Eastern Green Link 3

Marine Environmental Appraisal

Chapter 3 - Project Description

Prepared for: Scottish Hydro Electric Transmission plc (SHE-T)

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TRANSMISSION

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Abbreviations/Glossary

CBRA	Cable Burial Risk Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEMP	Construction Environmental Management Plan
CFE	Controlled Flow Excavation
CLB	Cable Lay Barge
CLV	Cable Lay Vessel
cm	Centimetre
CPT	Cone Penetration Test
CSV	Construction Support Vessel
DC	Direct Current
DDV	Drop Down Video
DESNZ	Department for Energy Security and Net Zero
eDNA	Environmental Deoxiribonucleic Acid
EGL	Eastern Green Link
EMF	Electromagnetic Field
GW	Giga Watt
HDD	Horizontal Directional Drill
HDPE	High Density Polyethylene
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
Hz	Hertz
JUB	Jack-up Barge
km	Kilometre
km^2	Kilometre squared
kV	Kilo volts
LAT	Lowest Astronomical Tide
m^2	Metre squared
MBES	Multibeam Echo Sounder
MCA	Maritime and Coastguard Agency
MD-LOT	Marine Directorate – Licensing Operations Team
MEA	Marine Environmental Assessment
MEAp	Marine Environmental Appraisal
MFE	Mass Flow Excavation
MHWS	Mean High Water Springs
μT	Micro tesla
MLA	Marine Licence Application
MLWS	Mean Low Water Springs
mm	Millimetre
NM	Nautical Miles
NPS	National Policy Statement
OWF	Offshore Wind Farm

PLGR	Pre-Lay Grapnel Run
pUXO	Potential Unexploded Ordnance
RLB	Red Line Boundary
ROV	Remotely Operated Vehicle
SBP	Sub-Bottom Profiler
SSS	Side Scan Sonar
TJB	Transition Joint Bay
UXO	Unexploded Ordnance
VC	Vibrocore
V/m	Volts per metre
XLPE	Cross Linked Polyethylene

3. Project Description

3.1. Introduction

This chapter presents a description of the Proposed Development, including details of design, construction, operation and maintenance and decommissioning. It represents the current understanding of the key design parameters which have evolved in response to feedback received during pre-application consultation with stakeholders, together with further ongoing environmental and design work.

3.2. Project Overview

Eastern Green Link 3 (EGL 3; the Project) would comprise a 2 gigawatt (GW) High Voltage Direct Current (HVDC) link between Peterhead, Aberdeenshire in Scotland, and King's Lynn and West Norfolk, Norfolk, with a landfall on the Lincolnshire coastline, England. The link would comprise approximately 700 km of subsea and underground HVDC cables between new converter stations at each end of the electricity transmission link. These in turn would be connected to the existing National Electricity Transmission System via High Voltage Alternating Current (HVAC) cables between the new converter stations and new substations. A second link between Fife in Scotland and Kings Lynn and West Norfolk in England is being developed in parallel and is known as Eastern Green Link 4 (EGL 4). Separate Marine Licences are being sought for these projects in Scottish waters owing to the different Transmission Operators in Scotland (who will each require to be applicants to the relevant Marine Licences), however consent is being sought for both EGL 3 and EGL 4 via a single Development Consent Order in English waters.

The existing electricity distribution networks in Scotland operate using predominantly HVAC systems. However, transmission projects such as the Project use HVDC technology because it is more efficient at transmitting large volumes of electricity over longer distances with lower losses compared to an equivalent HVAC system. A HVDC system also provides a greater degree of control over the magnitude and direction of flow, and this flexibility delivers complementary operational benefits. For large scale transmission projects such as EGL 3, specialised electrical plant and equipment contained within converter stations is required at either end of the transmission link to convert electricity from HVAC to HVDC (or vice versa).

For the purposes of seeking the necessary consents, EGL 3 has been split into different 'Schemes' i.e. English Onshore Scheme, English Offshore Scheme, Scottish Onshore Scheme and the Scottish Offshore Scheme (with the latter herein referred to as 'the Proposed Development'). Collectively all components are referred to as "the Project". This Marine Environmental Appraisal (MEAp) is written with specific regard to the Proposed Development for which a single application for a Marine Licence will be made. As a consequence of applications being sought under their respective Schemes, there will be a phased discharge of licence conditions for the Project as a whole.

3.2.1. Scottish Onshore Scheme

There is a proposed converter station located to the west of Peterhead at Netherton. From this, there would be an underground HVDC cable to a proposed landfall at Sandford Bay. The proposed converter station would be connected to a substation by underground HVAC cables. The substation would connect the Project to the existing Scottish transmission system. Separate consent will be sought for the onshore infrastructure including the convertor station.

3.2.2. The Proposed Development

The Proposed Development comprises approximately 145 km of subsea HVDC cable from the landfall at Sandford Bay to the boundary with adjacent English waters. The subsea cable system would consist of two bundled HVDC cables and fibre optic cables (up to the first offshore joint) for control and monitoring purposes.

3.2.3. Red Line Boundary

The proposed Red Line Boundary (RLB) is presented in **Figure 3.1**, which is presently the anticipated maximum extent of seabed in which the construction and operation of the Proposed Development may take place. The RLB covers the entire area within which development could take place comprised of both temporary and permanent components of the Proposed Development. These include the proposed seabed preparation and maintenance works which would take place. In addition, the RLB includes areas of mitigation which will be required as part of the Proposed Development.

3.2.4. Rochdale Envelope Approach

At this stage of the Marine Environmental Assessment (MEA) and consenting process, the project description for the Proposed Development is indicative. It is often the case that, where consent is applied for and obtained before construction commences, there may be design elements that are unknown to an applicant at the time of application.

In such cases, a Rochdale Envelope approach may be used. The Rochdale Envelope approach defines a design envelope and parameters within which the final design would sit. It allows flexibility for elements that are likely to require more detailed design subsequent to submission of the MEA, such as the final routeing and siting of infrastructure, construction and installation methods and final quantities of cable protection.

The adoption of this approach allows meaningful MEA to take place by defining a 'maximum design scenario' on which to base the identification of likely environmental effects. The maximum design scenario is the scenario that would give rise to the greatest impact (and subsequent effect), allowing for a realistic worst-case assessment to be undertaken. For example, where design options are under consideration, the assessment is based on the option predicted to have the largest magnitude of impact. This may be the option with the largest footprint, the greatest height or the largest area of disturbance during construction, depending on the topic under consideration. By identifying the maximum design scenario, it can be concluded that the impact (and therefore the resulting effect) would be no greater for any other design scenario.

This approach is recognised in the Overarching National Policy Statement (NPS) for Energy (NPS EN-1) (DESNZ, 2024a), the NPS for Renewable Energy Infrastructure (NPS EN-3) (DESNZ, 2024b) and the NPS for Electricity Networks Infrastructure (NPS EN-5) (DESNZ, 2025c).

This chapter describes the Rochdale Envelope for the Proposed Development, taking into account the policy set out in the NPSs and the advice in the Planning Inspectorate's Advice Note Nine (Planning Inspectorate, 2025). The Rochdale Envelope described within this chapter has been designed to:

- take into account site and route selection and design refinement work undertaken to date (see **Chapter 2: Project Need and Alternatives**); and
- to include sufficient flexibility to accommodate future stages of design refinement.

It should be noted that the Rochdale Envelope presented in this chapter is generally considered to represent a realistic, reasonable worst-case design scenario and in most instances these design parameters form the basis of assessment for each of the technical chapters presented throughout this Marine Environmental Appraisal (MEAp). However, there are instances where the reasonable worst-case scenario for a given design parameter might vary by environmental aspect, depending on how that particular parameter interacts with the receptor being considered. Therefore, each technical aspect chapter sets out the assumptions made regarding the Rochdale Envelope specific to that particular environmental aspect. The methodology for assessment for the Proposed Development is set out in more detail in **Chapter 4: Marine Environmental Appraisal Scope and Methodology**.

3.2.5. Sandford Bay Landfall

3.2.5.1. Physical description of the landfall

The landfall is the interface between the Scottish Onshore Scheme and the Scottish Offshore Scheme and would be located at Sandford Bay, Peterhead, Aberdeenshire. This is the location where subsea cable (which is commonly of a greater diameter compared to the onshore cables due to increased protection), would connect to the onshore underground cables at a buried transition joint bay (TJB) located above mean high water springs (MHWS). More specifically, the landfall is considered to extend from the Horizontal Directional Drilling (HDD) exit point below mean low water springs (MLWS) across the intertidal zone to the buried TJB located a short distance inland. A TJB is a permanent underground chamber constructed of reinforced concrete that houses the cable joints and a fibre chamber/link pit. A single TJB typically comprises an area of 15 m by 4 m (60 m^2). It is currently anticipated that a single TJB would be required, however this would be confirmed at the detailed design stage. No permanent above ground infrastructure would be required for the TJB. Once installation has been completed, the land would be reinstated to pre-existing conditions, the only infrastructure visible on the surface (on otherwise fully reinstated land) would be the cover of the link box pit.

All aspects of the landfall that are above MHWS are assessed as part of the Scottish Onshore Scheme and conversely everything that is below MHWS is assessed as part of the MEA reported in this MEAp.

The landfall would be constructed using a trenchless technique such as HDD. Three cable ducts would be installed from the TJB, positioned above the MHWS mark, to a point below 0 m lowest astronomical tide (LAT) (seaward of MLWS). Within two of the three ducts would be an unbundled HVDC cable, each with a fibre optic cable for monitoring purposes. The third duct would be empty, providing flexibility for potential future repairs. The exact exit points for the HDD and the cable ducts would depend on further technical studies and design. The HDD would 'punch out' (exit onto the seabed) between the 8 m and 20 m LAT water depth contours. A summary of the key characteristics of the landfall is outlined in **Table 3-1**.

