Scotland England Green Link 1 / Eastern Link 1 - Marine Scheme

Environmental Appraisal Report
Volume 2

Chapter 2 - Project Description

nationalgrid SP TRANSMISSION

National Grid Electricity Transmission and Scottish Power Transmission

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2. Marine Scheme Description

2.1 Introduction

This chapter of the Environmental Appraisal Report (EAR) describes the Marine Scheme for the Project, which comprises a subsea High Voltage Direct Current (HVDC) link extending approximately 176 km from the Scottish landfall at Thorntonloch Beach, East Lothian, Scotland, to the English landfall, at Seaham, England (see Chapter 1: Introduction, Figure 1-1).

The physical aspects of the Marine Scheme are set out in terms of installation, operation and decommissioning as summarised below:

- **Installation Phase**: Scale and key characteristics of the subsea cable system, infrastructure and equipment to be used during cable laying, jointing and burial. Options for cable installation, including pre-installation survey methods, types and numbers of vessels to be used, and installation techniques.
- **Operation Phase**: The in-situ physical characteristics of the subsea cable system, including information about design, operation, repair and maintenance. Emissions from the cables system generated during their operation, in the form of heat, and electromagnetic fields (EMF) are also discussed.
- **Decommissioning Phase**: Activities anticipated in decommissioning the subsea cable system at the end of its operational life.

This chapter considers the Marine Scheme only. Terrestrial aspects of the Project, the Scottish and English Onshore Schemes, are not presented here. They are presented in support of onshore planning applications under the Town and Country Planning (Scotland) Regulations 1997, and the Town and Country Planning Act 1990, submitted to East Lothian Council and Durham County Council respectively.

The Scottish and English Onshore Schemes and Marine Schemes overlap in the intertidal zone between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS), where marine and terrestrial planning systems overlap.

It is acknowledged that the Marine Scheme finally designed and constructed may differ from the details that have been presented in this chapter and reported in the EAR. At the time of writing, the contract to undertake the installation works has not been awarded, and therefore the proposed installation methodology and exact timing has not been finalised. However, in order to ensure the EAR is as robust as possible, the technical chapters appraise the range of likely installation methods to ensure that the envelope of effects appraised will encompass the worst case and actual installation method, once confirmed. The potential effects appraised within this EAR has considered the range of parameters within which the detailed design will be developed following appointment of the installation contractor.

2.2 Project overview

The Marine Scheme will provide 2 Giga Watts (GW) of transmission reinforcement from Scotland to England. It comprises a subsea HVDC cable system, within a marine installation corridor approximately 176 km long and up to 500 m wide.

The marine installation corridor extends from MHWS at the landfall on Thorntonloch Beach, Scotland, crossing Scottish and English territorial seas to MHWS at the landfall at Seaham, England (See Chapter 1: Introduction, Figure 1-1).

The marine installation corridor follows a broadly north to south alignment from the kilometre point (KP) 0, at the Scottish landfall, to KP 176 at the English landfall, as shown in Chapter 1: Introduction, Figure 1-1. Approximately 37.5 km of the marine installation corridor lies within Scottish territorial waters, with approximately 138.5 km within English territorial waters.

The 500 m wide marine installation corridor will allow potential routes for the trenches within the corridor to be subjected to micro-routing, informed by pre-construction evaluation of site-specific survey data.

The installation contractor (once appointed) will undertake detailed route development within the consented marine installation corridor. The potential routes of the cables within the marine installation corridor will then be subjected to micro-routeing, informed by pre-installation evaluation of site-specific survey data, to avoid or minimise localised technical and environmental constraints. This has the potential to alter the KPs referred to in this EAR. Furthermore, all water depths within this chapter are quoted below Lowest Astronomical Tide (LAT) unless otherwise stated.

The Scottish and English elements of the Marine Scheme fall within the regulatory responsibilities of the Marine Scotland - Licensing Operations Team (MS-LOT) and the Marine Management Organisation (MMO), respectively.

2.2.1 Indicative project programme

As shown in Figure 2-1, consent is anticipated in 2023, with construction contracts awarded in 2024 and construction of the Marine Scheme commencing in 2025 / 2026. Construction will take up to two years to complete and will avoiding winter months where feasible. Programme will be dependent on vessel and equipment availability and suitable weather conditions. Activities such as surveys, route preparation, cable burial and cable protection are expected to be undertaken all year round, including winter months. It is anticipated that there will be up to four cable laying campaigns with up to three months between campaigns depending on cable availability and the factory location.

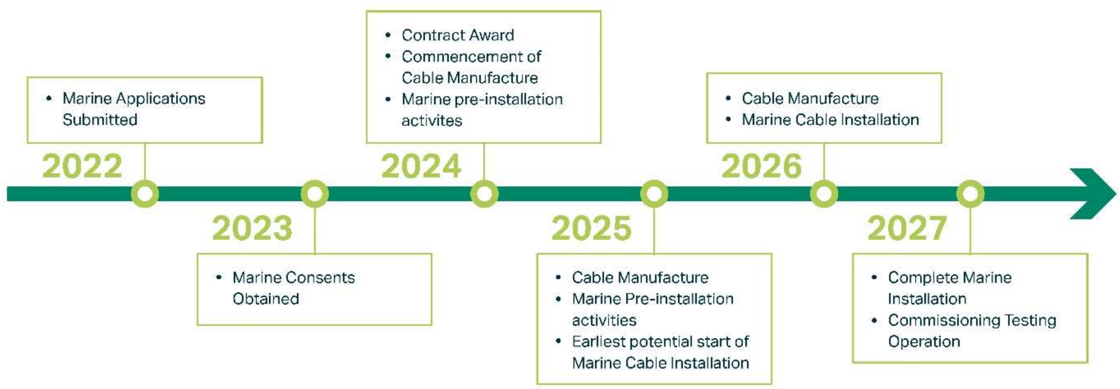

Figure 2-1: Indicative project programme

2.2.2 Marine installation corridor

The subsea HVDC cable system will comprise up to two subsea HVDC cables (the cable(s)), installed within the marine installation corridor. The two cables may be bundled together and buried in a single trench or may each be buried separately within their own trench. A bundled approach with a single trench is currently considered the most likely option to be developed, however a two trench approach cannot be ruled out, and therefore is appraised as the reasonable worst case for several aspects of the impact appraisal.

Each of the HVDC cables may be accompanied by a fibre optic cable (FOC), attached to the HVDC cable and contained within its trench.

One HVDC cable will be accompanied by a FOC along the full marine installation corridor length. The second HVDC cable may be accompanied by an FOC for the first 5 km of the marine installation corridor from each of the landfalls. The FOCs will allow monitoring of conditions along the cable route, such as cable temperature.

The cables will be buried to a minimum depth of 0.6 m, with a target depth of 1.5 m achieved where possible. Where the minimum depth of burial cannot be met, a risk assessment will be undertaken to determine whether the achieved burial depth provides sufficient protection or whether remedial external protection is required. Each trench will be between one and six metres wide (depending on the nature of the seabed), with a potential area of trenching associated seabed disturbance up to 15 m wide in some places. Pre-installation route preparation in some parts of the marine installation corridor will lead to limited wider areas of disturbance of up to 25 m. If a two trench approach is used, then the trenches will have a maximum separation of 30 m, within the marine installation corridor, with separation expected to be considerably less than 30 m wherever possible.

2.2.2.1 Summary of marine installation corridor parameters

Key marine installation corridor aspects and parameters are summarised below in Table 2-1.

Table 2-1: Summary of the marine installation corridor aspects and parameters

Aspect	Parameter	Value	Notes
Marine installation corridor	Width	500 m	
	Total Length	176 km	
	Length Scottish Waters	37.5 km	
	Length English Waters	138.5 km	
HVDC cables	Number	2	Up to two HVDC cables
Fibre Optic Cables (FOC)	Number	2	At least one FOC, installed alongside each of the HVDC cables
Cable installation trench	Number	2	Up to two trenches
	Burial depth	0.6 - 1.5 m	Minimum depth 0.6 m Target depth of 1.5 m
	Width	6 m	One to six metres
	Disturbed area of during trenching	30 m wide	Up to 15 m wide swath per trench. For two trenches up to 30 m wide.
	Separation between trenches (unbundled)	30 m	Maximum value. Separation will be less than 30 m where possible.
Pre-installation route preparation	Disturbed area during pre-installation preparation	50 m	Normally up to 15 m per trench for boulder clearance plough, but potentially to 25 m using grab. For two trenches up to 50 m.

2.2.2.2 Cable landfalls

No activities are proposed in the intertidal zone at either landfall as Horizontal Directional Drilling (HDD) technology will be used, see Section 2.3.2 for further details.

Scottish landfall – Thorntonloch Beach, East Lothian

The Scottish landfall is the interface between the Scottish Onshore Scheme and the Marine Scheme. The location for the landfall area is the southern end of Thorntonloch Beach in East Lothian, as shown in Figure 2-2. The Scottish landfall intertidal area is approximately 144 m wide (between MHWS and MLWS) at its widest point.

English landfall - Seaham, County Durham

The English landfall is the interface between the Marine Scheme and the English Onshore Scheme. The location for the landfall area is north of Seaham, County Durham, as shown on Figure 2-3.

The intertidal area within the English landfall is approximately 72.5 m wide (between MHWS and MLWS) at its widest point.

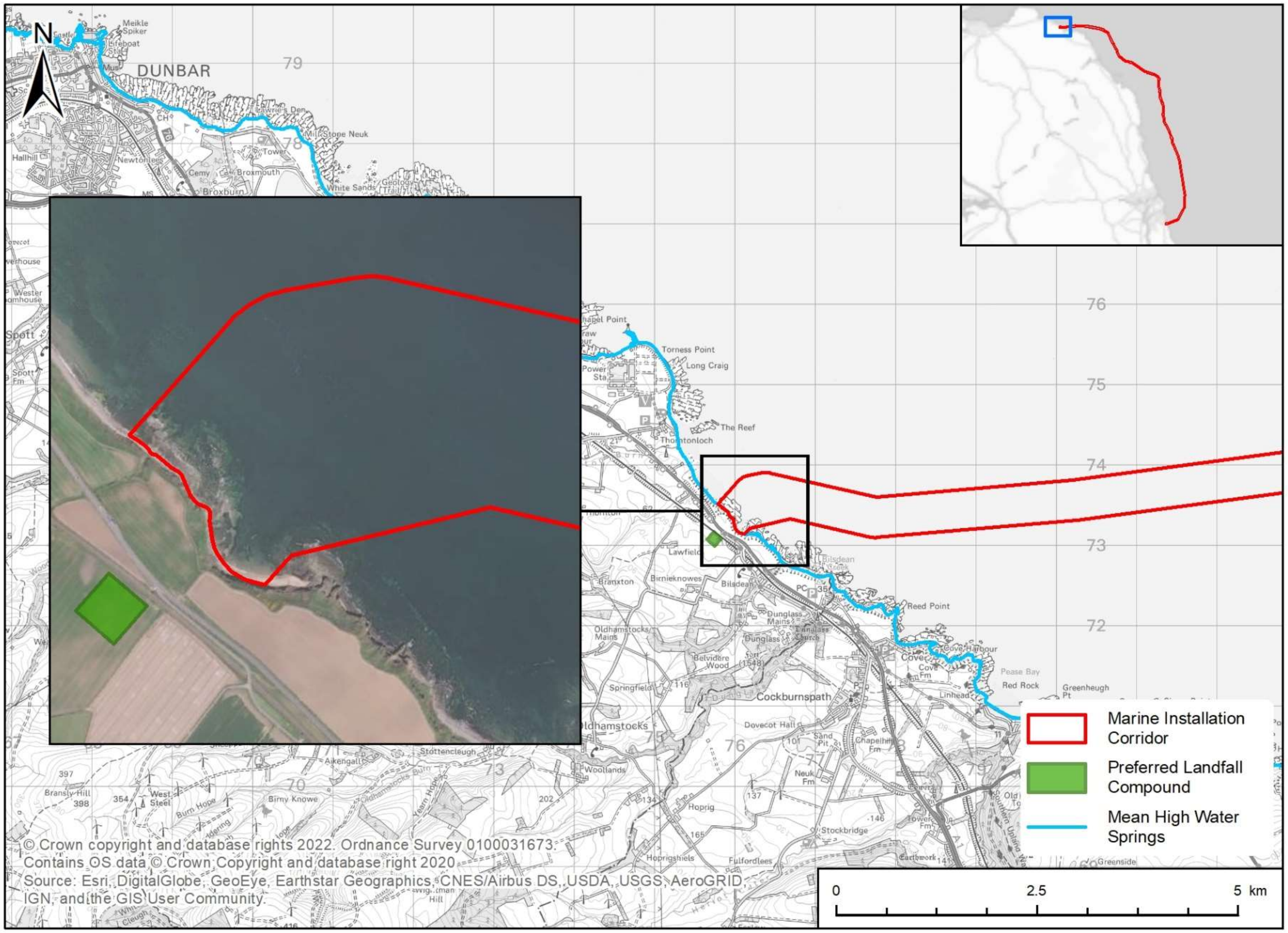

Figure 2-2: Scottish landfall area

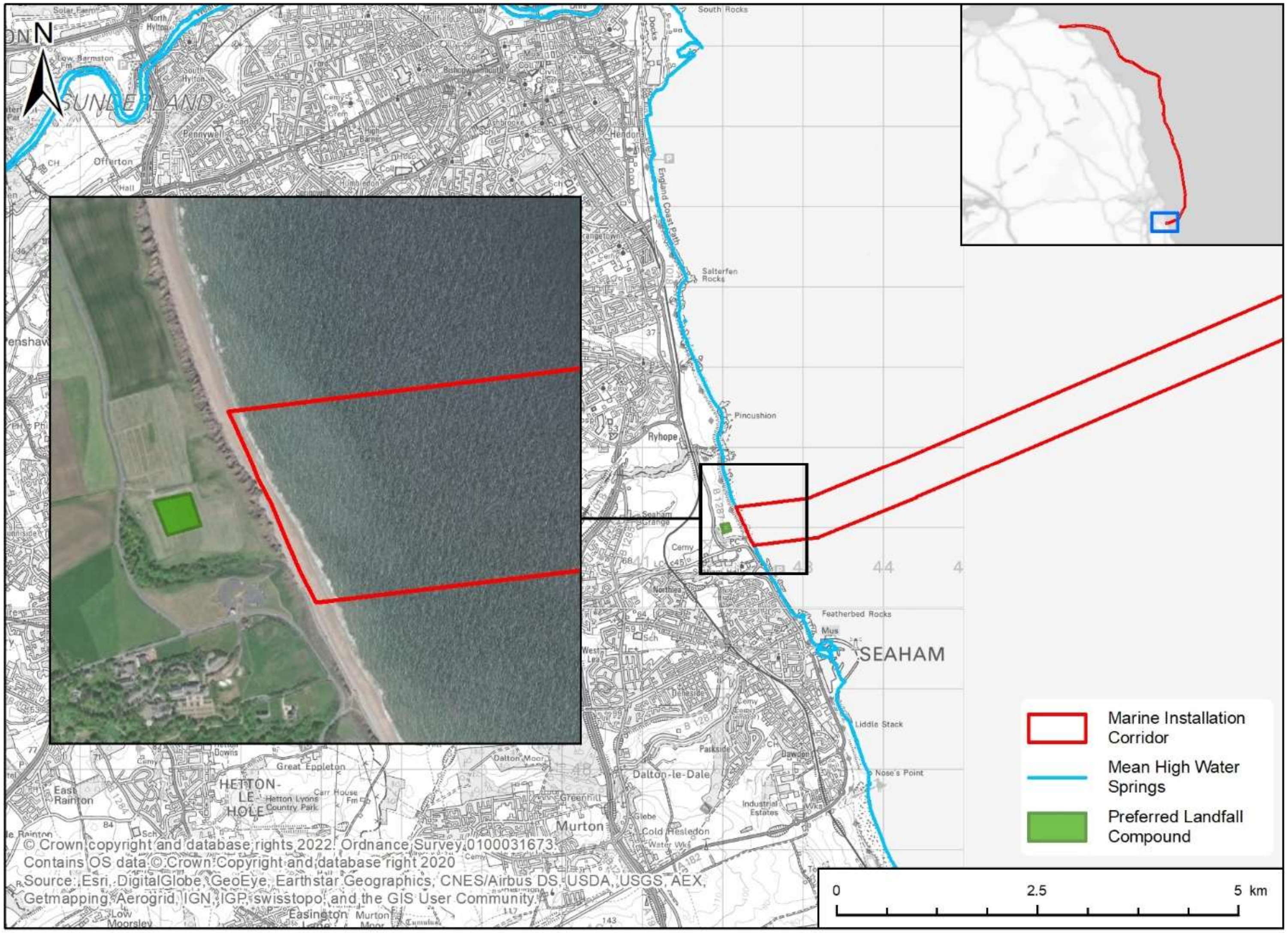

Figure 2-3: English landfall area

2.2.3 Subsea HVDC cables

2.2.3.1 Cable technology

The Marine Scheme will provide a major reinforcement of the electrical transmission system between southern Scotland and northern England via two HVDC subsea cables.

