well as the prospective consequences of initiating UXO and an analysis of the probability of encountering and of initiating UXO, in particular.

Therefore, it is considered highly unlikely that UXO will be encountered during the cable installation activities at Ullapool, within the confines of Loch Broom. The current UXO risk rating at the site has therefore been determined to be 'low'.

6 Alpha recommend that the UXO risks associated with cable installation operations, and any subsequent potential seabed intrusive operations, are further mitigated – within the bounds of the As Low as Reasonably Practicable (ALARP) risk reduction principle and in accordance with national laws - through the implementation of a proportionate and cost-effective risk mitigation strategy, which in this instance is likely to consist of limited proactive and reactive risk mitigation measures. SSEN will ensure the above is abided.

Conclusively, if UXO were to be encountered they would be avoided. As such, there will be no UXO clearance associated with the proposed activities.

7 REFERENCES

Ofgem (2019). DCRP/18/03 – Revision of Engineering Recommendation. Available online at: https://www.ofgem.gov.uk/publications/dcrp1803-revision-engineering-recommendation-erec-p2-security-supply