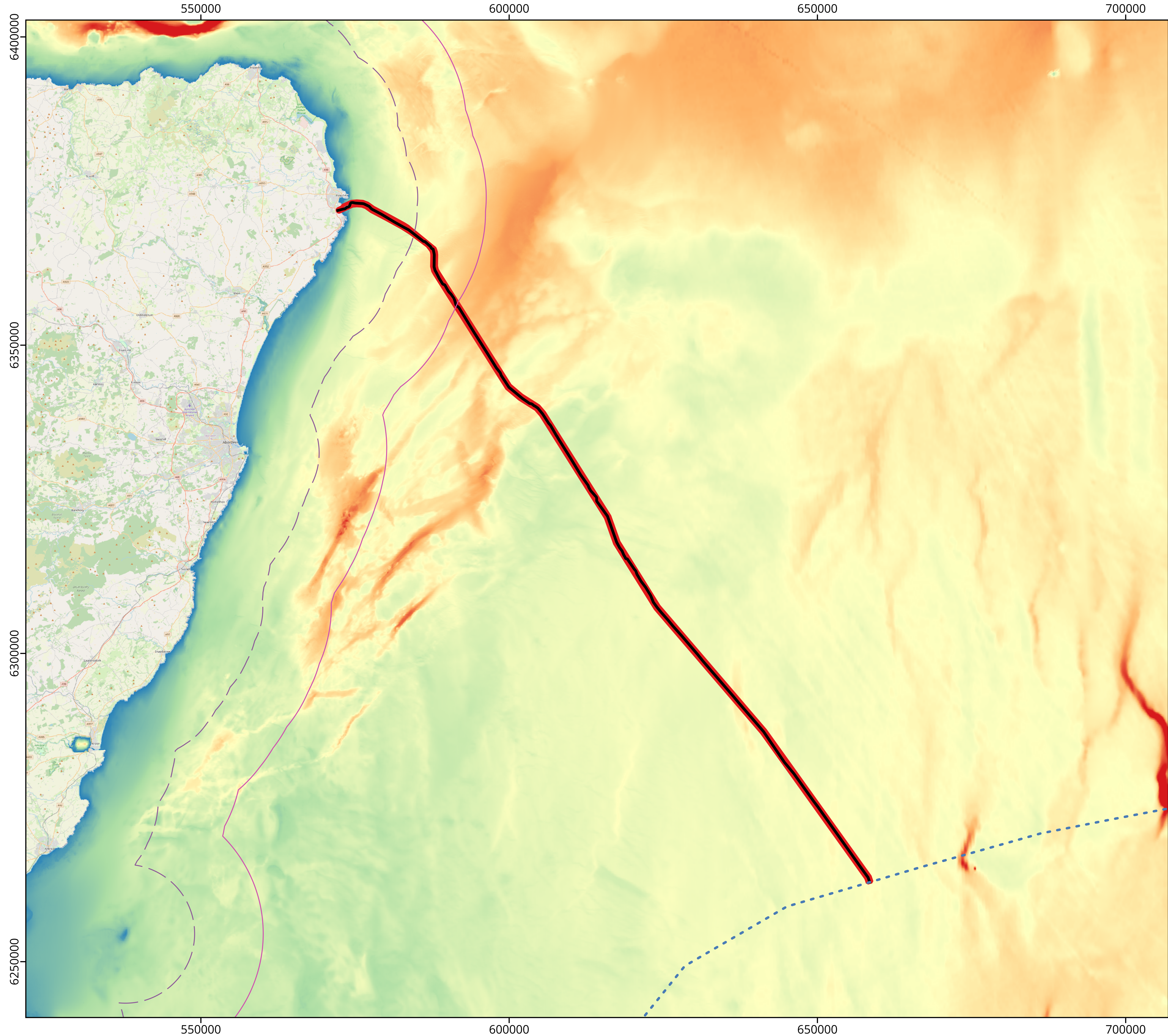
Table 3-1: Rochdale Envelope – Sandford Bay

Parameter	Maximum Design Parameter
Transition Joint Bay	
Number of transition joint bays	It is currently anticipated that a single TJB would be required. This would be confirmed at the detailed design stage.
Maximum permanent area of above ground transition joint bay covers (m^2)	TJB is typically a buried concrete chamber. No above ground infrastructure. TJB dimensions are approximately 15 m by 4 m (60 m^2).
Landfall	
Type of trenchless technique	Trenchless construction techniques include HDD, micro-tunnelling and using a direct pipe. These are techniques commonly used to install cable duct(s) underneath sensitive environmental features (such as sea defences, dune system, etc) or technical constraints (cliffs, shallow bedrock etc.). The information contained within this assessment relates to the typical approach for a HDD construction as this is the most likely trenchless technique that would be used at the Landfall. It is expected that up to three permanent cable ducts would be installed at the landfall.
Number of cable ducts	Up to three permanent cable ducts would be installed between the onshore TJB and the offshore exit location.
Indicative length of HDD or equivalent (m)	It is currently assumed that the length of each duct would likely extend from a compound location above MHWS to a punch-out point below MLWS, indicatively 1.6 km from MHWS.
Number of exit pits (below MHWS)	Three
Volume of excavated material per exit pit (below MLWS)	10 – 1,500 m^3

3.3. Cable Configuration

The subsea cables forming the Proposed Development would be buried along the length of the cable with the exception of infrastructure crossing points and areas where sufficient depth of burial cannot be achieved due to ground conditions.

The RLB encompasses the Proposed Development as shown in **Figure 3-1 (Drawing reference C01494-EGL3-MEA-LOC-001-A)** and is nominally 700 m wide. It includes the area over which geophysical, geotechnical and environmental surveys have been acquired by the Applicant.



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EGL 3 Red Line Boundary

C01494-EGL3-MEA-LOC-001-A

Legend

Cable Route

Red Line Boundary

Bathymetry (m)

0

-150

6NM Limit

12NM Limit

Scottish Adjacent Waters

0 12 24 36 KM

0 6 12 18 NM

N

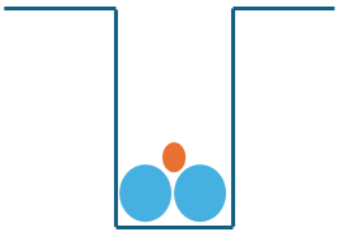
Date	13/06/2025
Coordinate System	ETRS89 / UTM zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	meters
Scale at A3	1:600,000
Created	AN
Reviewed	JC
Authorised	JDM

Document Path: X:\GIS\GIS_PROJECTS\C01494_EGL3&4\Project\QGS\EGL3\MEA\01_LOC\C01494_EGL3_MEA_LOC_001.qgz

3.3.1.1. Cable configuration

The HVDC cable system would each comprise two single core metallic conductors (one positive, one negative) and fibre optic cables. The system would be installed as a single bundle of two conductors and the fibre optic cable laid in a single trench. The configuration is shown in **Figure 3-2.** As the cables approach the landfall the cables would be unbundled and each core passed through its own duct, with a fibre optic cable.

Figure 3-2: Indicative configuration of cables within the trenches



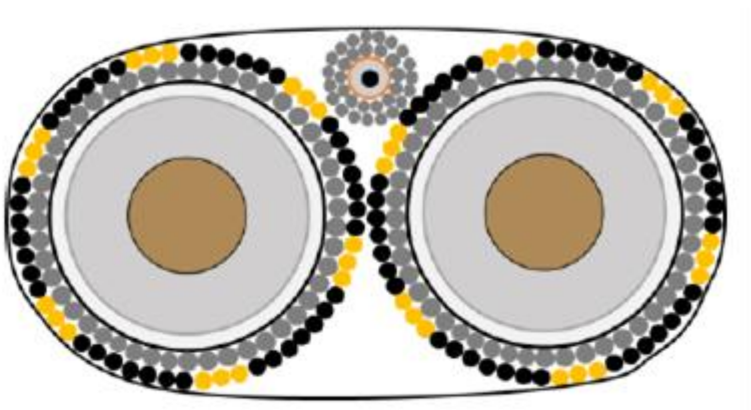
The length of cable that can be installed at one time is restricted by the cable lay vessel (CLV) used. It is anticipated that approximately 80 – 100 km could be laid in each construction campaign. This would mean installing the cable system in a minimum of two sections, with each section connected by a joint.

3.3.1.2. HVDC cable design

The cables would likely be cross linked polyethylene (XLPE). As illustrated in **Figure 3-3**: Example illustration of bundled HVDC cable with fibre optic cable (illustration shows double wire armoured sheathing and is indicative only)**,** the cables would have a central core (comprising of aluminium or copper), protected by insulation and a lead sheath. Heavy steel wire is wound in a helical form around the cable as armour to protect the cable from external damage during construction and operation.

The cables would have a nominal voltage of 525 kilovolts (kV) and typically have an outer diameter of 150 to 190 mm. The cables would be non-draining, containing no free liquid or gases that could be released into the marine environment even in the event of severe mechanical damage to the cables.

Figure 3-3: Example illustration of bundled HVDC cable with fibre optic cable (illustration shows double wire armoured sheathing and is indicative only)



3.3.1.3. Fibre Optic cable design

The fibre optic cable(s) would not run through the entire length of the HVDC link offshore, typically up to the first joint offshore from the landfall. The cable would typically comprise a core of optical fibres, armoured with layers of steel wires, and sheathed with either a polypropylene or polyethylene material for outer protection. The outer diameter of the fibre optic cable(s) would be between 20 mm and 30 mm.

The fibre optic cable(s) would not include any repeaters and would not have an electrical current running through it.

3.3.1.4. Summary of the RLB and cable parameters

Key aspects of the Proposed Development and parameters are summarised below in

Table *3-2*

Table 3-2: Rochdale Envelope – cable corridor and cable configuration

Aspect	Parameter	Maximum Design Parameters
Red Line Boundary	Width	The RLB is 700 m wide. The RLB encompasses the extent of the marine characterisation survey which was 500 m wide. The RLB is slightly wider to allow for future micro-routing around seabed features such as sand waves, challenging seabed conditions or sensitive habitats.
	Maximum Total length in Scottish Waters	~ 145 km (28.9 km inshore waters, 129.3 km offshore waters)
HVDC Cables	Configuration	Bi pole One cable per pole
	Number	Two
	Joints	Up to three joints
	Outer Diameter	150 - 190 mm
Fibre Optic Cable(s)	Joints	To be determined based on the agreed installation solution. Joints and number of installation campaigns will be dependent on the selected contractor's, chosen to undertake the works, agreed solution, which would determine the length of the fibre optic cable(s).
	Outer Diameter	20 - 30 mm
Cable trench	Number	1
	Maximum depth of trench	3 m Below non-mobile reference level
	Maximum trench width	5 m
	Disturbed area (from trenching)	20 m
	Maximum width of external cable protection	15 m

3.3.2. Construction Programme

The construction programme for the Proposed Development is expected to take approximately 55 months, commencing in 2028 with pre-lay activities. Works at the landfall may commence in 2028 / 2029 with installation of the HDD and ducts ahead of the main works.

Flexibility is required in the construction programme in order to accommodate a range of uncertainties. This would include the time taken to undertake procurement activities, variable lead times for components and equipment, and variable task durations dependent on the suppliers, technologies and methodologies selected. This may be affected by factors such as supply chain bottlenecks as well as implementation of any required mitigation measures for environmental sensitivities or sensitive receptors.

It is anticipated that the offshore construction works would be split into several activities:

- Landfall HDD preparation and construction.
- Route preparation.

Preparation activities that would be required for the cable installation are listed below, along with indicative durations. Cable route preparation may be undertaken in one single campaign along the entire length of the Proposed Development or may be split and undertaken ahead of each cable lay and burial campaign.