With a bundled approach, the two cables and the fibre optic cable (FOC) would be combined into a single bundle, as shown in Figure 2-4.

With a two trench approach, each cable would be laid in a separate trench, with the FOC laid within one trench alongside one of the cables, as shown in Figure 2-5**.**

Up to four cable joints may be required within the 176 km marine installation corridor (one every 50 to 100 km). Cable jointing is discussed in more detail in Section 2.3.4.1 and summarised in Table 2-2.

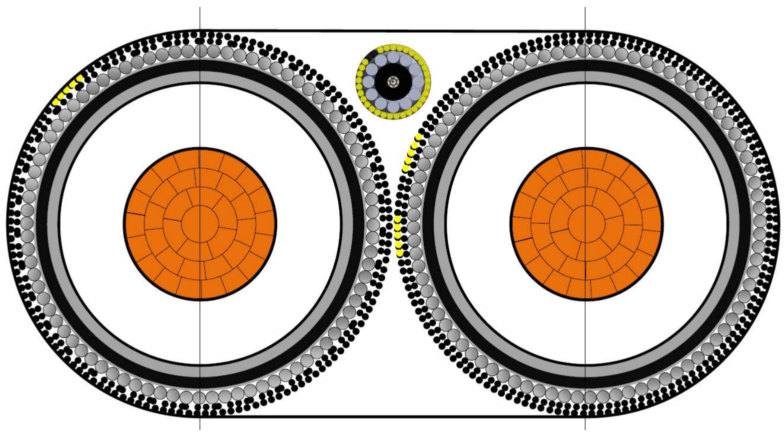

Figure 2-4: Bundled HVDC cables with piggy backed FOC

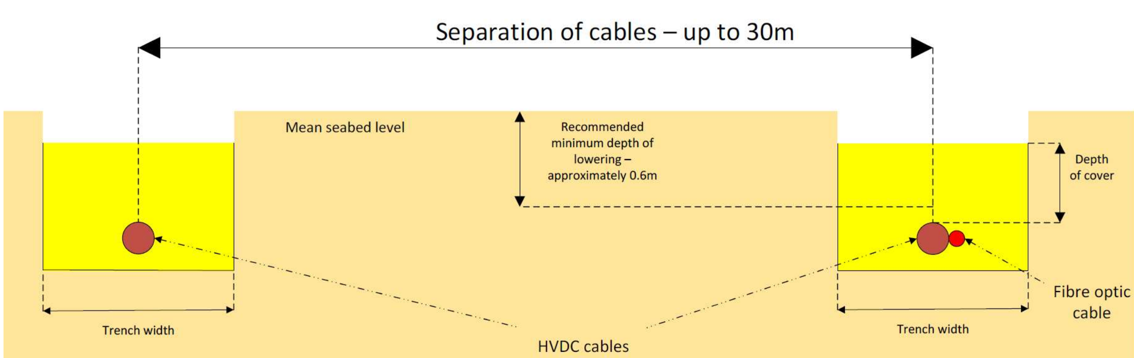

Figure 2-5: Separately trenched HVDC Cables and FOC

2.2.3.2 HVDC cable design

The Marine Scheme will consist of a bi-pole HVDC cable system, comprising two single core metallic conductor cables (one per pole) with a total transmission capacity of up to 2 GW. The HVDC cables will transmit power at a nominal voltage of ±525 kilo Volts (kV), one cable at +525 kV and the other at -525 kV. Typically each cable will have a diameter of 140 to 150 mm and a central core of either copper or aluminium, surrounded by sheathing and armouring, including an inert protective layer of lead sheathing (a long term engineering solution to prevent water ingress).

The cables used will be non-draining, containing no free oil. The cables contain no liquid or gases that can be released into the marine environment even in the event of severe mechanical damage to the cables.

The subsea cables will be designed to withstand mechanical forces during installation and repair/recovery operations.

2.2.3.3 FOC design

One of the FOCs will be installed along with the full length of one of the two HVDC cables to provide a communications link between the two ends of the Project. A second FOC will be installed for the first 5 km of the marine installation corridors from each of the landfalls. The FOC specification will be confirmed during detailed engineering but is expected to comprise a core of optical fibres, armoured with layers of steel wires, and sheathed with either a polypropylene or PE material for outer protection. The FOC will have an outer diameter of 20 to 30 mm.

The FOC is not proposed to have any repeaters within the marine environment.

2.2.3.4 Summary of subsea cable parameters

Key subsea cable design parameters are summarised in Table 2-2 below.

Table 2-2: Summary of subsea cable aspects and parameters

Aspect	Parameter	Value	Notes
HVDC cables	Configuration	Bi-pole	One cable per pole
	Number	2	Two HVDC cables
	Joints	8	Up to four joints per cable, with one every 50 – 100 km
	Operating voltage	525 kV	525 kV for each of two cables
	Transmission capacity	2 GW	2GW in total for the Marine Scheme
	Diameter	Up to 150 mm	Two cables, each of 140 to 150 mm
FOC	Number	1	
	Joints	4	Up to 4 joints, with one every 50 km to 100 km – FOC joints will be co-located with the HVDC cable joints.
	Diameter	Up to 30 mm	One cable of 20 to 30 mm

2.3 Installation phase

2.3.1 Installation vessels

The use of particular vessels, such as a CLV or a CLB, as well as particular installation technologies such as cable trenching tools or ploughs will be confirmed on award of the installation contract (post-consent).

Details of resources recently deployed or proposed for installation of cables similar in scale and character to the Marine Scheme have been used to inform the description of representative vessels below.

2.3.1.1 Cable laying vessel

The CLV is a specialist vessel designed to carry and handle long lengths of power cables. Figure 2-6 provides examples of CLVs, which are equipped with DP systems enabling the CLV to hold position accurately without the deployment of anchors. In combination with the cable tensioner onboard the vessel, the use of the DP system enables the cable to be accurately positioned on the seabed.

CLVs can carry long lengths of cable, typically up to 100 km or more (Figure 2-7) but are large vessels, and as such, maybe constrained by their draught when operating close to shore. Therefore, a CLB or jack up vessel (see below) may be used to undertake cable laying activities in shallow waters.

Figure 2-6: Representative Cable Laying Vessels (Left: Topaz Installer, Right: Aker Connector)

Figure 2-7: Typical factory and CLV turntables.

2.3.1.2 Cable lay barge

CLVs maybe constrained by their draught and therefore at the landfalls a separate shallow water vessel such as a CLB may be required (Figure 2-8). Shallow water operations are normally conducted from flat-top pontoon barges that are mobilised on an ad-hoc basis. The flat-top pontoon barge(s) will be fitted with all the necessary cable storage and working equipment and up to an eight-point mooring system which will be used to manoeuvre the barge during installation activities. Each anchor could be up to 2 m in length and deployed up to 800 m from the CLB (within the marine installation corridor) to allow the barge to hold station, whilst the installation works are undertaken. A combined seabed footprint of up to 32 m^2 at each anchored work location is anticipated.

Figure 2-8: Representative Cable Lay Barge

2.3.1.3 Jack-up barges

A jack-up barge with up to four spud can legs, each with up to 8 m diameter and giving a footprint of approximately 50 m^2 may be used at each work location. One work location is assumed for each of the four completed cable ducts in each landfall site, giving a total footprint of approximately 200 m^2 at each landfall.

2.3.1.4 Back-hoe dredgers

The use of a back-hoe dredger may be required to support with pre-installation trenching. A back-hoe dredger is essentially a bucket digger operated from a shallow water barge. It may be self-propelled for positioning on site, or non self-propelled and relying on the help of workboats. It will maintain position at each breakout by deployment of either spud can legs or an anchor array, with a seabed footprint (anchor or spud can) not exceeding 100 m^2 at each breakout. It may be used to excavate the shallow water sediment to provide a trench for the cable to be installed in. Excavated material will be side cast within the marine installation corridor.

2.3.1.5 Rock placement vessels

A rock placement vessel (Figure 2-9) features a large hopper to transport rock to the required location and a mechanism for deployment of the rock on site. The standard deployment techniques are:

- **Flexible fall pipe** – a retractable chute is used to control the flow of rock to the seabed. At the end of the fall pipe, a fall pipe remotely operated vehicle (FPROV) is mounted allowing for accurate control of the end of the fall pipe above the seabed and to survey rock placement locations; or
- **Side placement** –rock is placed over the side of vessel in a controlled manner. A side-placement vessel is typically used for shallow water rock placements. This will be done using either grabs or a side placement unit to ensure accurate placement and controlled rock flow.

Where cable protection using rock placement is required, a targeted placement method e.g., fall pipe vessel will be used rather than using vessel-side discharge methods.

Figure 2-9: Representative fall-pipe rock placement vessel.

2.3.1.6 Guard vessels

Guard vessels may be required to maintain surveillance around the CLV, CLB or other vessels with restricted manoeuvrability, particularly in areas of high-density marine activities, where it is considered necessary to ensure other vessels keep clear of the installation activity to avoid the risk of collision. Additionally, they may be required to protect the cable prior to trenching or external protection and also to protect free ends of cable left on the seabed whilst the CLV is reloading.

All guard vessels will use RADAR with Automatic RADAR Plotting Aid (ARPA) to monitor vessel activity and predict possible interactions.

2.3.1.7 Specialised support vessels

Specialised support vessels may be required to support a range of other activities, including surveys using ROV or geophysical equipment, diving activities, cable trenching (e.g. ploughing, jet trenching, trenching, PLGR), installation of required cable protection system.

2.3.1.8 Vessel operating parameters

Vessel speeds

Table 2-3: provides an indicative summary of vessel speeds that can be anticipated during the installation phase of the Marine Scheme.

Table 2-3: Indicative vessel speeds

Vessel	Operational speed	Transit speed
CLV (simultaneous cable lay and trenching)	0.5 km to 5 km per day (subject to sediment type, trenching equipment used etc.)	6 knots to 12 knots
CLV (cable lay without simultaneous trenching)	Up to 7 km per day	6 knots to 12 knots
CLB / Jack-up Barges	Stationary	4 knots to 10 knots
Trenching Vessels	0.5 km to 5 km per day	6 knots to 12 knots
Guard Vessels	0 to 4 knots	4 knots to 10 knots
Support Vessels	Up to 7 km per day	6 knots to 12 knots
Rock Placement Vessels	0.5 km to 3 km per day	6 knots to 12 knots

Vessel campaigns

Between two and four cable laying campaigns will be required, the duration of each related to the cable carrying capacity of the CLV or CLB, and coordination with other activities such as HDD at the landfalls. There may be three months between campaigns, with most avoiding the winter months and work taking two to three years to complete.

Cable lay activities can be expected to be undertaken in weather conditions up to Force 7 and a significant wave height of up to 3 m.

2.3.2 Pre-installation activities

2.3.2.1 Pre-installation studies and surveys

The potential for UXO to affect the development of the Marine Scheme will be informed by a desk-based assessment undertaken post consent and informed by the pre-installation survey data. The EAR considers the risk of encountering UXO within the marine installation corridor. Following the desk-based assessment, the current management strategy is anticipated to include:

- Site specific UXO surveys in areas of moderate and high risk;
- Micro-routeing to avoid potential UXO (pUXO), wherever possible;
- Where micro-routeing is not possible, it is anticipated that individual UXO target identification/verification surveys will be undertaken to confirm the status of each pUXO. This may involve carefully excavating a small area on the seabed (using a diver with handheld excavation tools in water depths of less than 10 m and an ROV in waters deeper than 10 m) at the target location, typically 2 m in diameter and 1 m in depth until the item is excavated sufficiently to identify the pUXO; and
- Should a target be confirmed as a UXO, then clearance of the target shall be undertaken before any further work occurs. Detonation activities will be subject to separate Marine Licence and European Protected Species applications, to be applied for if required.

Pre-installation surveys will inform detailed engineering and cable installation planning, including micro-routing, installation methods and potential use of cable protection. The surveys will be contained within the marine installation corridor, focussing on collection of detailed information along a preferred route for the subsea cables. The survey data will be used to confirm the absence or presence of any previously unrecorded obstructions, sensitive features (e.g. archaeological or ecological sensitivities) or significant changes to seabed conditions and bathymetry and to inform unexploded ordnance (UXO) assessment work. This will allow micro-routing within the marine installation corridor by the preferred contractor, once appointed.

Preinstallation surveys will include a range of standard survey methods and may include:

- **Bathymetry:** Swathe, multi-beam and single beam acoustic echo sounder systems to record water depth, prepare a three dimensional (3D) digital terrain model of the seabed and to identify relevant bedforms;
- **Side Scan Sonar (SSS):** Mapping of the seabed surface and identification of sediment types. Obstacles lying on the seabed, such as wrecks, debris, UXO and surface-laid or exposed pipelines and cables that might impede cable installation can be identified from the SSS outputs;
- **Sub-bottom Profiling (SBP):** Directing a pulse of acoustic energy into the seabed and using reflections from the sub-surface geology to assess the thickness, stratification and nature of seabed sediments;
- **Magnetometer/gradiometer:** Passively detect magnetic anomalies compared to the earth’s magnetic field. Such anomalies can be caused by geological faults and buried metallic objects such as UXO, pipelines, cables and archaeological features;
- **Benthic Ecology:** Drop Down Video or Remotely Operated Vehicle (ROV) mounted cameras may be used to confirm the locations and extents of sensitive benthic habitats or features. This would inform micro-routing of submarine cable systems to avoid or minimise interactions with these features in so far as practicable;

- **Geotechnical Investigations:** Vibrocore (VC) and Cone Penetration Test (CPT) samples may be obtained to inform engineering method decisions, micro-routing and installation tool selection at specific locations. This would verify whether ground conditions are suitable for cable burial as well as to assess the bearing capacity of the seabed sediments with regards to crossing structures and trenching equipment intended to be used; and
- **Visual Inspection:** Remotely operated vehicle (ROV) inspection of submarine assets to be crossed.

2.3.2.2 Route preparation

Route preparation activities likely to be undertaken prior to installation of the cables include:

- Sea trials;
- Cable route clearance;
- Pre-lay grapnel run; and
- Pre-lay subsea intervention e.g. installation of crossing infrastructure.

No pre-sweeping of sandwaves using dredgers is required or proposed within the marine installation corridor.

Sea trials

In areas of very hard or very soft seabed, submarine cable trenching tools may be trialled within the marine installation corridor, to determine if they meet the required target trench depth. It is anticipated that these may include:

- **Trials of proposed burial tools**: In areas of very hard or very soft seabed, submarine cable burial tools may be trialled prior to the commencement of installation within the marine installation corridor to determine their suitability and to confirm whether they can meet the required burial targets. Trials may be undertaken for both the use of pre-trenching using a displacement plough and/or mechanical trencher; and
- **Trials of boulder clearance techniques**: Trials may also be undertaken to determine the suitability and success of proposed boulder clearance techniques, particularly as successful boulder clearance increasing potential to achieve burial using standard techniques and therefore to minimise the potential use of rock placement.

Sea trials will be undertaken within the marine installation corridor and will not exceed 5 km in length or exceed 15 m width.

Cable route clearance

Prior to installation, obstructions that may hinder installation, including boulders, Out of Service (OOS) third party subsea assets and smaller debris such as discarded fishing gear, wires etc., will be cleared.

If they cannot be avoided, then it may be necessary to move large stones and/or boulders out of the way so that installation equipment can operate. To clear a path for the cable installation a plough, similar to that shown in Figure 2-10**,** will be towed across the seabed, pushing the boulders aside. Typically, a swathe of between 10 m and 15 m width will be cleared of surface boulders using the plough. Alternatively, a grab similar to that shown in Figure 2-11**,** may be used to clear a swath of between 10 and 20 m for the majority of instances, and potentially out to 25 m wide. A grab may also be used to relocate large individual surface boulders, and other debris, as required.

No OOS cables or subsea assets were identified crossing the marine installation corridor and no activities for the removal of OOS cables are planned. However, pre-construction surveys may identify unknown disused cables necessitating removal using appropriate methods, such as a grab.

Pre-lay grapnel run

Seabed debris, such as scrap trawler warps or ships' crane wires that may have been jettisoned by vessels onto the seabed, can be detrimental to the installation process.

A support vessel will clear the route of debris via an operation known as a 'pre-lay grapnel run' (PLGR) Figure 2-12. The vessel tows a wire with a string of specially designed hooks, or detrenching grapnels Figure 2-13, along the centreline of the cable route until it encounters debris, along an area up to 3 m wide. The PLGR grapnel is designed to snatch debris on the surface of, and just below, the seabed.

Debris caught with the grapnel will be recovered to the deck of the vessel for licensed waste disposal onshore.

Figure 2-10: Typical plough used to clear boulders.

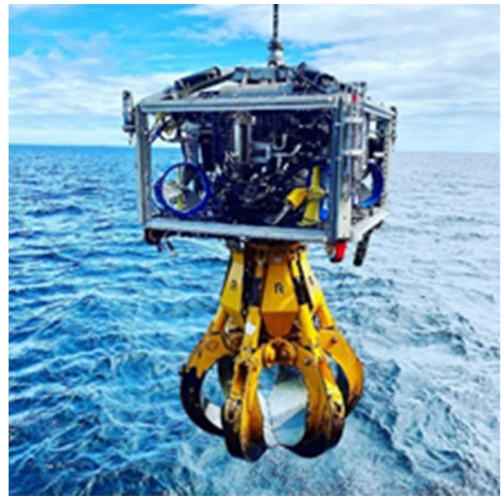

Figure 2-11: Typical grab used to clear boulders.

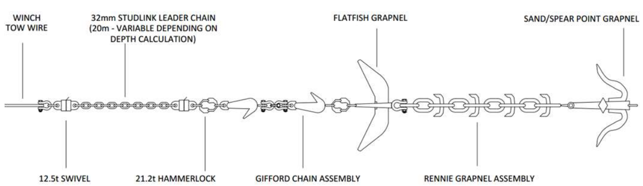

Figure 2-12: Typical PLGR grapnel

Figure 2-13: Typical de-trenching grapnel

Crossings preparation

Within the marine installation corridor there are third-party assets such as in service cables and pipelines to be crossed by the Marine Scheme's cables. Each crossing will be designed in detail as part of the development of crossing agreements for each of the cables and pipelines to be crossed in accordance with the ICPC recommendations.

Pre-installation activities include:

- Survey and visual inspection of the crossing location by ROV in advance; and
- Rock placement, concrete mattresses or separator is installed over the existing asset to create separation between it and the cables when they are later installed.

Further details on the crossing types proposed and typical installation activities to be utilised by the Marine Scheme is provided in Section 2.3.4.2.

2.3.2.3 Summary of pre-installation activity parameters

Key pre-construction aspects and parameters are summarised below in Table 2-4.

Table 2-4: Summary of pre-construction aspects and parameters

Aspect	Parameter	Value	Notes
Sea trial	Width	15 m	
	Length	5 km	
Cable route clearance (plough)	Swathe	10 m to 15 m	Per cable trench
	Length	80 km	50 km in Scotland 30 km in England
Cable route clearance (grab)	Swathe	10 m to 25 m	
	Length	80 km	As required
Pre-lay grapnel run	Swathe	Up to 3 m	
	Length	176 km	Entire cable route.
In-service cables and pipelines crossing preparation (rock placement)	Surface area	49,000m^2	Up to 1 km of berm length, up to 7 m wide per crossing (a 500 m long berm per crossing for two non-bundled cables at each of seven crossings (1000m x 7m x 7 crossings)).
In-service cables and pipelines crossing preparation (concrete mattresses)	Surface area	5,400 m^2	Up to 300 mattresses, each up to 18 m^2 (18 x 300 = 5,400).

2.3.3 Landfall installation

This section presents details of the installation works planned below MHWS at both the Scottish and English landfalls.

2.3.3.1 Horizontal Directional Drilling (HDD)

Horizontal Directional Drilling (HDD) is a non open cut installation method, which does not require any trenching works in the intertidal zone (between MHWS and MLWS), therefore avoiding any direct interactions within the intertidal zone. HDD will start from temporary drilling compounds, one within each of the Scottish and English Onshore Schemes. The temporary drilling compounds will be located close to the Transition Joint Bay (TJB), where subsea cables will connect to the onshore cable system, within both the Scottish and English Onshore Schemes. Each compound will be located above MHWS and outside the Marine Scheme.

Up to four boreholes, will be installed at each landfall (eight boreholes for the Marine Scheme in total), as follows:

- Two boreholes for HVDC cables (one for each cable).
- One borehole for the FOC; and
- One spare borehole.

It is assumed that there may also be up to two aborted or failed drills[1] at each landfall as a worst case (four aborted drills in total).

[1]A drill is the method used to create a bore under the ground before the duct is pulled in.

Completed boreholes will breakout between four and 10 metres below lowest astronomical tide (LAT) within the marine installation corridor, as shown in Figure 2-14 for the Scottish landfall and Figure 2-15 for the English landfall. Each completed borehole may be up to 1.5 km in length.

The use of a back-hoe dredger or mass flow excavation (MFE) will be required to support the creation of the exit pits in advance of breakout. Up to 5,000 m^2 of sediment may be excavated at each landfall to form the exit pits (10,000 m^2 total for the Marine Scheme). The target depth for each of the exit pits will be between 1 m and 3 m, however, the exit pit may need to be 3 m to 5 m deep to achieve this.

Initially a small diameter (250 mm) pilot bore hole will then be drilled from the temporary drilling compounds located within the Scottish and English Onshore Schemes, emerging at the excavated exit pit location, within the Marine Scheme. The pilot hole will then be widened in several stages using reaming (borehole widening) techniques until the required diameter of 660 mm is achieved.

HDD uses drilling fluid to suspend rock cuttings and carry them out of the borehole, while providing power to the downhole motor, cooling the drilling equipment, clearing debris from the drilling bit, sealing the borehole and reducing friction on the drilling equipment. The drilling fluid, once used, is pumped into a mud recycling unit so it can be treated. The majority of it is able to be reused post-treatment, with any waste drilling fluid taken offsite by tanker for treatment and disposal.

The drilling fluid will be selected by the contractor on the basis of drilling performance and environmental requirements, with the most commonly used fluids being bentonite[2] based. Drilling fluids used will be benign and biodegradable. Drilling fluids will be selected from the Centre from Environment, Fisheries, and Aquaculture Science (Cefas) approved list of drilling fluids, and the OSPAR List of Substances/Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR).

Some drilling fluid and solids (including drill cuttings and drilling mud) will be lost to sea during breakout, reaming and during duct installation (see Section 2.3.2).

During HDD works the estimated discharge to the sea per borehole is up to 2,000m^3 of fluid and up to 80 m^3 of solids. There is therefore estimated to be a total of up to 12,000 m^3 of fluid and 480 m^3 of solid discharged from up to 6 boreholes at each landfall. These losses are unavoidable, however will be minimised insofar as practicable through the implementation of industry best practice for example, clearing runs or reducing the volume of drilling fluids in the borehole prior to breakout to the marine environment.

[2] Bentonite consists predominately of clay minerals and is generated frequently from the alteration of volcanic ash. It is considered to be a clean, inert and non-polluting substance. As such it is included on the OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (Cefas, 2018).

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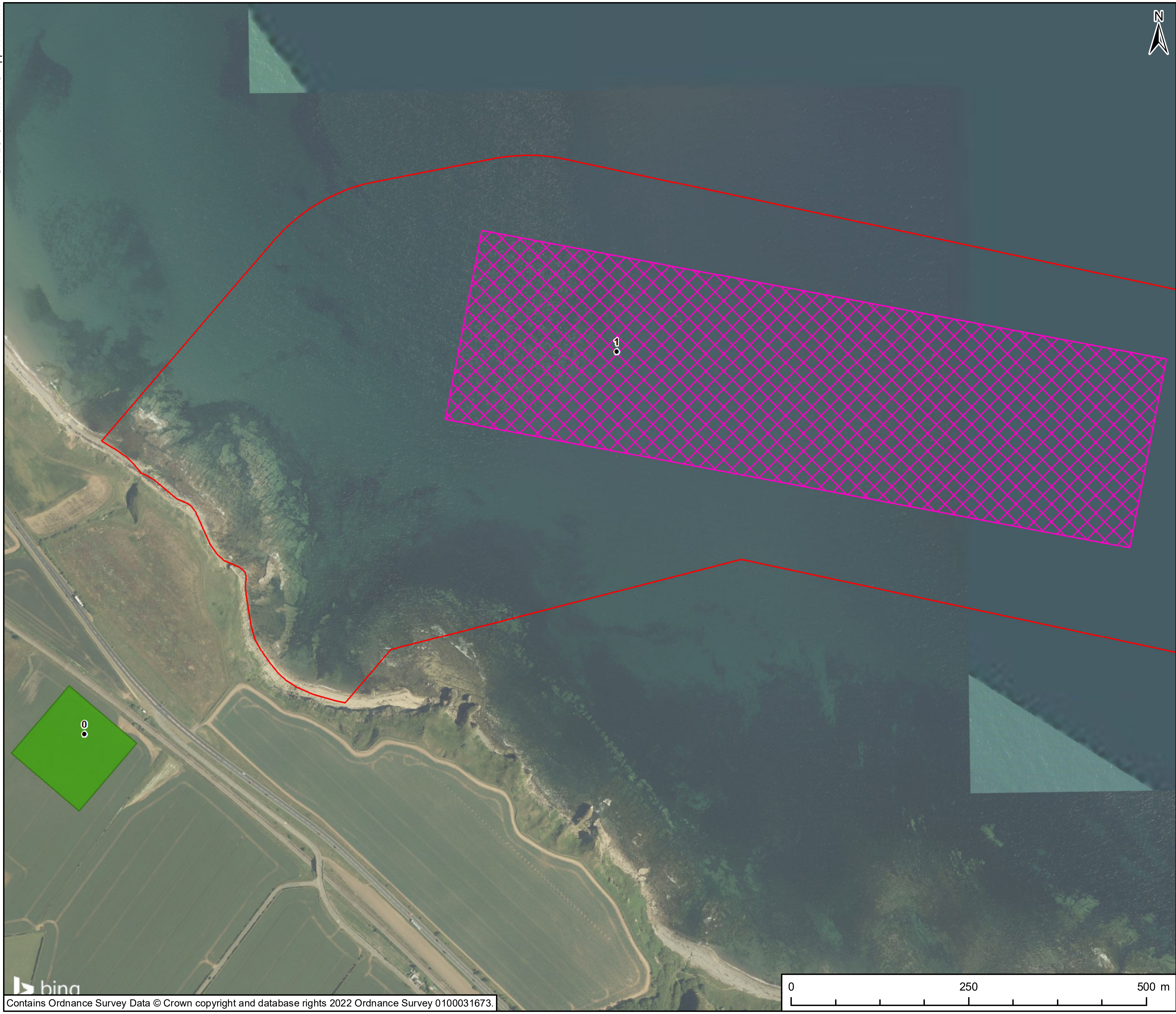

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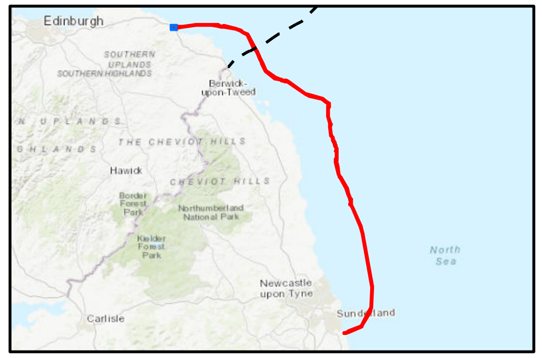
SP TRANSMISSION

PROJECT

Scotland England Green Link 1 / Eastern Link 1

KEY

- Marine Installation Corridor
- Kilometre Point (KP)
- Preferred Landfall Compound
- Potential HDD Breakout Area



TITLE

Figure 2-14
Temporary Drilling Compound and Potential Breakout Area at the Scottish Landfall

REFERENCE

SEGL1_M_EAR_2-14_v3_20220517

SHEET NUMBER | DATE

1 of 1 | 17/05/2022

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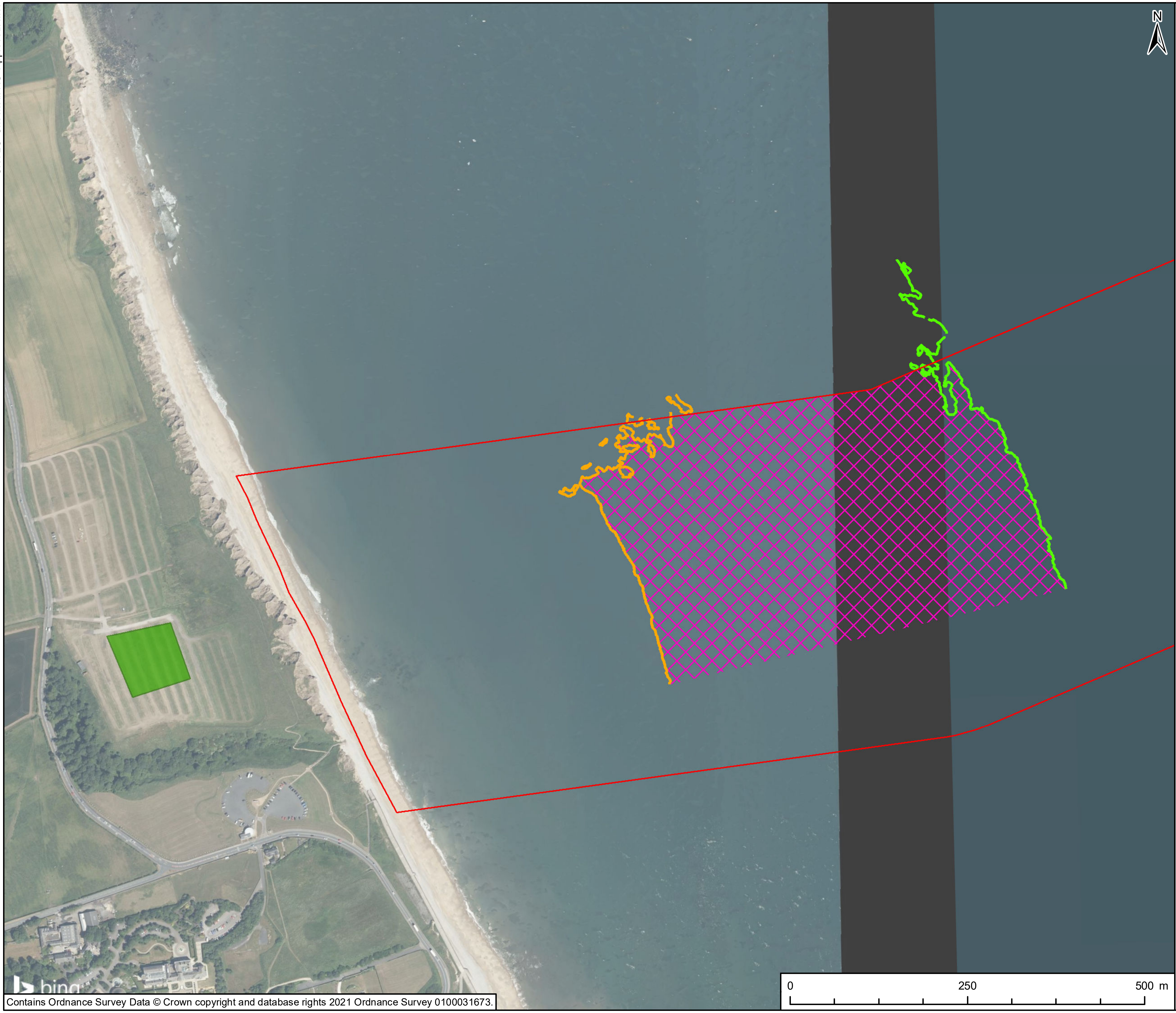

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SP TRANSMISSION

PROJECT

Scotland England Green Link 1 / Eastern Link 1

KEY

- Marine Installation Corridor
- Preferred Landfall Compound
- 4m Bathymetry Contour (Fugro Survey)
- 10m Bathymetry Contour (Fugro Survey)
- Potential HDD Breakout Area

TITLE

Figure 2-15
Temporary Drilling Compound and Potential Breakout Area at the English Landfall

REFERENCE

SEGL1_M_EAR_2-15_v2_20220425

SHEET NUMBER: 1 of 1

DATE: 25/04/2022

2.3.3.2 Duct installation

After reaming, a duct[3] will be installed to line the borehole and a messenger wire then passed through the lined borehole, with the wire's ends emerging from both the onshore drilling compound and the subtidal breakout. The messenger wire will later be used to pull the subsea cable system through the borehole.

Two potential methods may be used for HDD duct installation; both are described below.

Pulled duct installation

Pulled installation is most likely to be used for the Marine Scheme, and is undertaken as follows:

- The ducts would be prefabricated and stored at a marine facility such as a nearby port until they are required. This is considered to be part of the port's routine operations, is not a licensable activity and is not appraised within the EAR;
- The ducts will be towed by sea to the marine installation corridor prior to installation, and temporarily moored until needed;
- A pulling head is attached to the ducting and the ducting flooded with seawater to reduce its buoyancy;
- The pulling head and ducting is pulled though the HDD borehole towards the temporary drilling compound above MHWS; and
- Temporary protective mattresses are placed over the breakout point to protect the installed duct.

During pulling the ducting will displace drilling fluid from the borehole, which may be lost to sea at the breakout (see Table 2-5). All losses will be minimised wherever practicable.

Pushed duct installation

Pushed installation would include the following stages:

- The ducting is pushed from land through the HDD borehole until it emerges at the breakout point;
- Pushing may be assisted by a workboat using a cable to draw the ducting through the borehole towards the breakout; and
- Temporary protective mattresses are placed over the breakout point to protect the installed ducting.

During pushing the ducting will displace drilling fluid from the borehole, which will be discharged to sea at the breakout (Table 2-5).