- Pre-lay surveys.
- Pre-lay unexploded ordnance (UXO) survey and identification including minor excavations (clearance excluded from this Marine Licence Application (MLA)); and
- Cable route preparation, Pre-Lay Grapnel Run (PLGR), boulder clearance, pre-sweeping, infrastructure crossing preparation.

Table 3-3: Indicative programme

Parameter	Indicative Programme
Earliest construction starts (HDD)	At consent award (subject to discharge of Marine Licence conditions)
Earliest construction starts offshore	2028 for pre-lay activities 2030 for cable lay activities
Latest construction starts offshore	2028 for pre-lay activities 2031 for cable lay activities
Offshore construction duration window	2028 - 2033
Latest construction finish offshore	2033

For the Proposed Development, including the HDD trenchless crossing at landfall, construction would be a 24-hour operation to minimise overall installation time, maximise the use of suitable weather windows and take advantage of vessel and equipment availability.

3.4. Pre-Lay Activities

Certain activities would be undertaken to prepare the route for cable lay.

3.4.1.1. Pre-lay Survey

Although detailed marine characterisation surveys have been undertaken, further surveys may be carried out prior to the start of route preparation and cable lay. The objectives of these surveys would be:

- to confirm that no new obstructions have appeared on the seabed since the original marine surveys were undertaken;
- to establish the final position and number of infrastructure crossings (depending on third party project status);
- to establish a reference seabed level against which the depth of burial of cables can be compared;
- to determine the position of any potential UXO (note clearance is subject to a separate MLA process);
- to support the micro-routeing of the cables around any mobile bedforms, archaeological features or sensitive habitats within the RLB;
- to determine the rate of sandwave mobility, in order to determine the non-mobile reference layer; and
- to provide a pre-construction baseline should it be required for post-construction monitoring purposes.

The pre-lay surveys could involve a range of marine survey techniques including:

- Multi-Beam Echo Sounder (MBES): used to record water depth, prepare a three dimensional (3D) digital terrain model of the seabed, and to identify relevant bedforms and bathymetry.
- Side Scan Sonar (SSS): maps the seabed surface and is used for identification of sediment types, obstacles lying on the seabed, such as wrecks, debris, UXO, and surface-laid or exposed pipelines and cables that might affect cable installation.
- Sub-Bottom Profiling (SBP): directs a pulse of energy into the seabed. Using reflections from the sub-surface geology it can assess the thickness, stratification, and nature of the seabed sediments.
- Magnetometer: passively detects 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.
- Geotechnical surveys: consisting of cone penetration tests (CPTs) and vibrocores (VCs) to take measurements and core samples to assess the geotechnical properties of the seabed.
- Drop Down Video (DDV) or remotely operated vehicle (ROV) video: is a piece of marine survey equipment that typically comprises an underwater camera and lighting on a robust sled or frame which is able to stream live footage to the surface. It has built in depth sensors and lasers to provide a scale to estimate the field of view.
- Diver led surveys: for UXO target investigation, utilising handheld clearance tools.

- Grab sampling: is a technique of grabbing a sample of the seabed for testing e.g., to look at sediment composition and properties or to identify marine flora and fauna or eDNA. Types of grabs include hamon grab, dual van veen grab and shipek.

The pre-lay survey would typically be split into two elements: nearshore (<10 m depth of water) and offshore (>10 m depth of water), each requiring a survey vessel suitable for the different water depths.

An offshore vessel is generally larger and can conduct 24-hour operations. The towed sensors, sensor arrays and equipment are stored on the back deck potentially in dedicated garages and are deployed using a crane or vessel A-frame or through a moon pool in the ship's hull.

A nearshore vessel is generally smaller and due to its reduction in size can be used in shallower water depths. Operations are usually kept to 12 hours (or daylight hours) with the sensors and equipment stored in pallet cases/boxes on the back deck; however, if the size of the vessel allows night working or 24-hour working, operations would still be possible.

3.4.2. Unexploded Ordnance (UXO) Identification

A desk-based study and risk assessment for potential UXO across the Project has been undertaken by Ordtek, which has informed the position and development of the Proposed Development.

Publicly available data, historic maps, aerial photographs and records, internet research and research documents has been used to characterise the types of ordnance likely to be present within the Proposed Development. The types of ordnance that could be present are listed below:

- small arms ammunition;
- land service ammunition;
- high explosive bombs;
- sea mines;
- torpedoes;
- depth charges; and
- missiles / rockets.

The offshore geophysical survey completed in 2024 was designed to detect any significant seabed features and obstacles within the RLB and has been analysed as part of the MEA process e.g. for features of archaeological potential, or features that would significantly constrain cable burial.

A more detailed UXO specific pre-construction survey would be conducted using a magnetometer array, SSS array, MBES or other acoustic methods, prior to seabed clearance and cable lay, to characterise and investigate any anomalies, that may be UXO, in more detail. These surveys would also be designed to capture archaeological features.

The extent of the UXO survey would be nominally 40 m either side of the proposed cable centreline (80 m total width); the route along which the cable would be laid and buried within the RLB. It would be undertaken using a geophysical survey vessel(s).

The data acquired during the survey would be used to map potential UXO (pUXO) and undertake further micro-routeing of the cable centreline to avoid as many pUXO as possible. The survey is proposed to cover the cable route from landfall to the boundary with English waters. Separate surveys would be undertaken across the English Offshore Scheme.

Any pUXO detected during the survey that cannot be avoided by the cable centreline would be further investigated to confirm whether it is confirmed UXO, an archaeological feature or debris.

pUXO identified as a target for investigation would be surveyed in one of two ways:

- Diver survey using a circular search pattern with handheld magnetometer to identify the position of the target and using a low-pressure water jet and dredge system; and/or
- Remotely Operated Vehicle (ROV) equipped with magnetometer, dredge pump and sonar.

A 10 x 10 m grid would be investigated around each target. Should scrap/debris be identified during the survey e.g., objects with ferrous content, this would be removed to the surface to be disposed of according to the waste hierarchy (Scottish Government, 2017) and Waste (Scotland) Regulations 2011 (Scottish Government, 2011). Targets covered by sediment would be exposed. A small pit would generally be excavated up to 3.0 m deep, until the target is sufficiently exposed to confirm whether it is UXO. Where debris has been identified and removed, investigations would continue until the entire search grid is complete, in case debris had masked the presence of UXOs.

Any non-explosive debris that cannot be removed to the surface (e.g., for health and safety reasons) would be relocated on the seabed within the RLB.

A Written Scheme of Investigation and Protocol for Archaeological Discoveries (**Chapter 14: Marine Archaeology**) would be followed throughout the UXO identification campaign, and a marine archaeologist would be on hand in case any targets have archaeological potential.

UXO clearance would be undertaken following completion of the initial UXO identification survey and once all potential targets have been identified and where avoidance of targets, through micro routing, is not possible. A separate Marine Licence would be submitted to the Marine Directorate - Licensing Operations Team (MD-LOT) to permit the clearance activities. UXO clearance activities are excluded from this MEA and MLA, however a high-level assessment of effects has been provided in the relevant topic chapters.

3.4.3. Route Preparation

Prior to the construction of the Proposed Development, preparation of the seabed would be required to ensure installation equipment can operate efficiently and safely. The following activities may be undertaken within the RLB.

3.4.3.1. Boulder clearance

Geophysical data would be used to inform the requirement for boulder clearance within the RLB. Where possible micro-routing around boulders would be undertaken, however, where there are large volumes of boulders present micro-routing may not be feasible and therefore clearance of boulders from the route of the cables would be required to allow the use of burial equipment.

There are several methods that may be used for the clearance of boulders. Where there are few boulders to be cleared, a grab could be used to individually target and move boulders away from the centreline of the cables. Boulders would be repositioned within the RLB away from the final route of the cable.

Where there are high volumes of boulders, a SCAR plough or similar would be used. The plough would push boulders to either side of the centreline, clearing a swathe of up to 17 m wide. Multiple passes may be required to achieve the required clearance.

All clearance activities would be undertaken from a construction support vessel (CSV) or similar.

The worst-case in terms of boulder clearance is assumed to be the use of the SCAR plough as this results in the greatest footprint on the seabed. Up to 32% (50 km) of the Proposed Development would be required to be cleared using this method. A grab tool would be used where feasible, reducing the overall footprint.

The boulder clearance parameters are shown in **Table 3-4.**

Table 3-4: Boulder clearance parameters

Parameter	Maximum Design Parameter
Length of cable requiring boulder clearance using SCAR plough	50 km (estimated from length of boulder fields) in Scottish waters <32% of Proposed Development
Width of plough/cleared swathe	17 m swathe cleared
Total area of seabed disturbed by boulder plough	0.85 km^2
Depth of seabed disturbed by clearance plough	~10 cm (<2 m if trenching)

3.4.3.2. Pre-Lay Grapnel Run (PLGR)

A PLGR would be required to clear any debris from the seabed prior to cable lay to ensure the cable route is clear of snagging risks. The PLGR is a wire with specially designed hooks or grapnels at intervals along its length (as illustrated in **Figure 3-4** that is towed behind a vessel, typically a CSV**.**

The PLGR is designed to capture all types of debris at or just below the surface of the seabed, up to approximately 1 m depth. Debris, such as scrap trawler warps, old cable, ghost fishing gear, caught with the grapnel would be recovered to the vessel for appropriate licenced disposal onshore.

Due to the length of the cable as described above, cable lay and burial may be undertaken over a number of campaigns. The PLGR may therefore be undertaken in one single phase prior to the first cable lay campaign or in separate phases prior to each cable lay campaign to ensure the route is clear of debris. Typically, the PLGR is undertaken a few days prior to cable lay but may be undertaken up to a month prior to cable lay.