Up to 20 temporary protective concrete mattresses may be used at borehole breakouts within the Marine Scheme to protect the breakouts from damage before or during cable installation. Each mattress will cover an area of up to 18 m^2 (6 m x 3 m), be up to 0.3 m thick and weigh up to 9.1 tonnes.

All HDD work may take up to six months to complete at each landfall, with vessels being on site for a much smaller portion of that time.

2.3.3.3 Cable pull in

Cables will be installed through each duct-lined borehole as follows:

- The temporary concrete mattresses protecting the HDD breakout and ducting will be removed;
- Within the exit pit the end of the installed duct will be exposed using either a Mass Flow Excavator (MFE) (see description on Section 2.3.5.4) or diver assisted excavation machines;
- Pre-cut trenching will be undertaken using a back-hoe dredger or MFE to create a trench for each leaving the exit pit and following the final cable route.

[3] A duct is a component typically made from High Density Polyethylene (HDPE) which is used to reinforce the borehole ahead of onward use to support the installation of the cable system.

- A bell mouth[4] will be installed at the breakouts to help guide the cable into the duct;
- A CLV will bring the HVDC cable (and FOC if being installed in the same duct) to the location of the exit pit;
- The HVDC cable (and FOC if being installed in the same duct) will be connected to a messenger wire and winched landward through the duct-lined borehole. Alternatively, the FOC may be installed within its own duct;
- The cable will be winched to a position past the TJB where it can be jointed to the onshore cables;
- The bell mouth will be removed, and a flange installed to seal the duct;
- The cable may be fixed in the duct using an appropriate material, such as grout, bentonite or similar, which will be pumped into the duct from land, with a small amount of material lost from the bleed valve at the seaward end, although this loss will be minimised as far as practicable;
- If the FOC is installed in its own duct, it will then be bundled with one of the HVDC cables as they exit the capped duct; and
- In depths shallower than 10 m below LAT, cables will be buried using the most appropriate method(s) depending on conditions, including MFE or diver operated jetting.

Each cable pull will take up to one week of 24 hour working depending on the operability of the installation vessel and the availability of suitable weather conditions.

Once the cables are installed the exit pit will backfilled using rock placement, noting that concrete mattresses may be utilised below the rock placement to stabilise the HDD exits. The HDD exit pits are anticipated to be backfilled to the original mean seabed level, and as such no significant elevation from the seabed is expected.

2.3.3.4 Installation vessels

Several vessels may be used to install the cables at the landfalls, operating in depths of less than 10 m below LAT, including a CLV, CLB or jack-up barge. These vessels may also be supported by guard and anchor handling vessels. A description of the vessels is provided in Section 2.3.1.

Installation will be a 24-hour operation where viable to minimise overall installation time, maximise the use of suitable weather windows and take advantage of vessel and equipment availability.

2.3.3.5 Summary of landfall installation parameters

Landfall installation activities and parameters are summarised in Table 2-5.

Table 2-5: Summary of landfall activities aspects and parameters

Aspect	Parameter	Value	Notes
Completed boreholes	Number	8	Up to four at each landfall
	Length	12,000 m	Eight boreholes at up to 1,500 m each.
	Diameter	Up to 660 mm each	Final diameter after reaming
	Burial depth	1 to 3 m	At least 1 m
Aborted boreholes	Number	4	Up to two at each landfall
	Length	1500 m	Four boreholes at 1,500 m each
	Diameter	Up to 750 mm each	Final diameter after reaming
	Burial depth	1 to 3 m	At least 1 m
HDD and duct installation discharge	Liquid volume	24,000m^3	2,000 m^3 from each borehole, with up to 12 boreholes

[4] A bell mouth is a device which is used to help are guide the cable through the cable duct to avoid damage to both the cable and the duct.

Aspect	Parameter	Value	Notes
	Solid volume	960 m^3	80m^3 from each borehole, 480 m^3 for each landfall (six boreholes) and 960m^3 in total (12 boreholes)
Working periods	Duration of HDD works	6 months	Up to six months each landfall.
	Duration of landfall cable installation	3 weeks	Up to three cable pull operations each taking 1 week of 24 hours working at each landfall
Breakout protection – concrete mattresses	Number	20	Up to 20 mattresses at landfalls as require
	Footprint	360 m^2	20 mattresses, each measuring 3 m x 6 m to give an 18 m^3 footprint at each landfall. Two landfalls.
	Weight	182 tonnes	20 mattresses at up to 9.1 tonnes each, assuming a 0.3m mattress thickness at each landfall. Two landfalls.
HDD exit pit excavation	Area	10,000 m^2	Area of the seabed directly affected by works associated with the excavation of exit pits at each landfall (including equipment spread) 5000 m^2 per landfall.
Breakout protection after installation of cable ducts	Volume	18,000 m^3	Up to 9,000m^3 at each landfall to 10 m below LAT
Vessel seabed footprint	CLB	254 m^2	128 m^2 at each of two landfalls
	Jack up rig / barge	400 m^2	200 m^2 at each of two landfalls
	Back-hoe dredger	800 m^2	400 m^2 at each of two landfalls

2.3.4 Subsea cable installation

This section considers the potential cable laying methods proposed, with the trenching and burial of the cables after laying discussed in Section 2.3.4.

Cable installation will be carried out in several campaigns, the length of which will be related to the cable carrying capacity of the main installation vessel.

Key installation points to identify early are:

- Cables will be delivered in approximately 50 -100 km long sections for installation by a CLV or CLB;
- Installation will be a 24-hour operation to minimise overall installation time, maximise use of fair weather windows, and take advantage of vessel and equipment availability;
- The CLV / CLB will be supported by vessels that may include guard and anchor handling vessels; and
- Dredging vessels and/or other specialist vessels may also be required for limited periods and in response to localised conditions within the marine installation corridor.

The following cable laying methodologies may be used:

- Simultaneous cable lay and burial; and
- Surface cable lay followed by post-lay burial (PLB) of the cables.

During simultaneous cable lay and burial, the CLV may also deploy the burial equipment or it may be deployed by another vessel following less than 1 km behind the CLV, creating a single large group of vessels and equipment (Figure 2-16). The vessel(s) may move relatively slowly, depending on the seabed type encountered, as speeds of between 0.5 km and 5 km per day, appearing effectively stationary to other shipping.

When surface lay is followed by PLB of the cable the two parts are discrete operations separated in both distance and time (Figure 2-17). The CLV can progress at speeds of up to 7 km per day, with the burial vessel following behind more slowly.

An advisory 500 m safety zone will be established around the installation vessels, which ever method is selected for the installation of the cable.

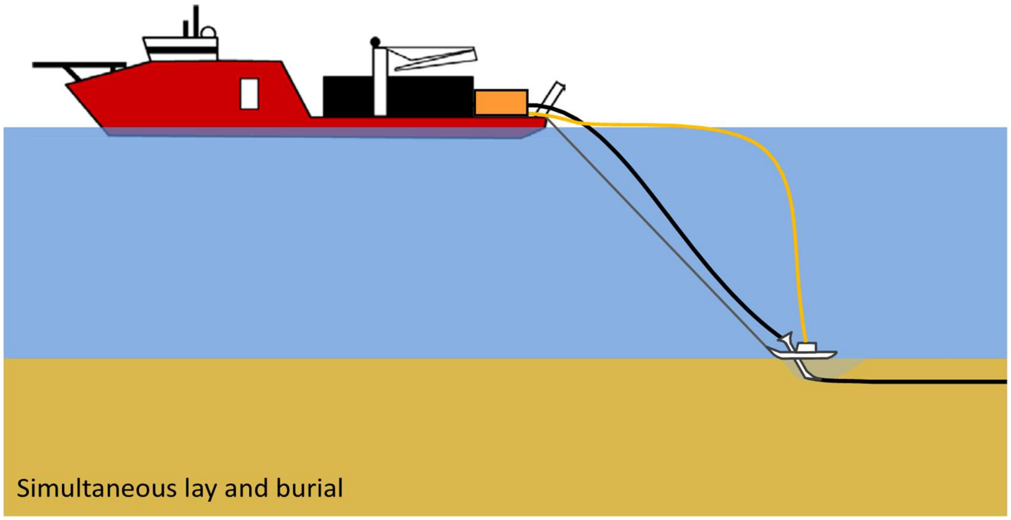


Figure 2-16: Simultaneous lay and burial

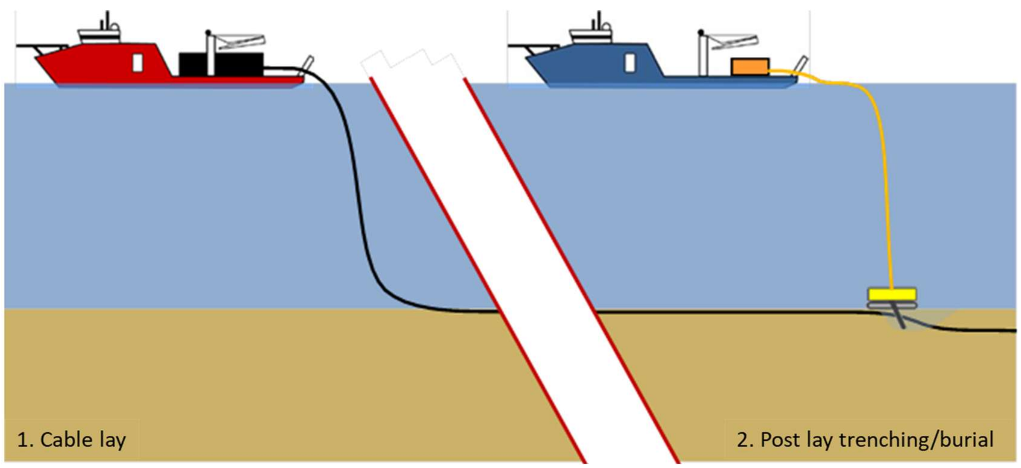


Figure 2-17: Post lay burial

2.3.4.1 Cable jointing

A CLV or CLB cannot carry cable for the whole subsea cable route length in a single load, so the cables will be installed in sections, with joints between the sections as follows:

- When a cable end is reached, the end will be temporarily left on the seabed, with a ground wire attached to enable retrieval;
- The CLV or CLB will leave site to load a new cable length, before returning and jointing the new cable length to the cable end left on the seabed. Cable laying then continues until the end of the new cable length is reached;
- Jointing will be required every 50 to 100 km, with the jointing distances determined by the amount of cable the CLV or CLB can carry; and

- Cable joints will be made on board the CLV or CLB and take up to a week to complete, during which the vessel will normally maintain position via DP but may anchor when in shallow water or close to shore.

Joints and adjacent cables on the seabed at the joint location will either be buried using a jetting machine or a MFE unit, or else protected by concrete mattresses or rock protection.

As far as possible, joints will not be located in higher risk areas, where the prolonged presence of installation vessels is not desirable.

2.3.4.2 Crossings

Six assets have been identified crossing the marine installation corridor (summarised in Table 2-6), four are installed and two are planned. In addition, the final route and proximity of the export cable for the Berwick Bank offshore wind farm is not finalised, and a potential crossing may be required. A further (seventh) crossing allows contingency and a worst case scenario with an unknown asset.

The Neart na Gaoithe offshore wind farm export cable landfalls approximately 700 m to the north of the Scottish landfall, and while a crossing will not be required, there may be a need for discussion with the operator regarding works to be undertaken in proximity to their cable route and landfall.

Crossing agreements will be made with parties owning assets crossed by the Marine Scheme and all parties have been informed about the potential for a crossing. The agreements will detail the physical design of the crossing and the rights and responsibilities of both parties to ensure the ongoing integrity of the assets. The physical crossing design will vary depending upon the specific requirements of the owner or operator of the third-party asset as well as the water depth, size, type, location and burial state of the asset to be crossed. The other assets will be crossed via one of the following:

- On ‘bridge’ comprised of aggregate (rock placement);
- On concrete mattresses; or
- Using a separator system put around the cable at its moment of installation.

The crossing will then be covered with a protective layer of either aggregate or concrete mattresses.

There is potential for presently unknown crossings to be required and if so, proximity and crossing agreements will be agreed with the asset owner and will be in line with the overarching detail provided in this section.

The following crossings listed in Table 2-6 are anticipated.

Table 2-6: Cable Crossings and Proximity

KP	Name	Owner	Type	Status
Landfall approximately 3 km north of KP 1	Berwick Bank Offshore Wind Farm	SSE	Power	Planned Up to two cables
128.8	NSL North Interconnector	National Grid	Power	Installed One cable
128.9	NSL South Interconnector	National Grid	Power	Installed One cable
137.4	Havingsten 2.1 North	Alcatel Submarine Networks (ASN)	FO	Installed One cable
141.4	Havingsten 2.1 South	Alcatel Submarine Networks (ASN)	FO	Planned One cable
135.4	NO-UK Fibre Optic Cable System	Altibox Carrier	FO	Installed One cable

A typical sequence of installation is:

- Survey and visual inspection of the crossing location by ROV prior to the operations;
- Rock placement, concrete mattresses or separator over the existing (buried) asset to create separation between it and the cables;
- An exclusion zone for use of trenching equipment will be defined on either side of the existing cable will be agreed with the existing asset owner for use of burial equipment. This means that, for example, a cable plough if used, must transition out of the seabed before reaching the exclusion zone boundary;
- The Marine Scheme’s cable(s) will be surface laid across the rock placement or mattresses;
- If the existing asset to be crossed is considered to be buried sufficiently deep, the cables may be surface laid over the crossing location within a separator system;
- After crossing, burial of the cable will continue outside of the burial exclusion zone; and
- Further rock placement or concrete mattresses will then be laid over the cable along the burial exclusion zone including the transition out and transition in zones.

A minimum vertical separation between the existing cable and the Marine Scheme subsea cables will be agreed with the cable owners; this will typically be 200 to 500 mm. The crossing will be engineered to achieve the agreed vertical separation.

A horizontal separation between the crossing structure and any anodes on pipeline crossings will be agreed with the owner of the third-party subsea pipeline as part of the negotiations for the crossing agreement. Typically, anodes are required to be avoided by any rock placement by approximately 10 m to 15 m.

The crossing design for each asset crossed will indicate the footprint of the impact to the seabed. Indicative diagrams of typical methods of cable / pipeline crossings are presented below in Figure 2-18 to Figure 2-20. These diagrams provide an indication of the size of the footprint for the different crossing structures. It should be noted that the actual footprint will depend upon the:

- Type of crossing structure;
- Burial depth of the asset which is to be crossed;
- Water depth (which dictates the size of the outer rock placement); and
- Extent of the exclusion zone.