PLGR parameters are listed in **Table 3-5.**

Figure 3-4: Typical PLGR arrangement

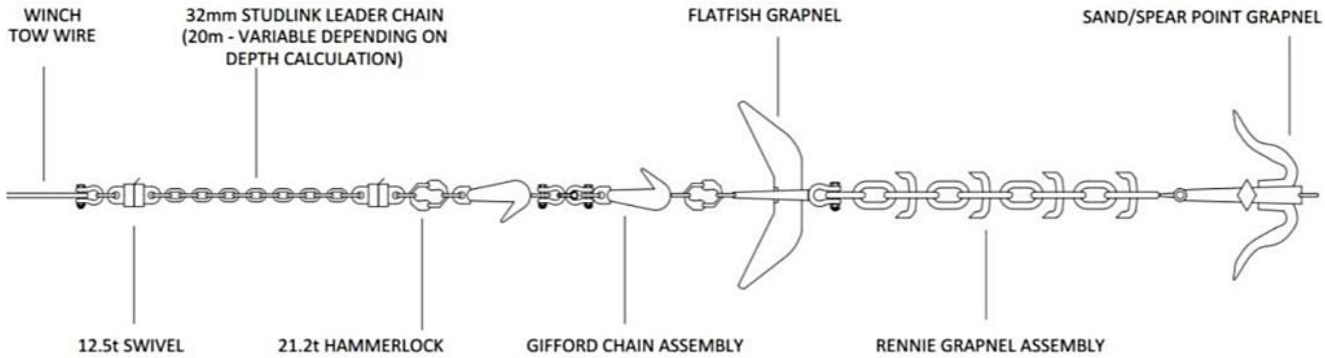


Table 3-5: PLGR parameters

Parameter (per project)	Maximum Design Parameter
Length of cable requiring PLGR	100%
Length of cable requiring PLGR	145 km
Width of PLGR clearance corridor	30 m
Total area of seabed disturbed by PLGR	4.35 km^2

3.4.3.3. Trial trenching

Trial trenching, if required to test the capabilities of the trenching tool to meet depth of burial requirements, would be undertaken within the RLB. The trial trenching would use the same methodology as that proposed for the burial of the cables. During the trial trenching, if cables were to be laid and buried, these would be subsequently removed following the trial. The total length of trial trenching would be up to 5 km. The total area of seabed disturbed by cable trenching would be 80,000 m^2 (0.08 km^2, 8 ha) assuming the maximum width of a burial tool would be 16 m.

3.4.3.4. Sand wave clearance

In areas where mega ripples (wave heights <1.5 m) and sand waves (wave heights > 1.5 m) are present within the RLB, pre-sweeping may be required prior to cable installation to:

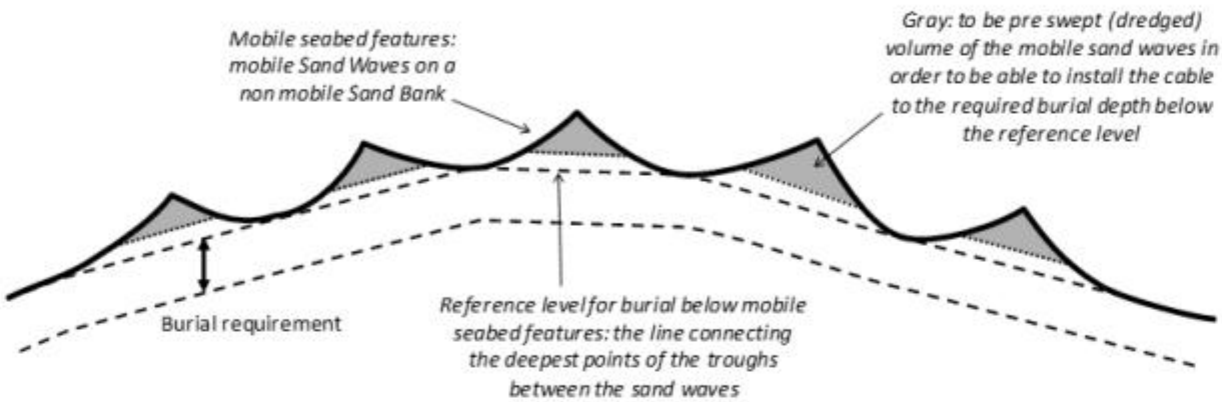
- ensure the burial equipment can operate safely along the cable centreline (i.e., avoiding step slopes); and
- ensure that the burial equipment reaches the required depth of burial, therefore preventing future exposures.

Sand waves can present a major technical challenge for both towed and self-propelled burial equipment. Burial equipment commonly works on long inclines of up to 10-15°. For commonly available machines, the practical limit for burial depth is 3 m. By removing a proportion of the sand wave prior to installation, the burial machine can reach further down and place the cables below the level at which they may be affected by the mobility of the bedform feature (the non-mobile reference level) and can reduce the slope angle, ensuring the burial machine does not topple or tilt over as illustrated in

Figure 3-5

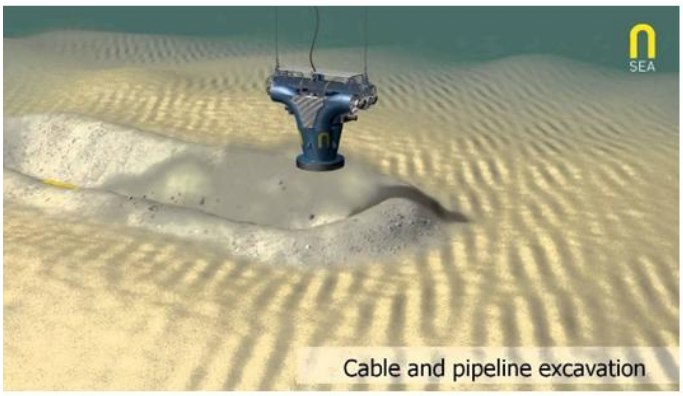
Figure 3-5.

Figure 3-5: Illustration of the process of sand wave pre-sweeping



Pre-sweeping would be undertaken using a controlled flow excavator (CFE) / mass flow excavator (MFE). The technique uses highly pressurised water directed at the seabed to push sediment to either side of a trench. An example is shown in **Figure 3**. This equipment works best where the sand waves are < 3 m.

Figure 3-6: Example Controlled Flow Excavator



The area to be pre-swept would be wide enough for the passage of the burial equipment at the base of the sand wave; expected to be up to 20 m wide. Where pre-sweeping is required, this would be undertaken up to a few weeks in advance of the cable lay and burial to ensure a cleared path for cable burial.

The requirements for sand wave clearance would vary along the Proposed Development cable corridor. The final determination of depths and locations would be made post consent and would be informed by the cable burial risk assessment and pre-lay surveys, which can be compared to the marine characterisation survey data to determine seabed mobility. However, indicative maximum areas and volumes are presented in **Table 3-6** to support assessments.

Table 3-6: Indicative sand wave pre-sweeping parameters

Parameter	Maximum Design Parameter
Length of cable requiring pre-sweeping	3.5 km
Maximum clearance width	20 m
Total area of seabed disturbed by pre-sweeping	0.07 km^2
Maximum volume of sediment disturbed by pre-sweeping	1,000 m^3

3.4.3.5. Preparation for infrastructure crossings

The proposed cable route would cross over several types of third-party infrastructure which have been identified through desktop studies, the marine characterisation survey and direct engagement with the operators and asset owners. A formal crossing agreement would be agreed with each of the infrastructure asset owners prior to making the crossing. This agreement would include the design of the crossing, describing aspects such as crossing angle and vertical separation distance between the third-party asset and the Proposed Development. Where out of service infrastructure is present, agreements would be made to cut and remove sections of this infrastructure to allow unimpeded burial for the Proposed Development. There are currently anticipated to be a total of seven crossings required (assuming the two out of services cables present are cut and not crossed). It is noted however that the offshore wind farms (OWF) in the region are all at an early stage of development; only Cenos OWF has submitted a consent application. Whilst programmes suggest that they would occur after the Proposed Development is constructed, as a worst-case assumption it is assumed that a crossing of these offshore wind export cables would be required.

At the time of writing, the infrastructure which would be crossed by the Proposed Development includes:

- 1 power cable (EGL 2 co-located at landfall, consent has expired for NorthConnect interconnector, licence being taken on by Cenos OWF developer and currently in application stage, noted below);
- Up to 3 x offshore wind export cables (Cenos OWF, Aspen OWF and Marram Wind OWF);
- 1 active telecoms cables (Tampnet);
- 1 active pipeline; and
- 1 abandoned pipeline.

3.4.3.6. Active power and telecommunications cables

The crossing of active power and telecommunications cables (telecoms cables) by the Proposed Development would comprise a "bridge" over the assets made of either aggregate (rock) or concrete mattresses. This would provide a protective layer and separation between the Proposed Development and the telecoms cable.

Separation could also be achieved by installing a protective material around the Proposed Development (such as Uraduct® or TekDuct). This protective material would be positioned during route preparation by a pre-construction vessel using either a crane or a fall pipe. A secondary layer of rock or mattressing would then be laid over the crossing once the cable is installed. This is described further in **Section 3.5.1.**

A list of the telecoms cables identified from spatially mapped data sources (e.g., KIS-ORCA and Admiralty charts), as crossing the Proposed Development, is provided in **Chapter 13: Other Marine Users**. It is assumed that infrastructure crossings would be required for all infrastructure noted above.

3.4.3.7. Power cables and export cables from OWFs

There is currently one power cable (electricity link) and three proposed OWF cables that could potentially cross the Proposed Development. The timings of installation of this infrastructure is not certain however for the purposes of assessment it is assumed that they would be in place prior to installation of the Proposed Development and would therefore require crossing. **Chapter 13: Other Marine Users** identifies potential future OWF connections as part of the baseline environment.

The crossing would be designed to a similar manner to the crossing of telecommunications cables, with a aggregate or concrete mattress bridge to provide separation and a secondary later of rock or concrete mattressing laid over the top to provide protection to the Proposed Development where they are surface laid across the bridge.

3.4.3.8. In-service Pipelines

The Proposed Development would need to cross 1 active pipeline and 1 abandoned pipeline. Where the pipeline is buried, it would use the same methodology as described above for telecoms cables and offshore wind farm export cables, comprising a "bridge" of rock or concrete mattresses.

Where the pipeline is surface laid a crossing bridge would be created using supporting structures to ensure the cable is supported as it crosses the pipeline. **Chapter 13: Other Marine Users** provides further details.