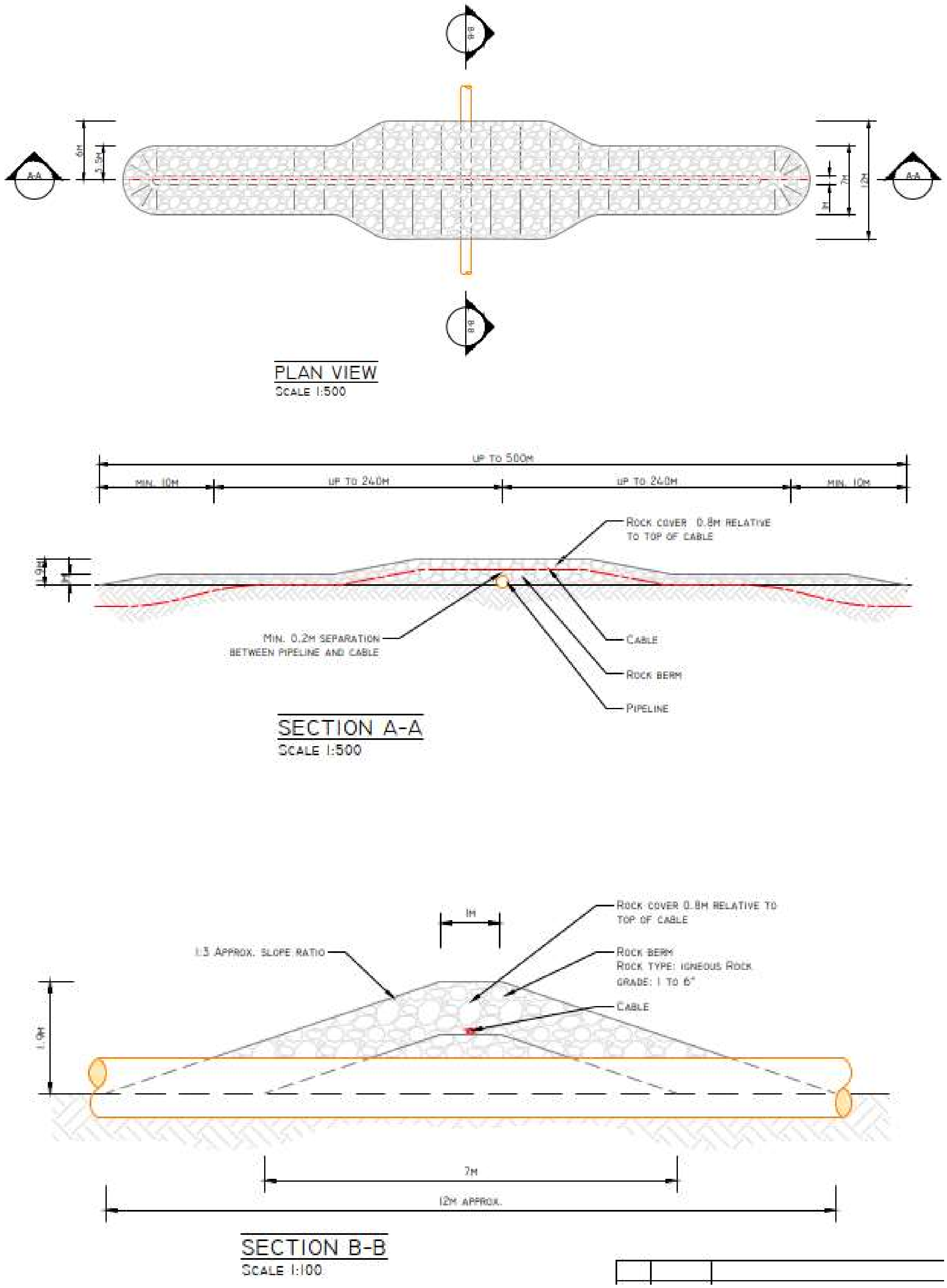


Figure 2-18: Representative rock – cable - rock crossing type

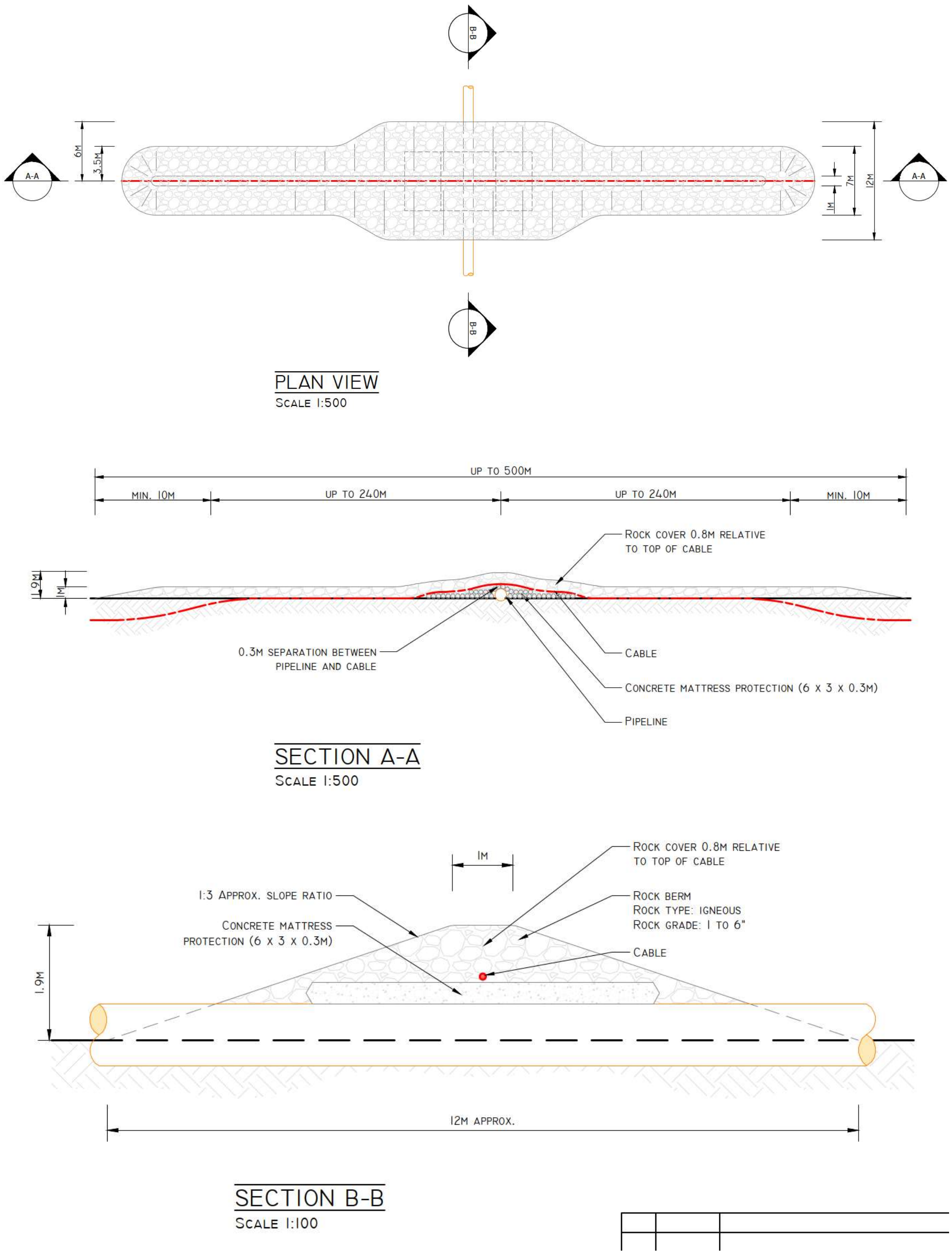


Figure 2-19: Representative concrete mattress – cable – rock crossing type

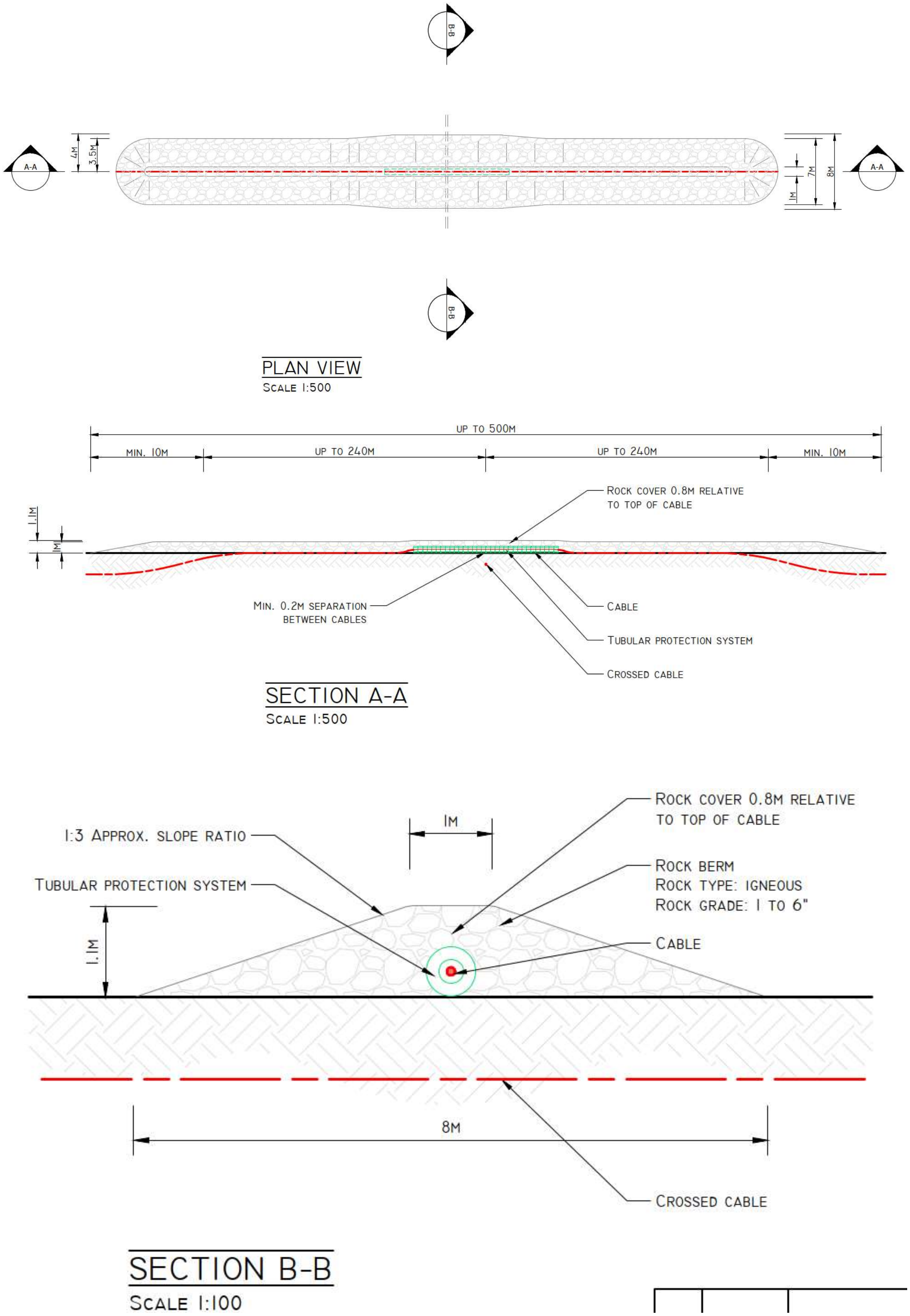


Figure 2-20: Representative separator – rock crossing type

2.3.4.3 Summary of subsea cable installation parameters

Key submarine cable installation activities aspects and parameters are summarised below in Table 2-7:.

Table 2-7: Summary of submarine cable installation activities aspects and parameters.

Aspect	Parameter	Value	Notes
Cable laying	Simultaneous cable lay	1 km	Maximum vessel separation
		0.5 km to 5 km per day	Range of vessel speeds
	Surface lay followed by post-lay burial	Up to 7 km per day	CLV can lay up to 7 km per day, with burial progressing more slowly
Cable jointing	Distance between joints	50 km to 100 km	Distance dependent on amount of cable carried by CLV or CLB
Cable crossings	Number of assets to cross	7	Six known crossings plus one contingency. For worst case scenario of two unbundled cables, up to 14 crossings.
	Total cable crossing seabed area effected	Total up to 49,000 m^2 for up to 14 crossings	Each crossing up to 1 km of berm (2 x cables with 500 m berm each), width of 7 m and up to 1.5 m high =7000 m^2. For seven crossings = 49,000 m2.

2.3.5 Cable burial

The primary protection method is to bury the cable along the majority of the marine installation corridor for protection purposes and to reduce the risks associated with potential fishing gear and anchoring interactions. A Cable Burial Risk Assessment (CBRA) (Anatec, 2021), was undertaken to inform the development of the Marine Scheme. The CBRA confirms the target burial depth of 1.5 m where achievable, with a minimum depth of at least 0.6 m for subsea cable installed within the Marine Scheme. This target burial depth is feasible for the majority of the cable length, provided that the correct burial tools are selected. Burial in the seabed provides the best protection for the cable and minimises potential for interference with fishing activity. Where the minimum burial depth cannot be achieved, cable protection, such as rock berms or mattresses, will be deployed.

Details of burial depths, dimensions of trenches required, and wider areas of potential seabed disturbance are discussed earlier in this chapter and summarised in Table 2-1.

The choice of burial technique or cable protection method will vary along the route depending upon the seabed conditions present in each section, informed by the findings of pre-construction surveys and micro-routing requirements for the subsea cable systems.

There are three generic types of equipment for burying cables, which may be deployed:

- Cable burial ploughs;
- Jetting machines (towed, free swimming or tracked); and
- Mechanical trenchers (tracked).

As discussed in Section 2.4.2, the cables will be laid and buried into the seabed by the main laying vessel directly (simultaneous lay and burial, see Figure 2-16), or by a support vessel following behind (post lay burial, see Figure 2-17).

2.3.5.1 Cable burial ploughs

Ploughs are towed behind a vessel and, although they are essentially passive, they can be steered and controlled remotely from the surface via an umbilical cable.

There are two principal types of cable plough: displacement ploughs, creating an open trench for the cable and non-displacement ploughs which lower the cable into the sediment. Non-displacement ploughs are towed either by the CLV or an auxiliary vessel following the CLV.

The displacement plough, creating an open 'V-shape' trench, is towed behind an auxiliary vessel, which displaces and piles up seabed material on either side of the trench.

Displacement ploughs are often used to pre-trench a cable, with the cable and trench left either to naturally backfill, backfilled using an MFE, or they may be backfilled with a relatively small amount of rock placement.

Non-displacement ploughs are typically used in simultaneous lay and burial but may also be used during a post-lay trenching campaign. Their use removes the need for backfilling, in comparison to displacement ploughing. A typical non-displacement plough is shown below in Figure 2-21.

The disturbance swathe for a displacement plough is typically 10 - 15 m wide, although the disturbed seabed footprint due to ploughing is only 2 - 5 m. The remainder of the disturbed area is due to the action of the skids and the berms to either side of the ploughed seabed.

For a non-displacement plough, disturbance is in a swath 8 -12 m wide and the actual disturbed seabed footprint due to ploughing is approximately 1 m, the remainder comprising the skids and plough.

Figure 2-21: Modular cable plough

2.3.5.2 Jet trenchers

Jetting trenchers may be self-propelling ROVs or they may be towed jetting sledges. Both use water jets to fluidise the seabed in front of, and around the cable, so that the cable sinks into the sediment under its own weight.

In medium to coarse sand and in gravels, the reconsolidation of fluidised sediments is significantly faster than in fine sands and silts.

Jetting is a viable technique in a wide range of sediments but performance decreases with:

- increase in sediment shear strength and cohesiveness (e.g. contents of clay);
- increase of organic content (peat); and
- increase of particle size (gravel, cobbles).

Systems can achieve burial depths in excess of 2 m in soft clays and fine sands, while in medium to coarse sands the achievable burial depths depend on the grain size of the sediment (i.e. on the re-sedimentation velocity) and on the presence and effectiveness of a backwash system.

Any trench remaining after re-sedimentation is left to back-fill due to the natural movement of sediment on the seabed.

In finer sediments the trench left behind is typically deeper than in medium sand and coarser seabed materials.

An example of a jet trencher ROV is shown below in Figure 2-22.

Figure 2-22: Canyon T750 tracked jet trencher

2.3.5.3 Mechanical trenchers

Mechanical trenchers are usually mounted on tracked vehicles and use saws, toothed wheels, or chisels to cut a trench. They work in a wide range of sediments, including weathered softer bedrock, and very soft sediment. However, they may have difficulty in certain types of rock (e.g., chalk with flints), large gravel, glacial till or boulder clays.

An example of a mechanical chain cutting trencher is shown below in Figure 2-23.

Figure 2-23: Canyon i-Trencher

A mechanical trencher makes a trench of 0.5 m to 1.0 m in width, with a wider swath of disturbance 5 m to 15 m wide.

A mechanical trencher follows cables that have been laid on the seabed, collects them, keep, them clear of active trenching, before guiding the cables into the trench and backfilling sediment back on top of the cable.

Backfill material and suspended sediment stays in the direct area of the trencher and the backfilled trench.

2.3.5.4 Mass Flow Excavation (MFE)

MFE may be used for the excavation of the HDD exit pits, displacement plough backfill and/or burial of joints, as well as to increase burial depth in sections of the marine installation corridor with medium to coarse sands, where achieved burial depths using other methods may not meet the required minimum burial depth. MFE uses low-pressure water to fluidise the seabed around the cable, allowing the cable to sink into the sediment. The MFE apparatus is kept above the cable and thus prevents any mechanical impact on the cable (Figure 2-24).

In medium to coarse sand MFE creates a depression with fluidised sediment in the seabed of typically 6 m – 12 m wide as it moves over the cable, this depression progresses over the cable as well. The majority of the fluidised sediment re-settles to the rear of the operation, thus backfilling the trench and covering the deeper buried cable.

Additional cable length is needed as the cable 'sinks' and this is achieved via a horizontal 'S-shape' of the 'as-laid' position of the cable as well as in the vertical 'S-shape' of the seabed terrain.

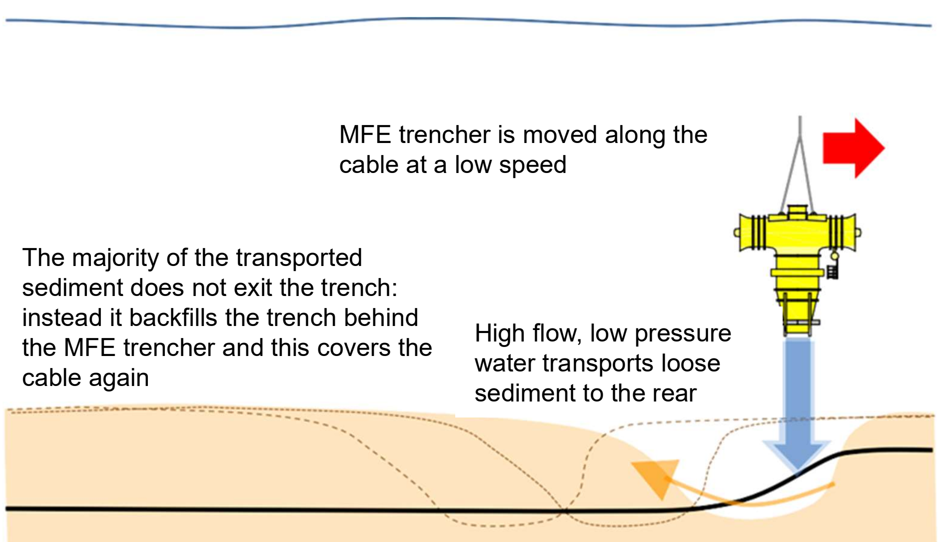


Figure 2-24: Progressing hole while lowering a cable using Mass Flow Excavation

In fine sand and silt MFE leaves behind an open trench with very little cover on the cable. MFE for reburial in fine sands therefore needs to be combined with active backfilling of the trench, for instance by using dredged sand.

Suspended sediment stays in the direct area of the operations and either re-settles in the created trench or in its direct vicinity. The seabed footprint of MFE depends on the density of the sediment, however, in more densely packed sands, this method creates a trench less than 10 m wide. In more loosely packed sand the width of the trench created can be over 10 m, but is less than 20 m.

2.3.6 Other cable protection measures

Additional cable protection will be required where the achievable burial depths using the methods outlined in Section 2.5.3 cannot meet the target depths detailed in Table 2-1. Measures and methods for providing additional cable protection are described below.

2.3.6.1 Rock placement

Rock placement will be required in locations where the target burial depth cannot be achieved and at cable crossings. The requirement for rock placement will be minimised and analysis of modifications to target burial depth, exact installation methodology and/or repeat burial will be considered first, with rock placement a 'last resort'.

A rock berm provides a strong protective cover to prevent potential impact and snagging and ensures stability by shielding the cable from the current flow. The size of the berm and grade of rock required will depend on the current and wave loading conditions. The size (grade) of rock needed for a dynamically stable rock berm decreases with increasing water depths. In shallower waters the wave induced water action at the seabed is larger than in deeper waters, requiring a larger rock grading.

Rock placements are designed to be dynamically stable; however, some level of maintenance (periodic inspections and replacement of disturbed rock) will be required, particularly in shallow water, where the impact of the waves under storm conditions is greater than in deeper water.

Where rock placement is required to protect an exposed or shallow buried cable, the height and width of these berms will be kept to a practical and safe minimum, typically, a height of 0.5 m to 1 m, with a width of 7 m. Up to 63 km of berm may be required for the protection of the cables (including estimated placement of approximately 52 km plus contingency), with a further 7 km estimated for cable crossings (assuming 2 cables crossing each of 7 cables, with each crossing 500 m).

Table 2-8: Rock berm footprint parameters

Aspect	Parameter	Value
Rock Placement - Berm	Total length	Up to 63 km
	Width	Up to 7 m
	Height	Up to 1 m
Cable crossings	Total length	Up to 7 km
	Width	Up to 7 m
	Height	Up to 1 m
Rock placement (berms, cable crossings, joints, and HDD exits)	Volume - Scottish waters - English waters	Up to 13,8983.228 m^3 Up to 400,695.871 m^3
	Tonnage -Scottish Waters - English waters	Up to 185,310.971 m^3 Up to 534,261.161 m^3

A representative drawing of a rock berm cross section is shown in Figure 2-25, with planned rock placement based on understanding of ground conditions illustrated in Figure 2-26.

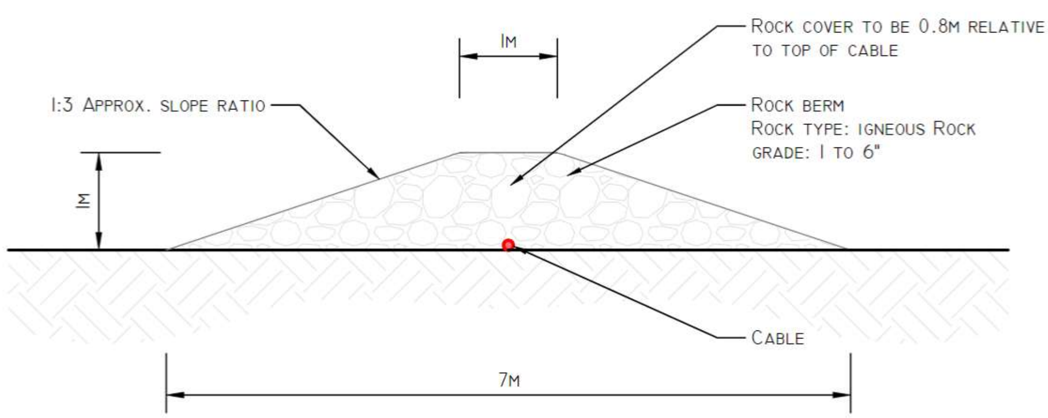
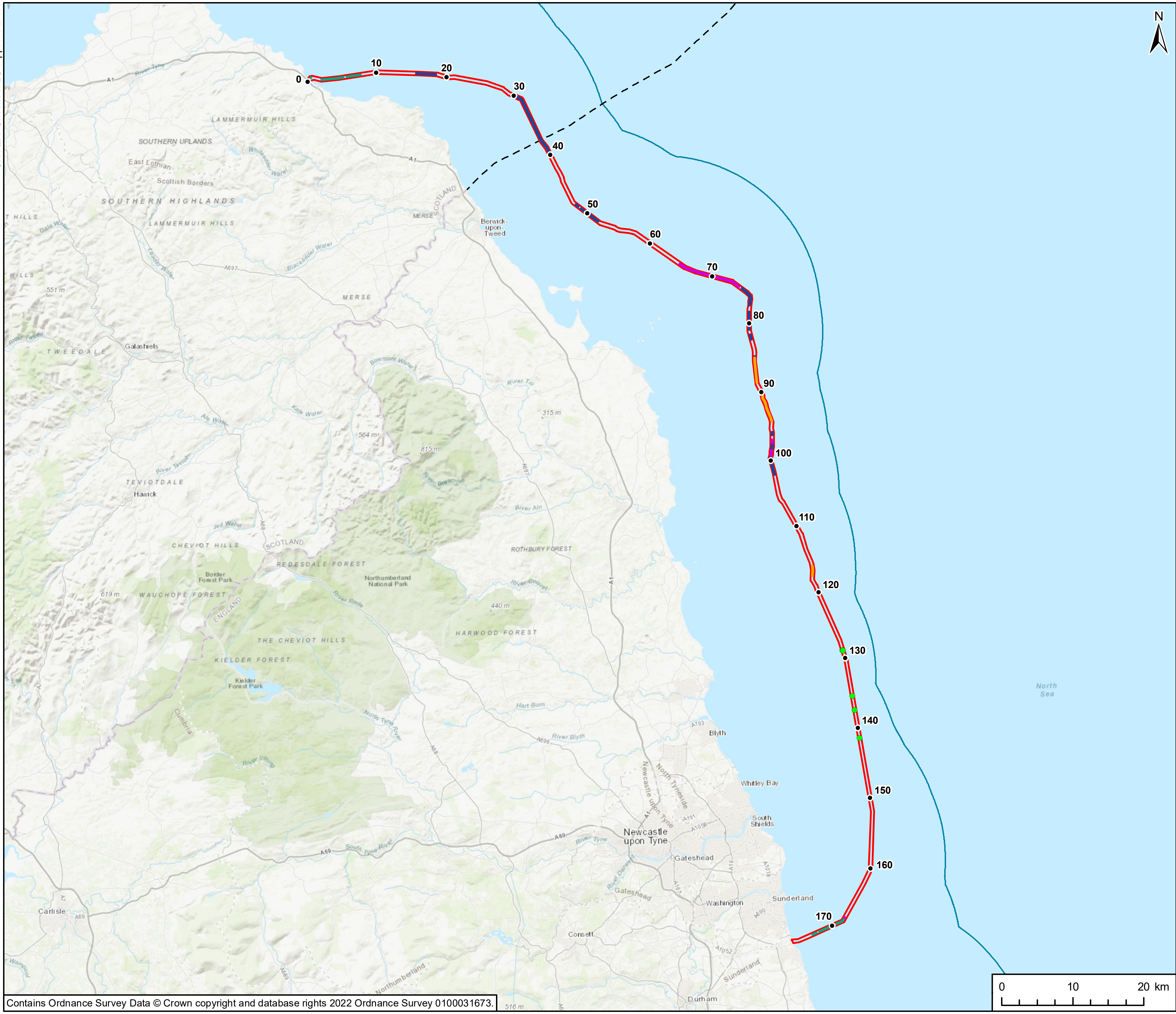


Figure 2-25: Representative drawing of rock berm

GIS: ER Checked: LC Approved: TN



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Coordinate System: WGS1984 Zone 30N

Scale @ A3 1:500,000

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SP TRANSMISSION

PROJECT

Scotland England Green Link 1 / Eastern Link 1

KEY

- Marine Installation Corridor
- Kilometre Point (KP)
- Scottish/English Water Border
- UK Territorial Sea Limit
- Indicative Rock Replacement Crossing Location

Indicative Rock Replacement Location

- Category 2
- Category 3
- Category 4
- Category 5

TITLE

Figure 2-21
Indicative Rock Placement Locations

REFERENCE

SEGL1_M_EAR_2-21_v3_20220421

SHEET NUMBER: 1 of 1

DATE: 21/04/2022

2.3.6.2 Concrete mattresses

Mattresses comprise pre-fabricated articulated concrete structures made of individual blocks connected by ropes or straps. These can be place directly on top of a cable to stabilise and provide protection.

Up to 300 mattresses may be required to protect the subsea cable systems at cable and pipeline crossings, and another 20 at HDD breakout locations. Standard mattress dimensions are 6 m by 3 m.

Table 2-9: Concrete mattress footprint parameters

Aspect	Parameter	Value	Notes
Mattresses (cable and pipeline crossings)	Number	Up to 300	
	Footprint	Up to 5,400 m^2	Assumes mattress of 6 m by 3 m
Mattresses (HDD breakouts)	Number	Up to 20	
	Footprint	Up to 360 m^2	Assumes mattress of 6 m by 3 m

2.3.7 Interim and as-built surveys

During the installation phase, interim surveys will be performed after each trenching operation to determine if trenching is sufficient and to identify areas requiring remedial activities such as additional trenching passes or rock placement.

Once the cables are fully installed and protected, an “as-built” survey will be undertaken to confirm the positions of the cables and associated protection measures. The “as-built” surveys will form the baseline for further monitoring during the operation phase as described in Section 2.4.1.

2.4 Operation phase

2.4.1 Monitoring surveys

During the operation phase, surveys will be undertaken to monitor condition of the cables. These surveys will determine the seabed level which will allow the cable burial to be assessed. Monitoring survey methods are anticipated to include ROV and geophysical survey techniques.

It is anticipated that surveys will be undertaken every one to two years following completion of the installation phase. The results of the initial surveys will be used to determine the frequency of future surveys and identify areas requiring more regular surveys based on the potential natural and anthropogenic threats to the cables.

Requirements for surveys of third-party assets such as cable crossings will be agreed as part of any required crossing agreements made with asset owners, may affect the frequency and nature of monitoring surveys. Furthermore, new or changed third-party activity in proximity to the cable throughout the life of the Project may also require the survey frequency to be reviewed.

2.4.2 Cable maintenance

Following installation, the cable system is designed to avoid the need for routine maintenance and therefore no planned maintenance work is anticipated for the cables or their infrastructure during the lifetime of the Marine Scheme.

However, monitoring surveys (see Section 2.5.2) may possibly indicate the need for preventative maintenance to increase burial protection along certain parts of the cable route in localised areas of mobile seabed where there may be risk of exposure of the cable over time. This may involve the use of methods to increase burial depth, for example a MFE, or rock / concrete mattress placement, to provide additional protection to the cables.

The methods and scale of materials anticipated to be required during the operation phase fall within the parameters of impacts appraised in this EAR for cable installation and protection, although and remediation will be on a smaller and more localised scale.

2.4.3 Subsea cable repairs

Repairs to subsea cables that have been designed, manufactured, installed and protected correctly are not common. Two situations may lead to a repair scenario:

1. Internal Faults – mechanical or electrical faults within the cable due to a design or manufacturing error or defect; and
2. External Faults – including third-party damage from anchor strikes, towed fishing gear or other third party works.

A suitable vessel may need several months to complete repair work, which may include:

- Find location and extent of the fault;
- Loading of spare cable to the repair vessel and transit to location;
- Cutting of damaged section using diver;
- Replacement and jointing of the damaged section;
- Lowering of the new repaired section and joints to the seabed; and
- Protection of the cable repair once laid in position on seabed.

2.5 Decommissioning phase

In the years leading up to the end of the Marine Scheme's operational life, the options for decommissioning will be evaluated through integrated environmental, technical and economic assessments. The objective in undertaking these assessments will be to minimise the short- and long-term effects on the environment, whilst ensuring that the sea is safe for others to navigate. The level of decommissioning will be based upon the regulations, best practices and available technology at the time of decommissioning.

It is acknowledged that current methods for the recovery and disposal of redundant cables are often difficult, expensive and potentially harmful to the environment. The Applicant will retain liability for any residual cable sections, should it be determined that they be left in-situ, in perpetuity or as agreed with Crown Estate Scotland and Marine Scotland (in Scottish waters) and The Crown Estate and MMO (in English waters). An Out of Service Deed will be entered into by the Applicant as required.

2.5.1 Decommissioning options

The objectives during the decommissioning process will be to minimise short and long term effects on the environment whilst making the sea safe for others to navigate. The level of decommissioning will be based upon current regulations/practices and available technology.

All offshore cables, sections of offshore cables or cable ends that are exposed at the time of decommissioning, or likely to become exposed, will be recovered unless studies show that they will not pose an enduring threat to other seabed users or that further burial or coverage can negate such circumstances. This will be determined by examination of the data on the seabed / cable stability and position from all surveys performed, prior to decommissioning of the site.

The principal options for decommissioning are:

- Leave in situ, buried;
- Leave in situ and provide additional protection where exposed;
- Remove sections of the cable that present a risk; or
- Remove the entire cable.

Any subsea trenches left after cable removal would be allowed to naturally infill where this does not represent a risk to marine users, otherwise they may be subject to remedial works where required. If natural backfilling of the trench has not occurred, remedial backfilling could be considered, subject to trench depth and profile.

Prior to decommissioning, a contingency plan will be developed for resolving the potential issue of cables becoming exposed post-decommissioning.

Mattresses and scour protection materials (rock placement material) are expected to be left in situ.

2.5.2 Leaving cables in situ

Should the recommendations of the environmental and economic assessments be to leave the cable in situ, the approach taken will be determined by the burial status of the cable. This itself, will be determined based on the mobility of the seabed and/or cable over the design life as indicated by operational surveys. Any mattresses and rock placement materials will also be left in situ.

Prior to decommissioning, a contingency plan will be developed for resolving the potential issue of cables becoming exposed post-decommissioning should it be determined that the cables are to remain in-situ.

2.5.3 Removal of cables

Cable removal, either in sections or entirety involves pulling the cable out of the seabed and reeling onto a carousel for transfer and disposal.

The strength of the sediments and depth of burial will dictate whether the cable is likely to be 'stripped-out' of the seabed along sections of the route, or whether removal of material burying the cable is required.

Unburying the cable will use a jetting device to expose a short section of cable or a grapnel tool to raise the cable to the surface. Various grapnel types are available (see Section 2.3.2.2) and could be deployed.

Typically, the most efficient way to remove excessive overburden is an MFE, as other means of deburial risk damaging the cable and making recovery even more difficult.

Once the cable is exposed, there are two ways to expose the full length of cable. If cable "peel out" forces are not too excessive, a gripper could be attached to the cable to then lift a cable end back to the cable recovery vessel. Cable recovery could then proceed directly. Alternatively, a cable under-roller could be used to run the full length of the buried cable. This device would be connected back to a vessel by a steel wire and raises the cable back to seabed level.

Both schemes would ensure that a cable end is recovered back onto the cable recovery vessel with cable recovery then commencing for the full cable length. Alternatively, lengths could be cut and stored separately.

The cable recovery process would essentially be the reverse of a cable laying operation, with the cable handling equipment working in reverse gear and the cable either being coiled into tanks on the vessel or guillotined into sections approximately 16 m to 10 m long immediately as it is recovered. These short sections of cable would be then stored in skips or open containers on board the vessel for later disposal through appropriate routes for material reuse, recycle or disposal.

Prior to decommissioning, a contingency plan will be developed for resolving the potential issue of cables becoming exposed post-decommissioning should it be determined for the sections of the cables to remain in-situ. Post decommissioning route would then be surveyed to ensure that all cable had been removed, with survey results provided as proof of removal.

2.5.4 Disposal of cable

During the decommissioning of the assets the wastes must be handled, stored and disposed of according to waste management legislation and environmental best practices. The waste hierarchy will be considered, which rank the disposal options in order of most-favoured to least-favoured: prevent, re-use, recycle, other recovery, disposal.

2.5.5 Decommissioning programme

The decommissioning programme is expected to be similar to that during installation and to involve similar vessels and timescales to the installation phase.

No post-decommissioning monitoring of the seabed is proposed for the Marine Scheme at this stage.