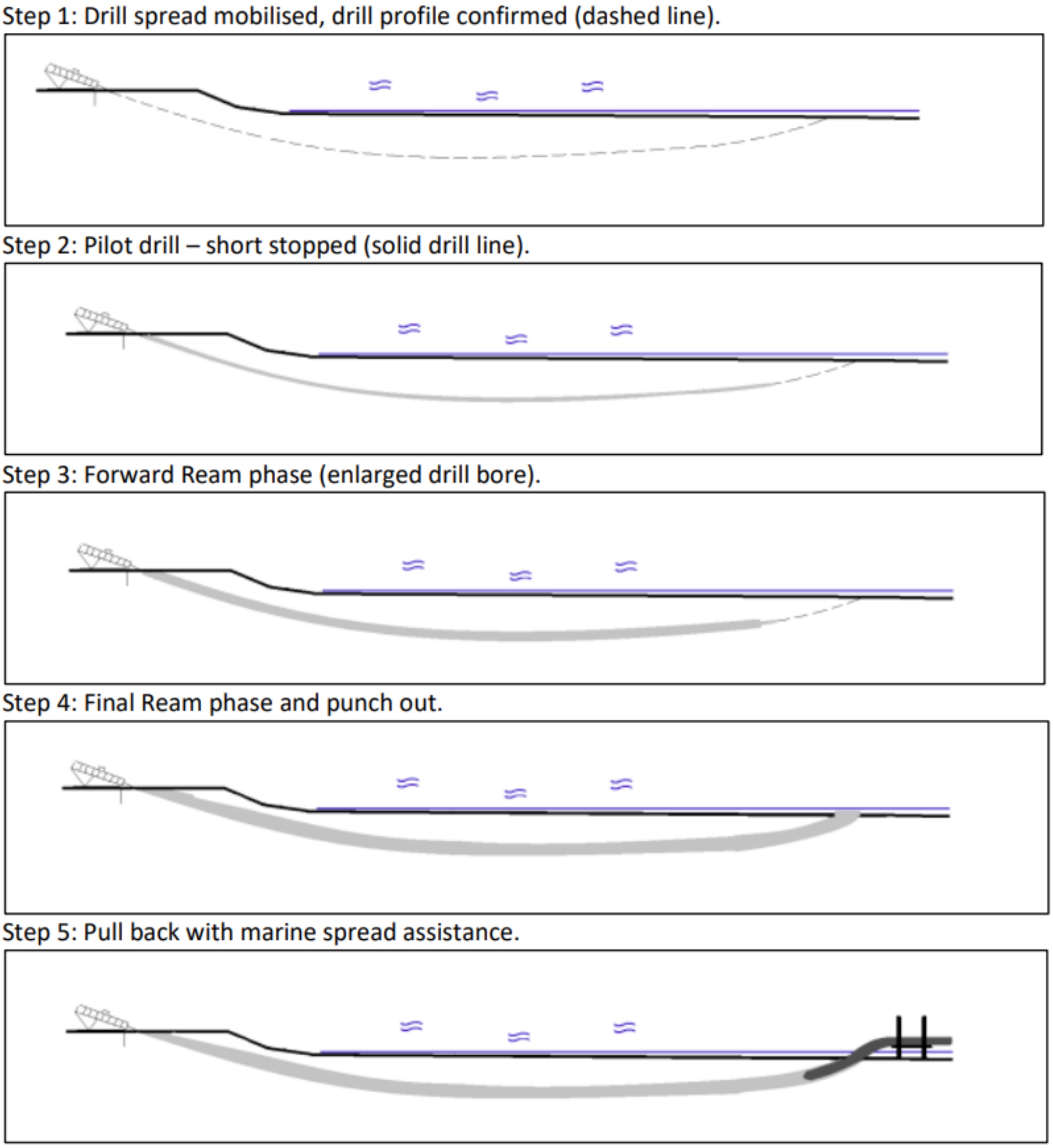
3.4.4. Landfall Enabling Works and Cable Pull-in

The method for drilling cable ducts from the HDD compound to the offshore exit point is described below and illustrated in **Figure 3-7.** There would be up to three High Density Polyethylene (HDPE) or steel ducts installed exiting in the nearshore (between 8 m and 20 m LAT). Depending on the final design and depth of the ducts, there would be a 25 m separation between adjacent HDD exit points.

The HDD entry point would be located onshore and directed out to sea. The HDD would reach 25 m at its maximum depth. For each borehole, a pilot hole would be drilled and then widened to the full diameter required. The primary HDD activity that interacts with the offshore environment is where the HDD breaks through the sediment (or punches out) onto the seabed. During the HDD punch out, drilling fluid and cuttings would be released from the bore on to the seabed. The HDD works would broadly involve the following activities:

- mobilisation and aligning the HDD Rig;
- pilot hole drilling;
- forward reaming;
- excavation of HDD pits (if required);
- punch out;
- installation of ducts;
- demobilisation;
- re-excavating the HDD pits (if required); and
- pulling of cables.

Figure 3-7: Indicative illustration of the HDD process



Note: Alternatively step 5 may involve push through from onshore

The drilling fluids that would be used for the HDD are likely to be a modified bentonite, a biodegradable drilling fluid additive, a modified natural cellulosic polymer, soda ash (sodium carbonate) and a natural biodegradable polymer which does not contain synthetic polymers, and a solidification reagent (or similar). All products used would be certified as being environmentally friendly according the Offshore Chemical Notification Scheme (Cefas, 2025). Bentonite is classified by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) (scientific advisors to the Department for Energy Security and Net Zero (DESNZ)) as posing little or no risk to the marine environment.

The volume of drilling fluid and cuttings lost during punch out would be minimised by several factors, including the boreholes having been drilled to their maximum diameter prior to punch out and the continuous removal of drilling fluid and cuttings prior to punch out. Lower drilling fluid pumping rates would also be used during punch out to minimise the loss of drilling fluid. It is estimated that approximately 110 m^3 of drilling fluid would be released into the marine environment per duct.

An excavated exit pit may be required at the HDD exit points to clear unconsolidated sediment layers that may jam HDD equipment during punch out or prevent duct installation once the boreholes have been drilled. This excavation would be undertaken by either a backhoe excavator (barge mounted) or a controlled flow excavator. Up to three exit pits may be required measuring up to 75 m x 15 m each. Sediments would be side cast next to the pits for later backfilling. Exit pits would then be refilled with a combination of manual infilling (backhoe excavator) and natural backfilling. Exit pits would remain open until the cable pull in. Ducts laid in the bottom of the exit pits may be weighted to the seabed using clump weights or rock bags.

Should an exit pit not be required, the drill and duct would exit directly onto the seabed. Once installed, the ducts may still require to be weighted using clump weights, rock bags or temporarily buried.

Upon completion of borehole drilling, ducts would be installed in each borehole. These may be pulled through from either onshore or offshore or pushed through from onshore. The method requiring the most offshore activity is a pulled installation from onshore. This would require a completed duct to be floated to the HDD exit point and pulled through the borehole to the HDD entry point in the onshore TJB. Floating the ducts would involve several vessels and tugs.

A jack-up barge, spud barge or multi-cat would be on site at the HDD exit for a period of 2-4 months. This is to support the installation of the ducts as they are pushed or pulled through the boreholes. The vessels would be equipped with cranes, winches and dive support facilities. Other vessels used at this time may include a guard vessel, crew transfer vessels, a diver support vessel and tugs.

Depending on the construction programme and any seasonal sensitivities at the landfall, there may be a break in works between the HDD finalisation and the cable pull-in. The offshore end of the cable ducts would be "wet stored" for this period by fitting a temporary flange to stop water ingress. This would be either a blanking plate (flat plate) or marine bell mouth (not to be confused with onshore bellmouth; a junction relating to highways infrastructure) with blanking plate to cover. A bell mouth in this context, is a cone type structure, as illustrated in **Figure 3-8**. It would support the cable as it is pulled into the duct to ensure that the cable does not snag on sharp duct edges or bend too far. The duct ends would then be stabilised as described above.

To prepare for the cable pull-in, any deposits would be fitted with lifting rings, which divers would fit a chain from the surface deck

Figure 3-8: Example of a marine bell mouth

crane. If the ducts have been buried into the seabed, they would be exposed using a barge mounted excavator, hydraulic dredge pump or controlled flow excavator. Once the bell mouth or flange is exposed, temporary bags of sand, rock or grout could be placed underneath the bell mouth to keep it raised off the seabed and prevent egress of sediment into the bell mouth during works.

At the start of cable pull-in, a messenger wire would be fed through each HDPE duct from the HDD compound. The messenger wire would be attached to a winch within the HDD compound. The CLV would approach the landfall position to approximately the 10 m water depth contour. The cable end would be transferred to a multi-cat or construction support vessel and the cable end sailed to the messenger wire at the HDD duct exit. Floats would be installed along the cable to keep it from sinking to the seabed. Workboats would be positioned along the length of the floating cable, always ensuring the steady positioning of the cable.

The onshore winch would start to pull the cable through the duct. Divers would remove the floats as the cable approaches the duct, allowing the cable to sink into and be pulled through the duct. Floats may either be allowed to wash to the beach in a controlled manner for retrieval or would be picked up by a support boat.

A cofferdam will not be used for the landfall enabling works. This activity would be repeated for each cable to be installed.

3.4.4.1. HDD Frac-out

Frac-out is the term for an unintentional or inadvertent loss of drilling fluid during the drilling of the boreholes. This occurs when a fracture in the underlying geology is encountered and drilling fluid finds an alternative path to the intended route, returning to the drill entry point for re-use and recycling. Drilling fluid can either be lost in the geological formation or can emerge at the surface. When released on an intertidal or sub-tidal surface, drilling fluid is rapidly diluted, dispersed and breaks down in the marine environment.

The components of the drilling fluid, including bentonite, are not hazardous to the marine environment (i.e., it is biodegradable, does not bioaccumulate and is non-toxic) and if released at the surface in the intertidal or sub-tidal area would not have any adverse effect on water quality or the environment. Construction contractors would be required to ensure that chemicals used in the marine environment are where possible listed on the Cefas Offshore Chemical Notification Scheme as posing little or no risk to the environment.

The amount of drilling fluid used in a drill is closely monitored and therefore most frac-outs are of small quantities. However, if there were to be a large release, this could be visible as a plume in the marine environment for a short period (typically the length of the tidal cycle over which the release is occurring). Once drilling fluid is in contact with sea water, Natrium Chloride molecules (which are present in salt sea water) would react with the clay particles and polymers of the bentonite. The particulates in bentonite flocculate on contact with seawater. Immediately after this flocculation, the bentonite particle shrinks and becomes a flat platelet (de-flocculation). The seawater would discolour at the outbreak, but the particles would be mixed by tidal and wave driven currents and dilute over time and with distance from the outbreak so that any discolouration would be localised. Once the drilling fluid is diluted, the clay and polymer molecules would be separated from the freshwater component of the drilling fluid and would be broken down into such small particles they would no longer be visible to the human eye. Dilution would continue during the following 1 to 2 tidal cycles until the discolouration disappears.

Measures to manage any such spills would be detailed in the Marine Pollution Contingency Plan.

3.5. Cable Installation

3.5.1. Cable Laying

There are three possible configurations for cable installation:

- **Pre-cut trenching** – A pre-cut trenching vessel would tow a plough along the seabed creating a V-shaped trench. A separate CLV would follow, laying the cables directly into the trench. The CLV would generally be followed by another CSV towing a back-fill plough which would push the spoil heaps into the trench, covering the cables. Alternatively, the trench would be left to naturally backfill or be filled using external cable protection.
- **Simultaneous lay and burial** – This technique would simultaneously create a trench excavation and lay the cable into the trench at the same time. The CLV may tow the burial equipment, or it would be deployed by another vessel following close behind the CLV, creating effectively a single large spread. The cables would be fed into the burial equipment directly from above and the cables would be buried as the spread progresses along the route.
- **Post-lay burial** – The CLV would lay the cables on the seabed and a post-lay burial vessel would follow later to bury the cables. As the post-lay burial is a stand-alone operation, the post-lay burial vessel may operate with a longer separation distance from the CLV, so there would be two operations separated physically by distance and in time.