2.6 Emissions

There are several emissions which may occur to varying degrees during installation or operation of the Marine Scheme. These emissions include:

- Electric and magnetic fields (EMF);
- Heat; and
- Noise.

2.6.1 Electric and Magnetic Fields (EMF)

EMF are generated when electrically charged particles are accelerated. EMF occurs naturally within the marine environment, and are defined as:

- Magnetic Field: Both bundled and non-bundled HVDC cables in a bipole [5] arrangement are currently considered for the Marine Scheme as introduced in Section 2.2.3.1. When HVDC cables are installed in a bipole arrangement the strength of magnetic field produced by the cable will depend on the current flowing in the cables, the separation of the cables and the distance from the cables of measurement;
- Electric field (E field): The cables themselves produce no external electric field because of the presence of a metallic outer sheath;
- Induced Electric field (iE field): iE fields are induced in the sea water as it passes through the geo-magnetic field. The strength of these fields is dependent on the geo-magnetic field strength and sea water chemistry, viscosity, its flow velocity and direction relative to the direction of the geomagnetic field; and

Naturally occurring induced electric fields also occur and for the North Sea have been measured at 35 μV/m (Pals, Peters, & Schoenhage, 1982). Given the background EMF levels, the induced electric fields could range between 24.5 and 61.3 μV/m (Tripp, 2016). However, the strength of the electric field in the sea varies continuously because of the varying speeds and directions of the water flow that are consequences of the tides and weather conditions, but it is essentially a static field.

An EMF Assessment has been undertaken for the Marine Scheme and is provided in EAR Volume 3 Appendix 2.1.

2.6.1.1 Magnetic fields

Both bundled and non-bundled bipole systems are being considered for the Marine Scheme.

Table 2-10 shows assumed operating conditions for the two options in consideration, while Table 2-11 shows the maximum calculated field at a burial depth of 1m.

[5] Bipole cable arrangement has two conductors - one is positive, and the other one is negative to the earth. This contrasts with a monopole cable which as a single conductor of negative polarity.

Table 2-10: Operating conditions for cable design options

Cable Configuration	No. of cables	Power per cable	Current per cable	Voltage
Bundled bipole (0.2 m)	2	1 GW	2000A	550kV
Bipole 30 m separation	2	1 GW	2000A	550kV

Table 2-11: Maximum total magnetic field from the cables and geomagnetic field for increasing vertical distance from the seabed and maximum current load

	Maximum cable and geomagnetic field					
Distance above seabed	Seabed	0.5 m	1 m	5 m	10 m	20 m
Bundled bipole (0.2 m)	126.8	83.69	68.68	51.79	50.33	49.88
Bipole 30 m separation	404.4	273.2	212.7	102.8	82.99	66.82

Figure 2-27 shows the magnetic field with and without geomagnetic field at the seabed for a bundled bipole design at maximum current load.

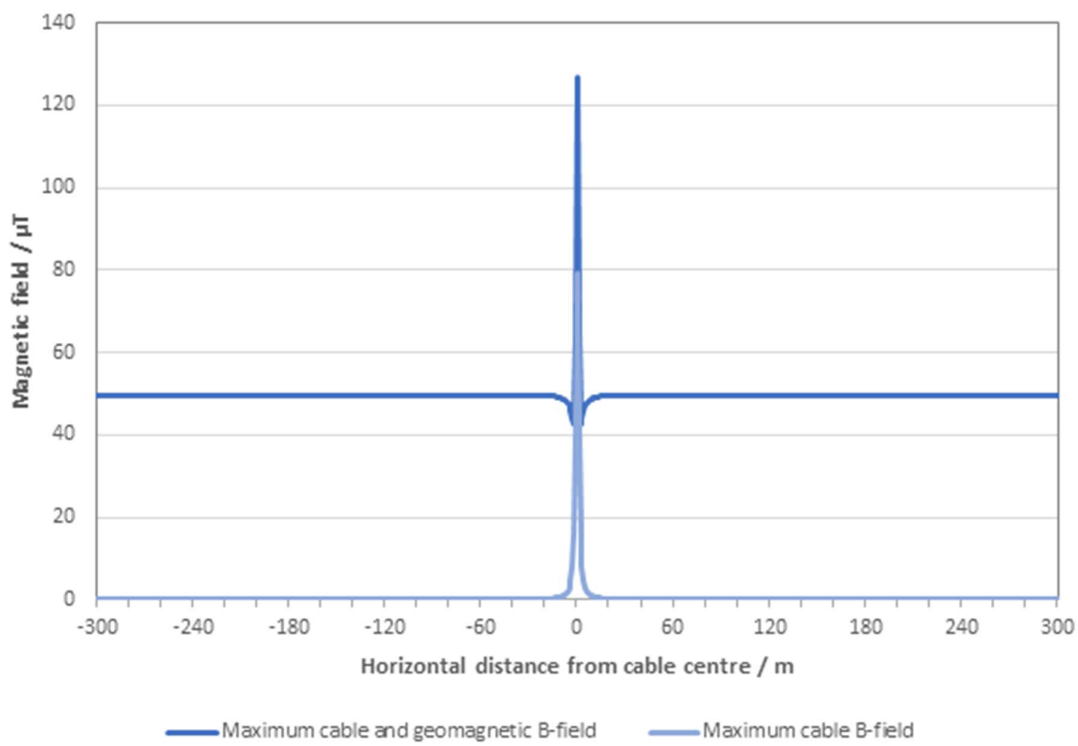

Figure 2-27: Magnetic field with and without geomagnetic field at the seabed for a bundled bipole design

Table 2-12: Anticipated maximum magnetic field strength of cable bundle at seabed

Distance to Cable (m)	Cable magnetic field strength (μT)	Earth geomagnetic strength (μT)	Total magnetic field strength (μT)
0.5	35.4	83.69	119.09
1	19.95	68.68	88.63
5	2.22	51.79	54.01

2.6.1.2 Induced electrical fields associated with subsea cables

The magnetic field produced by the cables decreases with distance from the cables. The movement of the sea through that magnetic field results in a small localised electric field being produced, the induced electric field. A background electric field will also be present in the sea due to the geo-magnetic field and localised magnetic anomalies.

The convention for calculating induced electric fields for the Basslink, BritNed HVDC and Western Link connections is as follows:

- Induced electric field (μV/m) = Velocity (m/s) x Magnetic field (μT)

The induced electric field for both bundled and non-bundled approaches to cable arrangement for the Marine Scheme, under a range of tidal velocities, is shown in Table 2-13.

Table 2-13: Induced electric field using the calculated magnetic fields provided in Table 2-13 for a range of tidal velocities at increasing vertical distances from the cables.

		Induced electric field (μV/m)			
	Tidal velocity	0.1 m/s	0.3m/s	0.75 m/s	1.25 m/s
Bundled bipole (0.2 m)	Seabed	12.68	38.04	95.10	158.50
	0.5 m	8.37	25.11	62.77	104.61
	1 m	6.87	20.60	51.51	85.85
	5m	5.18	15.54	38.84	64.74
	10 m	5.03	15.10	37.75	62.91
	20 m	4.99	14.96	37.41	62.35
Bipole 30 m separation	Seabed	40.44	121.32	303.30	505.50
	0.5 m	27.32	81.96	204.90	341.50
	1 m	21.27	63.81	159.53	265.88
	5 m	10.28	30.84	77.10	128.50
	10 m	8.30	24.90	62.24	103.74
	20 m	6.68	20.05	50.12	83.53

2.6.1.3 Magnetic compass deviations

A Compass Deviation Assessment was undertaken for the Marine Scheme (see EAR Volume 3 Appendix 2.1). In a bipole arrangement, the magnetic fields produced by the cables will depend on the current flowing in the cables, the separation of the cables and the distance from the cables. A bipole system, such as that proposed for the Marine Scheme, will result in the cancellation of the magnetic fields when the cables are in close proximity, however, in separate trenches they will act like single cables which is the worst-case for magnetic fields, which this appraisal is based upon.

The magnetic fields from the cables, if large enough, will combine with the Earth's magnetic field and can cause a compass to indicate north in a different direction to the magnetic north pole. Current MMO advice states that they would be willing to accept a three-degree deviation for 95% of the Marine Scheme and for the remaining 5%, no more than five-degrees of deviation.

The Compass Deviation Assessment was undertaken using the worst-case scenario of two cables in separate trenches 30 m apart operating at 2000 A per cable. Bathymetry data collected in 2021 was used to confirm the cables' orientation and water depths, which will all impact the extent a compass is deviated from the Earth's magnetic north. The Compass Deviation Assessment confirmed that using the worst-case scenario, 31.1% of the Marine Scheme has less than three-degree deviation and 69.3% has less than five-degree deviation.

It is possible to reduce these deviation effects, and further assessment will be undertaken following appointment of the installation contractor and once detailed design of the cable routes within the marine installation corridor has been undertaken. The detailed engineering design will aim to optimise cable configuration to minimise compass deviation across the Marine Scheme.

2.6.2 Heat

The process by which subsea power cables and other imperfect conductors generate heat is termed resistive heating. It is caused by energy loss as electric current flows and leads to heating of the cable surface and warming of the surrounding environment.

The use of high voltages minimises heat losses and resultant environmental warming effects because current loads are relatively small. Additionally, DC systems result in less heat loss to the environment for a given transmission rate than AC cables (OSPAR, 2009) such that relatively smaller environmental heating effects would be expected for a given power transmission.

Where subsea power cables are buried, the surrounding sediment may be heated but cables, whether buried or not, have negligible capability to heat the overlying water column because of the very high heat capacity of water.

For the purposes of this EAR, Figure 2-28 below provides an indicative temperature distribution profile for bundled cables buried at a depth of 1.5 m, as a worst case, where the ambient seabed maximum temperature has been assumed to be 15^{o}C.

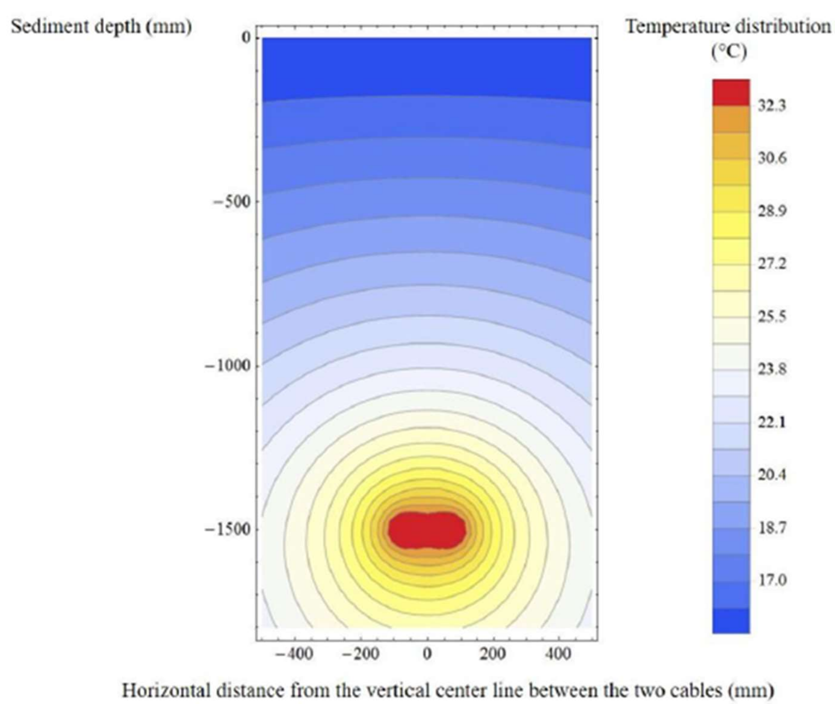

Figure 2-28: Temperature distribution in the vicinity of a bundled pair of 1800mm^2 Cu SLPE cables operated at +/- 515kV

2.6.3 Noise

The predominant noise generating activities during the Marine Scheme are:

- Geophysical survey equipment (e.g. multi-beam echo sounder (MBES), sidescan sonar (SSS), sub-bottom profiler9 SBP) and ultra short baseline (USBL) acoustic positioning;
- Cable trenching, mechanical cutting and MFE;
- Placement of rock protection or concrete mattresses;
- Vessels using DP; and
- Support vessels.

These activities will occur during the installation, the maintenance and repair elements of operation and decommissioning phases of the Marine Scheme.

The activities include examples of both impulsive and non-impulsive (or continuous) sound sources. Impulsive sound, such as that generated by geophysical survey equipment, is characterised by short duration pulses (< 1 second), these sounds have a broadband bandwidth have a rapid rise and decay period with a high peak pressure. In contrast non-impulsive sound, such as generated by vessel movements and dynamic positioning, do not have rapid rise and decay times or a high peak pressure.

2.6.3.1 Background noise context

Underwater sound produced by the Marine Scheme must be considered against a background of noise produced by other human activities in the area, and in particular, shipping. These ships include merchant vessels, tankers and ferries, fishing vessels and offshore industry support vessels (Chapter 13: Shipping and Navigation). The number of vessels involved in the Marine Scheme phases, will make a very minor contribution to the overall intensity of vessel movements.

Underwater sound in the North Sea is dominated by shipping sounds. Total underwater sound levels, from both shipping and natural sound range from 105 dB to 130 dB re 1 µPa Sound Pressure Level (SPL) and are significantly higher than natural noise levels (Joint Monitoring Programme for Ambient Noise North Sea, 2022). Ambient underwater sound is higher in the southern part of the North Sea, including in the Humber region and towards the English Channel.

2.6.3.2 HDD

Sound measurements made during a generic HDD operation, in shallow riverine water, recorded, in the absence of vessel noise, a maximum unweighted Sound Pressure Level (SPL), of 129.5 dB re. 1µPa (Nedwell, Brooker, & Barham, 2012).

2.6.3.3 Geophysical survey

Table 2-14 provides typical acoustic properties associated with the survey techniques that may be required during geophysical surveys.

Table 2-14: Acoustic properties of survey equipment

Sound Source	Example equipment	Frequency (kHz)	Maximum Sound Source Level (SPL_{PEAK} dB re 1 uPa @1m)
Multibeam echo sounder (MBES)	Kongsberg Maritime EM 2040 Dual Rx system	170 – 450	221
Side scan sonar (SSS)	Edgetech FS4200 SP (300-600kHz dual frequency)	300 - 600	210
Sub-bottom profiler (SBP)	Innomar SES-2000, Edgetech Chirp & Applied Acoustics 201 boomer	0.5 – 12	238
	Innomar Medium 100	100	238
Ultra-short baseline (USBL)	Kongsberg HiPAP 502	21 - 31	207

2.6.3.4 Cable laying activities

The cable installation will comprise, as a worst-case, two installation vessels (one laying the cable and one burying the cable). These offshore vessels will be moving at a rate of 0.5 km to 5 km per day, but if separate lay/burial is conducted progress is up to 7km/day, on a 24-hour basis, therefore noise generated at any one location will be transient and temporary. However, at joint locations, the installation vessels could be stationary for approximately 1 week. Whilst it is not possible at this stage to specify the exact joint locations, it is anticipated that they will be some distance offshore.

A study undertaken by Nedwll et al.(2003) recorded noise emissions during the installation of the submarine cable associated with the North Hoyle Offshore Wind Farm. Levels were recorded at a range of 160 m from trenching activities with hydrophones at 2 m depth (necessary because activities were being undertaken in very shallow water). The SPL was recorded at 123 dB 1m Pa, with trenching noise found to be a mixture of broadband noise, tonal machinery noise and transients (assumed associated with rock breakage). It was noted that the noise was highly variable, depending on the physical properties of the area of seabed. Analysis of the data indicated that if a transmission loss of 22 log (R) is assumed, a Source Level of 178 dB re 1μPa @ 1m results. The above measurements are comparable to the stated source noise level for dredging activity in Richardson et al. (1995) of between 172 and 185 dB re 1 μPa @ 1m and in OSPAR (2009) of between 171 and 189 dB (peak) re 1 μPa @ 1m.

2.6.3.5 Rock placement

In studies of noise generated by rock placement, it was noted that it was possible to faintly hear rocks falling through the fall pipe to the seabed, but the underwater sound was dominated by the sound of dynamic thrusters of the vessel (Nedwell, Brooker, & Barham, 2012). SVT Engineering Consultants (2010) estimated source noise levels were expected to be in the region of 120 dB re 1 μPa @ 1m. An earlier study by Nedwll et al. (2003) estimated that the expected noise levels for rock placement and similar activities was approximately 177 dB re 1 μPa @ 1m. This is broadly comparable with cable laying activities.

2.6.3.6 Vessel sound

Vessels operating under dynamic positioning (DP) to maintain station using thrusters can create cavitating bubbles which can implode with high acoustic energy in the water. Cavitation can cause damage to impeller and tunnel materials and also lead to the propagation of underwater sound in the marine environment. The source sound levels, and sound characteristics will depend on the exact vessel being used, however quoted sound levels range between 177 and 197 dB re 1 μPa @ 1m and frequencies lie towards to the lower end of the spectrum at 3 kHz and below (AT&T, 2008) (Ross, 1993) (Genesis, 2011).