During cable lay and burial a safety zone would be in place around construction vessels; typically, 500 m in radius to allow safe manoeuvring of the construction vessels. This would be extended to cover an anchor spread if one is used. Depending on the burial tool used, the vessels would be moving at speeds of 50 to 1,000 m per hour during cable lay and burial. During jointing operations vessels will be stationary for the duration of the activity, safety zones will be maintained during this period to ensure safe working.

The cable laying operations can generally continue in weather conditions up to force 7 winds and wave heights of up to 3 m, operating limits will be lower during jointing operations typically 1.5 – 2 m wave height. Operations would continue until the total cable length within that cable section has been installed.

If the weather is more severe and the vessels can no longer remain on station, there would be two options:

- The cable lay vessel would continue to slowly lay the cable onto the seabed, against the wind. After riding out the storm, the length of the cable laid during the storm would be retrieved from the seabed and cable lay operations started again from the point of suspension.
- If the weather is too severe, it might be necessary for the cable lay vessel to cut the cable and leave the site until it is safe to return. This would be considered as a last resort. On return, the vessel would retrieve the end of the cable, make a joint and then continue the laying operation.

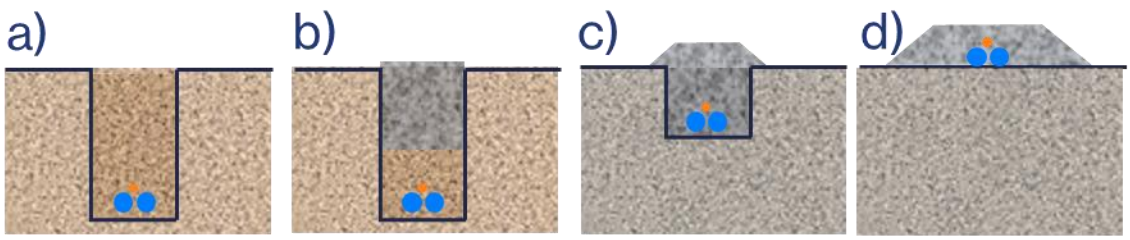
Cable lay and burial operations typically operate 24-hours a day to maximise the vessel and equipment time, and minimise disruption to shipping channels, fishing grounds or any other sensitive areas.

3.5.1.1. Burial depths

Burial in the seabed is recognised as the best protection method for marine HVDC cables. However, ground conditions may not always allow full cable burial to the depth necessary to protect from external risks. The cable would be buried below the seabed wherever possible, with a target burial depth defined post-consent in a pre-construction Cable Burial Risk Assessment (CBRA) and Burial Assessment Study undertaken by the construction contractor. The minimum and maximum cable burial depth would vary along the Proposed Development, depending on numerous factors such as soil type, presence/absence of sub-cropping or outcropping rock, shipping and fishing activity and the type of burial tool utilised.

Information on seabed conditions provided by the 2024 geophysical and geotechnical surveys has indicated ground conditions along the Proposed Development as well as the depth of water which would limit the burial tools that can be used, and full burial may not be possible along the entire route. **Figure 3-9**: Cable burial and protection scenariospresents the various cable burial and protection scenarios that may be encountered along the Proposed Development.

Figure 3-9: Cable burial and protection scenarios



a) Target depth of burial achieved - full burial in sediment.
b) Target depth of burial achieved - insufficient natural backfill, cable protection required to seabed level.
c) Target depth of burial not achieved - additional cable protection required above seabed level to achieve adequate protection.
d) Cables surface laid - protection provided fully by external measures.

The design envelope of the Proposed Development is provided in **Table 3-7** below and is based on information from an outline CBRA. At this stage in the Proposed Development, no burial tools, as outlined in the section below, can be ruled out.

Table 3-7: Indicative design envelope for cable burial

Parameter	Maximum Design Parameter
Length of cable	145 km
Indicative length of route where cable burial in seabed can be achieved	135 km
Maximum burial depth	2.5 m
Footprint of cable installation equipment	16 m
Indicative area of seabed disturbed by cable installation	2,320,000 m^2
	2.32 km^2

3.5.1.2. Burial tools

There are a range of burial tools and techniques that could be used to bury the cable. The selection of the tool would be based on numerous factors including the seabed geology and mobility, burial depth to be achieved, the construction contractor selected, proximity to existing infrastructure and environmental sensitivities and mitigation defined during the assessment process.

For all burial techniques, machine function would be controlled from the surface vessel via an umbilical cable. In shallow water, divers may be used to assist e.g., load cable into the machine.

The nature of the seabed, the target burial depth and the tool selection would influence how successful the first attempt at burying the cable is. Additional passes (i.e., where the burial equipment makes a number of attempts at burying the cable to get it deeper each time) would be made where the target burial depth is not achieved on the first attempt.

The following sub-sections describe the burial tools that could be used.

3.5.1.3. Cable plough

Cable ploughs are used in non-cohesive soils such as loose coarse sand to fine dense sand and cohesive soils such as clay through to rock. They are either towed behind the cable lay vessel to simultaneously lay and bury the cables or towed by a separate vessel to bury the cables post-lay.

The cable plough would be positioned on the seabed with the cable fed into the front of the burial machine. The cable would be guided through the machine to a plough 'share' to emerge in the trench the share leaves as it passes through the seabed. Soil displaced by the share is pushed to either side of the trench. The displaced soil may be simultaneously pushed by the plough back into the trench to cover the cables; pushed into the trench by a separate back-fill plough; or left in place to naturally back-fill the trench via natural seabed sediment movement.

The action of the plough has a greater seabed footprint of disturbance (in comparison to other techniques such as jet trenching).

Figure 3-10: Example of a typical cable plough

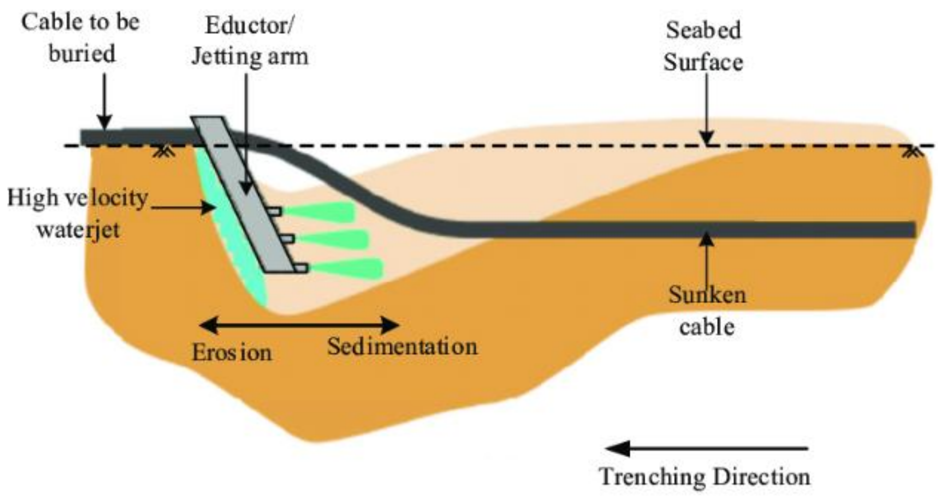
Source: KIS-ORCA

3.5.1.4. Jet trenching and / or vertical injector

These burial tools are tracked or ROV fitted with jetting swords. Most jet trenchers are self-propelled ROVs, although some can be towed from the cable lay vessel. The trencher would be lowered to the seabed above pre-laid cables. High pressure water is pushed through jetting swords into the seabed on either side of the cable, to fluidise the sediment. Lowering mechanisms allow the swords to be lowered into the seabed to the required burial depth, usually with a transition to the target depth of burial. The pre-laid cables sink through the fluidised soil to the bottom of the trench. The seabed sediments naturally re-form and back-fill the trench covering the cables. If the required depth of burial is not achieved, several passes can be made.

Jet trenchers operate in unconsolidated sediments (sand, silt) and can achieve burial depths of up to 3 m. Vertical injectors operate using a similar principle to jet trenchers, but can achieve greater burial depths down to 10 m.

Figure 3-11: Schematic of typical jet trenching method



Source: (Atangana Njock et al., 2020)

3.5.1.5. Cutting

Cutting is used on hard clay, cemented sand, sandstone and other types of rock. It would be used to either create a pre-cut trench into which the cables would be laid, or post-lay. The burial machine is usually a tracked vehicle that uses chain saws or wheels armed with tungsten carbon steel to cut a defined trench. Soil from the trench is ejected by the cutting action to either side of the trench. This action may be augmented by eductors that suck cut spoil out of the trench and deposit it on either side. The open trench would be backfilled or left to refill naturally.

The operation is slower than other burial methods and typically requires more frequent maintenance stops.

3.5.1.6. CFE / MFE

CFE / MFE is a technique that uses highly pressurised water directed at the seabed to push sediment to either side of a trench. The technique can also be used for the pre-sweeping of sand waves.

The CFE is operated and directly connected to the installation vessel and is suspended over the seabed unlike the previous methods noted above which are on the seabed.

3.5.1.7. External cable protection

External cable protection may be required in various areas along the Proposed Development. Areas that require protection would include:

- infrastructure crossings; and
- areas where depth of burial cannot be achieved.

A preliminary review of the 2024 geophysical and geotechnical data has provided an indication of potential areas along the RLB where external cable protection may be required. The Outline CBRA sets out the routeing and burial risk considerations at this point in time and provides a starting point for the pre-construction CBRA that would be undertaken post-consent by the construction contractor. The pre-construction CBRA would take into consideration, the environmental measures, the final recommended target burial depths, the capabilities of the actual burial tools to be used, any contractual requirements such as the number of passes each burial tool is required to make to reach burial depth, as well as any new information on ground conditions.

Cable protection would be required at up to seven infrastructure crossings, this cannot be avoided and is discussed in the following sections.

The design parameters for cable protection are listed in **Table 3-8.**

Table 3-8: Maximum design parameters for Cable Protection (excluding Infrastructure crossings)

Parameter	Maximum Design Parameter
Indicative Length of Cable requiring cable protection (excluding infrastructure crossing)	7 % due to geology
Indicative Length of Cable requiring cable protection (excluding infrastructure crossings)	10 km
Maximum width of cable protection on seabed	10 m
Maximum height of cable protection berm	1.5 m
Indicative area of seabed covered by cable protection	100,000 m^2
Indicative area of seabed covered by cable protection	0.1 km^2
Indicative volume of cable protection (excluding infrastructure crossings)	100,000 m^3

3.5.1.8. Rock Placement

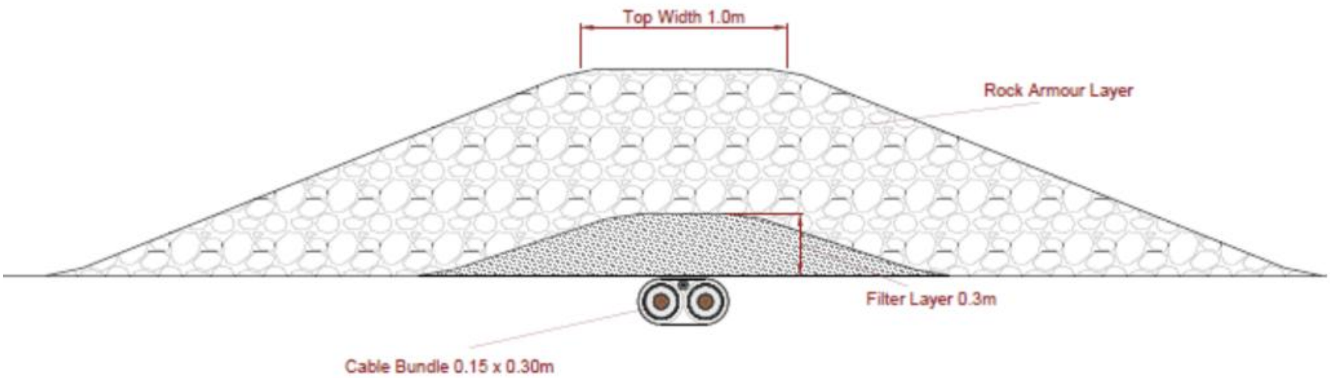
Rock placement is used to protect subsea cables by covering the cable with a continuous berm of graded rock which would be profiled. The berm is typically made up of two layers, a filter layer and then a layer of armour.

The filter layer is made of smaller particle size rock which is laid first to provide a stable layer for the armour layer, which comprises larger sized rock. The outer armour layer is designed to provide protection from external threats such as fishing gear or anchors as well as withstanding the metocean conditions.

Typically, the rock used would be an inert material such as granite to prevent the chances of non-native species being introduced to the area. The size of the berms would depend on the location of the berm and seabed conditions and would be individually designed as indicatively shown in **Figure 3-12**Figure 3-12Figure 3-12**.**

The berm is typically constructed using a fall pipe vessel which would place rock over the cable in a targeted manner.

Figure 3-12: Example schematic of a rock berm



3.5.1.9. Concrete mattresses

A concrete mattress comprises of matrices of interlinked concrete which are connected with rope and wire. They are installed using a crane from a construction support or diving vessel, which would lower the mattress into position over the cable.

Concrete mattresses are typically 6 m in length and 3 m wide and provide a strong protective cover to prevent potential snagging of fishing gear or anchors. They are not as protective as rock berms and it is possible for the mats to be caught and dragged by anchors or moved by strong currents, so they cannot be used in all locations. Multiple mattresses can be laid to provide larger area of coverage. For infrastructure crossings, mattresses are used in combination with rock protection.

There are various companies in the market that are investigating alternative designs for concrete mattresses to make them more nature inclusive. Concrete blocks are designed with complex surface structures and textures to encourage marine life to colonise them once installed. The concrete may also include chemical additives which promote the growth of encrusting organisms such as oysters and barnacles.

3.5.1.10. Flow dissipation devices

The purpose of a flow dissipation device is to reduce the velocity of water passing over, encouraging sediment to drop out of suspension and accrete. They are often used to protect structures from erosion. The most commonly used device is a fronded system/mat which can be either used on its own or attached to a concrete mattress. The system comprises of Ultra Violet stabilised polypropylene fronds secured to a polyester webbing. Once laid, they resemble seaweed which interrupts and reduces the velocity of the local currents. The drop in velocity allows the sediment to drop out of suspension and build up on the mats to form a natural embankment on and around the mat.

Fronded mats are suitable to be used in areas where the seabed is primarily sand, as they are designed to capture sediment as it moved over the mattress, they would not be appropriate on a rocky seabed environment. The mats can be custom made but are typically 5 m in length and 2.5 m wide, with the fronds being up to 1.25 m in length.

As technologies develop, there are opportunities for fronded mats to be made of non-plastic products.

3.5.1.11. Protective coverings, claddings or pipes

There are several varieties of protective coverings for subsea cables currently on the market such as Uraduct® or TekDuct, which are polyurethane half tubes and used to enclose the cable bundle. They can include a ballast should the cable system need to be weighted down further.

There are also cast iron and concrete versions of the half pipe which can also be used. This type of protection is typically used in combination with another type of protection such as rock placement. However, it can be used as a standalone method for short lengths of cables.

3.5.1.12. Rock, gravel/sand bags

Rock bags consist of various sized rocks (or sand and/or gravel) within a rope or wire netting bag, although there are new products coming on to the market whereby the bags are made from specially developed basalt fabric. They would be installed using a crane from a construction vessel placing them over the cable in the correct position.

3.5.1.13. Nature Inclusive design

Wherever possible and appropriate, opportunities to incorporate nature inclusive design solutions into the cable protection will be considered. Nature inclusive design incorporates measures that are integrated into or added to the design of cable protection to increase suitable habitat for native species (or communities). This could include designing the cable protection to encourage growth of benthic fauna to increase biodiversity.

3.5.1.14. Cable jointing

Cable lay vessels are limited in the length of cable they can carry in a single load (typically 5,000 to 11,000 tonnes). For the cable system design, this equates to cable lengths in a bundled configuration of 60 – 150 km. Sections of offshore cables would be connected by a cable joint. The cable system would therefore require up to 3 joints within the Proposed Development due to its length.

At the cable joint position, the end of the installed cable would be temporarily left on the seabed whilst the cable lay vessel returns to port to pick up a new cable length. A ground wire would be attached to the cable end to enable retrieval when the cable lay vessel returns. The cable end may be temporarily buried into the seabed or protected with rock bags or mattresses, marked with a buoy and/or guarded by a guard vessel whilst the cable lay vessel is offsite.

The cable joint would be made on board the cable lay vessel and would take up to two weeks per joint location. During this time, the cable lay vessel would likely anchor to maintain position. Once the cable joint has been made, the cable lay vessel would continue to lay the new cable section.

In-line joints would be made where cable laying can be continued after the cable end has been picked up. Where the cable is laid towards the cable end, or where a repair is required in an existing cable, an omega joint is made, as illustrated in

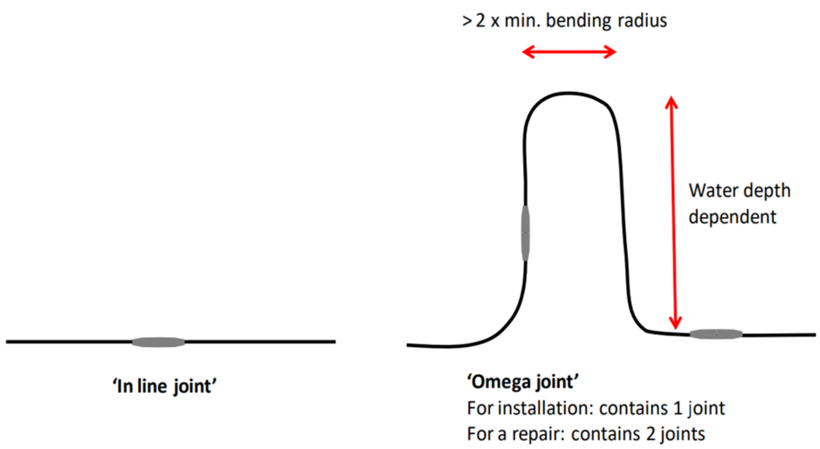
***Figure** 3-13*

Figure 3-13. In this scenario, both cable ends would be bought on board the cable lay vessel to make the joint. The process requires extra cable, approximately equal to twice the depth of water to allow for the transition of each cable from the seabed to the surface to make the joint. When the cable is returned to the seabed the additional cable would be laid on the seabed to one side of the centreline in a loop.

For both types of joint, the joint and cables would be buried (as the preference) or protected by external cable protection.

It is assumed that the seabed footprint for cable jointing is within the design envelope for seabed preparation and cable installation described above. Cable Operations and Maintenance (O&M) requirements are described in **Section 3.6**.

Figure 3-13: Indicative illustration of subsea cable joints



3.5.1.15. Infrastructure crossings

The works that would be undertaken to prepare the seabed for infrastructure crossings are described in **Section 0**. This would involve installing a protective layer between the existing infrastructure and the Proposed Development.

An exclusion zone either side of the existing infrastructure would be agreed as part of the crossing agreement. The burial tool would transition out of the soil before reaching the exclusion boundary, and the Proposed Development would be surface laid over the infrastructure 'bridge' created during the seabed preparation works. A minimum vertical separation between the existing infrastructure and the Proposed Development, typically 300 mm, would be agreed with the asset owners, and the crossing engineered to achieve the agreed vertical separation. Burial (as applicable) would continue after cable lay progresses outside of the burial exclusion zone on the opposite side of the crossed infrastructure.

External cable protection would then be laid over the Proposed Development along the surface laid cable (including the zones where the Proposed Development transited out and into the soil). **Figure 3-12** Figure 3-12 illustrates a typical crossing berm.

The physical crossing designs for each infrastructure crossing would vary according to, among other things, the size, type, location and burial state of the crossed asset, and the exclusion zone. However, the crossings would not exceed the maximum design parameters presented in **Table 3-9**Table 3-9**.**

If the Proposed Development is exposed for any period e.g., between cable lay and deposition of external cable protection, a guard vessel would be deployed.

Table 3-9: Maximum design parameters for infrastructure crossings

Parameter	Maximum Design Parameter
Total number of crossings required	Up to 7
Typical length of crossing	500 m (at some locations crossings may be combined due to proximity of infrastructure)
Total length of cable crossings	3,500 m
	3.5 km
Maximum width of crossing	10 m

Maximum height of crossing	2.2 m
Total area of seabed covered by cable crossings	35,000 m^2
	0.035 km^2

3.5.1.16. Cable wet storage

It may be necessary to temporarily store sections of the cable on the seabed prior to installation. Sections would be placed on the seabed within the RLB and its location communicated to mariners through a Notice to Mariners.

3.5.1.17. Construction Installation Vessels

A range of different vessels would be required during construction of the Proposed Development. The use of specific vessels such as the CLV or a Cable Lay Barge (CLB) would be confirmed once the installation contract has been awarded (post consent).

Details of vessels deployed on similar cable installation projects to the Proposed Development have been used to inform the description of representative vessels. It is expected that the following types of vessels would be used, descriptions of each are provided in the subsequent sections:

- CLV;
- CLB;
- Anchor handling tug;
- Jack-up barge;
- Guard vessel;
- Construction and dive support vessels; and
- Rock placement vessels.

3.5.1.18. Cable Lay Vessel (CLV):

The CLV is a specialist ship designed specifically to carry and handle long lengths of heavy power cables. The CLV would be equipped with a dynamic positioning system, which enables the vessels to be held very accurately in position despite the effects of adverse weather. The shallowest depth in which the cable ship can operate would depend on the vessel used but is typically around 10 m LAT, although some vessels can operate in much shallower depths.