Project support vessels, in the small to medium size range (up to ~ 100 m long) not be operating on DP, are likely to produce broadband non-impulsive sound in a range between 160 dB re 1 μPa @ 1m (tug/barge assumed equivalent to a guard vessel) and 180 dB re 1 μPa @ 1m (supply ship) (Richardson, Greene, Malme, & Thomson, 1995) (OSPAR, 2009).

2.7 Marine scheme footprint and zones of influence

The zone of influence (ZoI), i.e. spatial extent, over which the Marine Scheme is predicted to have an impact on the receiving environment, has been established for the marine installation activities discussed above. ZoI is based on worst case assumptions as presented in Table 2-15.

Table 2-15: Installation footprint and zones of influence

Project Activity		Description	Maximum Zone of Influence
Shallow water cable installation (out to 10m water depth)	Vessel positioning	Anchors may be used to maintain the position of vessels in shallow waters: CLB: Up to 8 anchors may be used, secured up to 500 m from vessel. Shallow draft vessel: similar to CLB, or 2 spud cans, associated with 4 point mooring systems (30-Ton pull	Various points within 800 m radius of the vessel within the marine installation Corridor

Project Activity		Description	Maximum Zone of Influence
		anchor winches), 800 m wire rope and 5t Flipper delta anchor. Jack up barge [x spud cans (2-4) of 6-8 m diameter/area - inform anchoring system and footprint]	Spud cans – 50 m² (for 4 spud cans) at various locations within the marine installation corridor
		Vessels will be requested to remain a safe distance (500 m) from anchoring systems.	If anchors are located up to 800 m from vessel (detailed above) a 500 m advisory safety zone gives a ZoI of up to 1300 m from vessel
		Vessels will be requested to remain at a safe distance from the CLV, CLB, shallow draft vessel or jack up barge.	500 m radius
	HDD and installation of cable ducts	Breakout will be excavated using a jack-up or barge mounted excavator, such as back-hoe dredger or MFE. Ducts ends will be buried using an excavator located on jack up / barge, such as back-hoe dredger, MFE or possibly by diver jetting / eductor (venturi lift)	5,000 m² (area of the seabed directly affected by works at breakout point) at both landfalls
		Up to 4 ducts will be installed in each landfall site, with an estimated diameter of 660 mm, and maximum length of 1500 m.	No footprint at the seabed surface
		Volume loss (see HDD feasibility study)2000 m^3 of drilling fluid and 80 m3 of solids (drill cuttings) to be discharged for each hole. Potential worst-case (6 **drills**, up to 4 **ducts**).	12,000 m^3 of drilling fluid and 480 m^3 of solids for each landfall
		Breakout point protection after installation	It is anticipated that ducts and cable will be buried using MFE/excavator/diver. The only possible temporary protection is mattresses say 6 per duct. 10,000 m² Pre-cut trenching 20 mattresses 9000 m^3 for each landfall
Cable installation (water depths greater than 10 m)	Vessel positioning	Vessels will be requested to remain at a safe distance from the cable laying vessels	500 m exclusion zone
	Pre-installation	Use of ploughs or grabs to remove boulders and obstructions	Where required, across a swathe of up to 25 m wide
		Pre-lay grapnel run to remove debris	Swath up to 3 m wide
		Sea trials	Up to 5 km of trial trenching, up to 15 m wide.
		Pre-installation trenches, only required at a short section close to Seaham and Torness landfalls (up to 200 m)	Up to 200m long, 1.5 m deep and 30 m wide.

Project Activity		Description	Maximum Zone of Influence
	Installed footprint	Trenches: Two cables, plus a fibre optic cable will be laid, bundled in one single trench or separated in two trenches within the marine installation corridor. Cable trenches will be typically 1m wide but could reach (or 6 m in soft/sandy substrates), with burial target 1.5m, with minimum of 0.6m.	Up to 25m route preparation and burial tool footprint. Trench typically less than 6m. Corridor length of 176 km
		Disturbance during cable burial: Displacement Ploughs: The swath of disturbance when burial is achieved using a plough 8 to12 m wide (displacement plough). The actual disturbed seabed footprint due to ploughing is up to 1 m wide, comprising the skids and plough. Jet trenches: The swath of disturbance when burial is achieved using a jetting is typically 6 to10 m wide. The actual disturbed seabed footprint due to jetting is circa 1 m. Mechanical trenches: The swath of disturbance when burial is achieved using a plough is typically 8 to 15 m wide. The part of the swath disturbed due to trenching is 1 to 3 m wide.	Disturbance caused by: Ploughs up to15 m wide Jet trenches: up to10m wide Mechanical trenching equipment: up to 15m wide
	Cable protection MFE (temporary)	The seabed footprint of MFE depends on the density of the sediment. In more densely packed sands, the width of the swath disturbed is typically 3 to 5 m. In more loosely packed sand the width of the trench created can be up to 10 m but typically stays less than 6 m. (example from previous project)	Generally, 10 m but up to 20 m wide swath. 1.5 km for the pre-cut trench at the HDD exit. Possible remediation on sandwaves (up to 6km).
	Cable protection (definitive)	Rock placement. Total length up to 63km + 7km for crossings Mattresses – worse case 300 for crossings and 20 for HDDs	Rock berm Up to 7 m wide Up to 1 m high Up to 9.1 tonne / mattress
Installation sound		DP component of vessel generated sound has most potential for propagation and disturbance.	Up to 5 km
Electromagnetic field (EMF)	HVDC cables	Non bundled with trenches at maximum separation	Up to 20 m
Turbidity	Sediment dispersion	Displacement plough	Up to 1.5 km
Heat	HVDC cables	Heating of sediment surrounding buried cables	1.5m burial to achieve no more than 3 degrees increase above ambient sediment surface temperature at 0.5m below surface

2.8 Embedded mitigation and regulatory requirements

The design of the Marine Scheme has facilitated mitigation, with potentially significant effects avoided or minimised as far as reasonably practicable through the design process.

A summary of the mitigation and regulation considered embedded in the design and development of the Marine Scheme is provided below in Table 2-16.

Table 2-16: Summary of embedded mitigation

Activity / issue	Embedded mitigation commitment
Pre-installation	
Micro-routeing	Detailed route development and micro-routeing to be undertaken within the marine installation corridor to avoid or minimise localised engineering and environmental constraints.
Pre-installation surveys	Pre-installation surveys will inform detailed engineering and cable installation planning. They will focus on collection of detailed information within the preferred route for each of the cables, all within the marine installation corridor. They will confirm the absence or presence of any new obstructions or significant changes to seabed conditions and bathymetry, and also help to inform detailed Unexploded Ordnance (UXO) assessment. Survey methods may include: • Acoustic methods such as multibeam and single beam echo sounders, side scan sonar (SSS), and sub-bottom profiler; • Magnetometer/gradiometer to identify magnetic anomalies and metallic targets; • Visual methods including drop down video or remotely operated vehicle (ROV); and • Geophysical investigations such as vibrocore and cone penetration test (CPT).
Geophysical Surveys – underwater sound	Given the potential for injury from the use of the Sub-Bottom Profiler (SBP), mitigation measures recommended in the JNCC guidelines for minimising the risk of injury in marine mammals will be adopted, available from: https://data.jncc.gov.uk/data/e2a46de5-43d4-43f0-b296-c62134397ce4/jncc-guidelines-seismicsurvey-aug2017-web.pdf. The measures below will be included in a Marine Mammal Protection Plan (MMPP), as part of the CEMP developed for the Marine Scheme: The JNCC guidance minimises the potential for injury to cetaceans from the SBP activities using marine mammal observation. Thus, before a geophysical activity begins, there will be a period of observation by a qualified Marine Mammal Observer (or passive acoustic monitoring in the case of operations during the hours of darkness). Thus, the likelihood that any animals are within 500 m of the source, the standard observation zone, at the point at which the SBP is activated is very low. Following the observation period, SBP survey activities only commence after a period when no animals have been seen.
Profile of rock berms	The profile of rock berms will be designed to minimise the potential for scour to occur as much as possible. Adopting such a best practice approach will reduce the impact associated with elevated suspended sediment concentrations due to localised scouring at the edge of berms from minor to negligible and is to be implemented where practicable.
CEMP	A CEMP, including an Emergency Spill Response Plan, Waste Management Plan, Marine Mammal Protection Plan, Fisheries Liaison and Co-existence Plan (FLCP) and Fisheries Management and Mitigation Strategy (FMMS) will be developed prior to commencement of works.
Fisheries Liaison Officer	A Fisheries Liaison Officer (FLO) will be appointed for the installation phase and as required during the Operation (including maintenance and repair) Phase. Requirements for decommissioning phase will be determined following economic and environmental appraisals. Adherence to good practice guidance on the approach to fisheries liaison and mitigation (e.g. FLOWW, 2014; 2015).
Fisheries Liaison Officer	A Fisheries Liaison Officer (FLO) will be appointed for the installation phase and as required during the Operation (including maintenance and repair)

Activity / issue	Embedded mitigation commitment
	Phase. Requirements for decommissioning phase will be determined following economic and environmental appraisals. Adherence to good practice guidance on the approach to fisheries liaison and mitigation (e.g. FLOWW, 2014; 2015).
Procedures	Development of a procedure for the management of a claims for loss of/or damage to fishing gear during installation.
Code of Good Practice	Development of a Code of Good Practice for contracted vessels.
Notifications	Notifications of the Marine Scheme will be made to: • Notice(s) to Mariners' (including Kingfisher), Radio Navigational Warnings, NAVTEX and/or broadcast warnings will be issued prior to the commencement of installation works; • Third-party infrastructure asset owners, to notify them of any activities associated with the Marine Scheme and avoid spatial and temporal interactions between vessels; • Regular vessel operators (e.g. ferry operators) to notify of installation works; • Other marine energy infrastructure operators to confirm operation dates and otherwise rationalise activity schedules, as required; and • Notification of Regular Runners.
Route preparation works	Route preparation works would be carried out as locally as possible to minimise disturbance to sensitive habitats potentially suitable for marine ecological receptors.
Legislative requirements and mitigation: - vessel-to-vessel collision - deviation from established and identified vessel routes and areas - interaction with vessel anchors and anchoring activity - interaction with fishing gear - reduction in under keel clearance - interference with marine navigational equipment	• All vessels will follow the International Regulations for Preventing Collisions at Sea 1972 (COLREGS) and International Convention for the Safety of Life at Sea 1974 (SOLAS); • All vessel wastes will be managed in accordance with the requirements set out within the International Convention for the Prevention of Pollution from Ships (MARPOL) (the discharging of contaminants is not permitted within 12 nm from the coast to preserve bathing waters); • Vessel contingency plans for marine oil pollution in the form of Shipboard Oil Pollution Emergency Plan (SOPEP) and chemical handling procedures will be in place; • All vessels will display appropriate lights and shapes; • All vessels will broadcast their status on AIS at all times; • All non-local vessels will operate to IMO regulations for ballast water management to manage INNS risks; • Guard vessels will use radio detection and ranging (RADAR) with Automatic RADAR Plotting Aid (ARPA) to monitor vessel activity and predict possible interactions, will be employed to work alongside the installation vessel(s) during installation and maintenance work (which will also minimise anchor disturbance on the seabed); • An advisory 500 m safety zone will be established around all vessels associated with the installation works; • The discharging of contaminants is not permitted within 12 nautical miles (NM) from the coast to preserve bathing waters; • Route selection will avoid so far as is practicable main navigational features; • Promulgation of information to local clubs, marinas and harbours in the vicinity of the landfalls; • Piloting of large vessels; • Limits to wave height / wind speed conditions for operations / activities will be followed by all vessels; • All vessels will follow Port bylaws and General Directions; • Very High Frequency (VHF) Broadcast Safety Navigational Warnings; • Industry guidance on the avoidance of fishing in the vicinity of subsea cables will be followed; • As-built locations of cable and external protection will be supplied to UKHO (Admiralty) and Kingfisher (KIS-ORCA);

Activity / issue	Embedded mitigation commitment
	• Cable burial and protection measures are designed to minimise risk of snagging; • Routine inspection and maintenance throughout the lifecycle of the asset to identify and remediate cable exposures or other potential snagging risks; • Reduction in charted water depth to LAT limited to less than 5% where possible; and • Route Selection (specific planning for location of cable routing in shallow areas). • Promulgation of information to local clubs, marinas and harbours in the vicinity of the landfalls; • Piloting of large vessels; • Limits to wave height / wind speed conditions for operations / activities will be followed by all vessels; • All vessels will follow Port bylaws and General Directions; • Very High Frequency (VHF) Broadcast Safety Navigational Warnings; • Industry guidance on the avoidance of fishing in the vicinity of subsea cables will be followed; • As-built locations of cable and external protection will be supplied to UKHO (Admiralty) and Kingfisher (KIS-ORCA); • Cable burial and protection measures are designed to minimise risk of snagging; • Routine inspection and maintenance throughout the lifecycle of the asset to identify and remediate cable exposures or other potential snagging risks; • Reduction in charted water depth to LAT limited to less than 5% where possible; and • Route Selection (specific planning for location of cable routing in shallow areas).
Installation	
24-hour cable installation	Installation will normally be a 24-hour operation where viable, minimising overall installation time and, maximising use of fair weather windows, and take advantage of vessel and equipment availability.
Securing of cable	Ends of any out of service (OOS) cables cut will be secured to the seabed in accordance with International Cable Protection Committee recommendations or reburied.
Landfall installation	Horizontal Directional Drilling (HDD) will be used at both landfalls to install the cables beneath the shallow subtidal and the intertidal (between MHWS and MLWS) zone to the landfall. This will keep sediment disturbance to a minimum, significantly reduce (if not avoid) the use of cable protection measures close to shore and avoid directs on sensitive coastal and intertidal habitats and features.
Biodegradable drilling fluids	Drilling fluids used will be biologically inert and will be selected from the Centre from Environment, Fisheries, and Aquaculture Science (Cefas) approved list of drilling fluids, and the OSPAR List of Substances/Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR). During drilling, drilling fluids will be recycled, treated, and reused, and any waste drilling fluid will be transported offsite for treatment and disposal.
Third-party cable crossings	Each cable crossing will be designed in detail in accordance with the International Cable Protection Committee recommendations. Proximity and Crossing Agreements will be agreed with cable and pipeline owners. The Crossing Agreement describes the rights and responsibilities of the parties and also the design of the crossing. Crossing design will be in line with industry standards, using procedures and techniques agreed with the cable and pipeline owners.

Activity / issue	Embedded mitigation commitment
	• Proximity agreements describe the approach to works close to, but not crossing third party assets, to ensure safety.
Cable burial	Minimum cable burial depth of 0.6 m, with a target cable burial depth of 1.5 m. The use of cable burial will also prevent snagging with fishing gear.
Cable protection	The use of cable protection will be limited to areas where cables cannot be buried to a sufficient depth and at crossings with 3rd party infrastructure.
Cable protection chartering and dissemination of information	Information on the areas where cable protection is used will be provided to relevant organisations for inclusion in charts and information bulletins.
Rock placement	Where rock placement is used for cable protection this will be designed to minimise potential snagging risk (i.e. use of graded rock and 1:3 berm profiles). A vessel able to undertake a targeted placement method will be used, such as one fitted with a flexible fall pipe.
Transiting vessels to move at low speeds	Where the marine installation corridor passes through the Outer Firth of Forth & St Andrews Bay Complex Special Protection Area (SPA) as it leaves the Scottish landfall and the Northumberland Marine SPA , a commitment will be included with the CEMP to ensure that transiting vessels move at low speeds allowing any rafts of birds to disperse naturally well in advance of an approaching vessel. This will minimise the energy expended and avoid unnecessary flushing. This is especially important during the immediate post breeding dispersal periods of auks from early July to mid-September.
Post-Installation	
Post-lay and cable burial inspection	Undertaking of post-lay and cable burial inspection to confirm the burial status of the cables, identify potential seabed hazards associated with installation, and, where appropriate and practicable, undertaking of rectification works.
Operation (including maintenance and repair)	
Operation and Maintenance Strategy, including Operational Environmental Management Plan	An OEMP will be developed to prepare for the event that maintenance is required. It will be implemented during the operation of the Marine Scheme in order to provide a mechanism by which to deliver environmental mitigation commitments and in case of changes in environmental condition.
No planned routine maintenance work	Following installation, the cable system is designed to avoid the need for scheduled maintenance during the lifetime of the Marine Scheme.
Cable exposures	In the event that cable exposures are identified during the operational phase of the Marine Scheme, the location of these will be shared with stakeholders and where appropriate, additional temporary measures put in place (e.g. surface marker buoys, use of guard vessels, etc).
Existing monitoring programmes	The Marine Scheme will be monitored via existing monitoring programmes, such as the Coastal Explorer programme designed by the East Riding Yorkshire Council (ERYC) and data from the Scottish Coastal Observatory.
Decommissioning	
Options for decommissioning	Options for decommissioning will be evaluated in both environmental and economic assessments, taking account of the regulations, best practices and available technology at the time of decommissioning.

2.9 References

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