The cable would be loaded onto powered turntables (carousels) on the back of the CLV at the cable production factory. The cable would be transported in this manner to prevent any twists or kinks in the cable.

3.5.1.19. Cable Lay Barge (CLB):

A CLB may be required at the proposed landfall. These types of vessels typically operate in water depths less than 10 m LAT. These shallow water operations are generally conducted upon flat top pontoon barges. These barges are fitted out with the necessary cable storage and working equipment.

Typically, a CLB uses anchors (up to 8 in total) to hold position covering an area of between 500 m and 1,000 m radius from the vessel, alternatively the CLB may use spud legs which can be jacked up and down allowing the barge to tether to the seabed if required.

The CLB typically is assisted by a team of other vessels and possibly divers depending on the cable laying technique being used. The small vessels are used to move anchors, monitor traffic and guard the vessel spread.

3.5.1.20. Anchor Handling tug

Dedicated anchor handling tugs may be used to support the CLB. They can move the anchors to allow the barge to propel itself within the RLB. These specialised vessels are typically 30 m in length and have the ability to work in the shallower depths of the nearshore area.

3.5.1.21. Jack-up Barge (JUB)/anchored barge or multi-cat vessel

These types of vessels may be used at the trenchless technique punch-out point to support the drilling and pull-in of the cables.

A JUB is a platform that generally has four to eight legs which can be adjusted for the sea conditions. A JUB does not have its own propulsion system, so is towed into position by a tug.

3.5.1.22. Guard vessel

Guard vessels are used to ensure the safety of mariners operating in the vicinity of construction and maintenance activities associated with the cable. They may be required to accompany the CLV or CLB, particularly in areas of high-frequency shipping. The guard vessel or other construction support vessels maintain surveillance around the CLV/CLB to monitor traffic and would notify other vessels to keep away from the installation spread to avoid the potential threat of collision.

Guard vessels are also used to protect areas of exposed cables prior to burial or deposit of external cable protection. A guard vessel may also be used to warn fishing vessels from areas of the route that are temporarily unprotected during the gap between cable lay and burial or the installation of external cable protection, to avoid any snagging of fishing gear.

Guard vessels are typically quite small, preferably locally sourced and crewed to the project location to ensure that they are familiar with areas they are guarding. They are frequently fishing vessels who are unable to fish their normal grounds due to the construction works.

3.5.1.23. Construction support vessels (CSVs)

There are several other types of support vessels which would be used during the construction of the Proposed Development. These are likely to include dive support vessels, crew transfer vessels, general construction vessels and small rigid inflatable boats. The CSVs would vary in size depending on the type of activity they would be required to do and the working conditions. They may also undertake several different roles on a project, such as inspections for UXO or archaeology, PLGR, anchor handling or the placement of mattresses at crossing locations.

3.5.1.24. Rock placement vessels

Vessels used for rock placement are highly specialised. They comprise of a large hopper to transport the rock and a mechanism for the deployment of the rock at the correct location. This can use the following techniques:

- side dumping where rock is pushed or tipped over the side of the vessel;
- split hopper where the hopper separates to allow the rock to fall straight through the vessel on to the seabed below; and
- flexible fall pipe where a retractable chute is used to accurately control a flow of rocks over the cable on the seabed.

The use of the fall pipe is the most accurate technique but can only be used in waters over 10 m in depth.

3.5.1.25. Indicative vessel movements

A condition of the Marine Licence could be for the construction contractor to confirm the number and types of vessels to be used during all phases of construction. **Table 3-10** provides an indication of the types of vessels to be used during construction based on experience on other projects. Vessels would typically transit in a linear manner along the Proposed Development. However, their port of origins are unknown at this stage and will not be known until a construction contractor has been appointed.

Table 3-10: Indicative vessel requirements for the Proposed Development

Construction activity	Maximum Design Parameter
Preconstruction survey	1 x survey vessel
UXO identification	1 x CSV
Boulder clearance	1 x CSV
Sand wave pre-sweeping	1 x CSV
Crossing preparation	1 x CSV 1 x rock placement vessel
PLGR	1 x CSV
landfall enabling works	1 x JUB / multi-cat 1 x tug 1 x crew transfer vessel 2 x small workboats
Cable lay and burial	1 x CLV 1 x CSV 2 x tug / anchor handler 5 x guard vessel 1 x rock placement vessel

3.6. Cable Operation

The Proposed Development would be designed to minimise any maintenance requirements. Following installation the following activities may be periodically required during the operational phase:

- inspection surveys, including geophysical surveys;
- cable repair (if required) (noting that emergency repairs requiring immediate action are exempt and therefore not included in this application) and
- reburial, remedial protection or maintenance and reinstatement of external cable protection features.

3.6.1. In-Service Survey Requirements

Geophysical surveys would be undertaken periodically to monitor cable burial and the status of external cable protection e.g., remedial or at infrastructure crossings. If results of the in-service survey show that the Proposed Development is not at the required burial depth or has become exposed, remedial works could be undertaken as described in **Section 3.5.1**. Additional surveys may be undertaken after storm events which exceeded the design conditions.

Surveys would use the standard suite of geophysical techniques described in **Section 3.4** (i.e., MBES, SSS, SBP, magnetometer etc). Nearshore and offshore survey vessels or an automated underwater vehicle would be used.

3.6.2. Subsea Cable Repairs and Maintenance

Should a fault be identified by the cable monitoring system, it would be necessary to access the relevant location of the fault and retrieve the cable to the surface for inspection. The damaged section would then be repaired or replaced. The most common reason for a repair of a subsea cable is damage caused by third parties, typically by a vessel anchor strike on a shallow or exposed cable segment.

A cable repair would typically be carried out by a single vessel. For a shallow water repair, in less than 10 m of water, an anchored barge would typically be used. In deeper water, a CVS would be used. Vessels carrying out cable repair operations are restricted in their ability to manoeuvre and divers and/or ROV would be expected to be used with associated vessels.

The actual operational details and the precise configuration of a repair spread would depend on the type of repair identified. The typical steps would comprise:

- loading of spare cable to the repair vessel;
- survey to locate the damaged cable;
- cable de-burial;
- cable cutting and recovery to the surface;
- splicing in the replacement section of cable; and
- re-deployment of cable onto the seabed and re-burial.

A repair would require the insertion of additional cable and two additional cable joints. The additional cable length may be equal to or greater than approximately three times the depth of the water at the site, depending on how much damage the cable has sustained.

If the repair is of a single cable in a bundled pair, the pair of cables would need to be cut, and both brought to the surface. However, it is possible that both cables might be repaired as a precaution against undetected damage.

The extra length of a repaired cable section means that the repaired cable cannot be returned to its exact previous position and alignment on the seabed. The excess cable would be laid on the seabed in a loop to one side of the original route to form an 'omega' loop, as illustrated in

***Figure** 3-13*

Figure 3-13**.** This new piece of cable would then be buried into the seabed, or external cable protection would be deposited if burial is not feasible due to ground conditions or position.

A cable repair operation would be expected to take between two and six weeks depending on the type and extent of the damage, the burial requirements, and operational constraints such as weather.

The requirement for repair operations during the lifetime of the Proposed Development would depend on the number of faults, location of the faults, and the burial/protection method used for the original installation. Safety zones around the vessel undertaking the repair works would be in place for the duration of the works, these will likely be the same as during construction and comprise a 500 m area around the vessel.

3.7. Cable Decommissioning

3.7.1. Landfall

The expected minimum operational life of the proposed landfall infrastructure is 40 years, with replacement only expected to occur upon the failing of specific assets.

The below ground TJB providing onshore to offshore cable interface may be left in place as well as the ducts installed to bring the cables onshore. As a result, it is expected that there would be similar methods to remove these components as those used to install the asset.

3.7.2. Offshore Cable

The minimum design life of the Proposed Development subsea cables is 40 years, although with repairs, some cable systems last upwards of 60 years. The Proposed Development would require a Licence or Lease from Crown Estate Scotland for the elements within 12 NM of the coast. As part of the Licence process the Applicant is required to prepare an Initial Decommissioning Plan. The Initial Decommissioning Plan will form the basis of the Final Decommissioning Plan which would be developed in consultation with Crown Estate Scotland and in line with the following decommissioning principles:

- The measures and methods for any decommissioning would comply with any legal obligations which would apply to the decommissioning of the Proposed Development when it takes place;
- All sections of the cables within 12 NM would be removed except for any section or sections which are preferable to leave in situ having regard to the principles below:
    - that the measures and methods for any decommissioning are the best for, or minimise the risks to:
        - the safety of surface or subsurface navigation;
        - other uses of the sea;
        - the marine environment including living resources; and/or; and
        - health and safety.
    - the seabed would be restored, as reasonably as possible and to the extent reasonably practicable, to the condition that it was in before the cable was installed.

The Initial Decommissioning Plan is periodically reviewed and updated in line with the applicable guidance and regulations at the time of writing.

The full environmental impact of works required to decommission the Proposed Development would be assessed at the time of decommissioning and a separate Marine Licence would be applied for in relating to any decommissioning works proposed. Removal of the subsea cable is a similar process to the installation of the cable, but in reverse. The environmental impact can therefore not be fully assessed until the environmental conditions at the time of decommissioning are established.

3.7.3. Environmental Effects of Decommissioning

It is anticipated that rather than the Proposed Development being decommissioned, parts would be replaced to extend the operational life. As such, the operational assessments in this MEAp have been undertaken under the assumption that the Proposed Development will continue to operate in perpetuity. It is not anticipated that impacts from decommissioning would be any greater than impacts from the construction phase.

Acknowledging the complexities of completing a detailed assessment for decommissioning works 40 years in the future, and given the level of information available regarding the approach to decommissioning for the Proposed Development, reasonable assumptions with regards to likely environmental impacts at the time of decommissioning can be made. These are set out and assessed in each of the technical chapters.

3.8. Environmental Management

Control and management measures relevant to the Proposed Development have been outlined in each of the chapters; these will be captured in the final Construction Environmental Management Plan which will be submitted post consent and pre-construction to satisfy the likely conditions of the Marine Licence.

Several management plans would be provided to discharge the Marine Licence conditions prior to the start of construction. These would include a Construction Environmental Management Plan (CEMP), a Marine Mammal Mitigation Plan (MMMP), a Marine Pollution Contingency Plan (MPCP), and a Fisheries Management and Mitigation Plan (FMMP). These documents will outline measures to be implemented to comply with legislation, such as Prevention of Pollution at Sea (MARPOL) and Safety of Life at Sea (SOLAS), and the mitigation commitments proposed within this MEAp. An Outline CEMP is provided as part of the MLA (**Appendix 3B: Outline Construction Environmental Management Plan**). In addition, design measures identified through the MEA process have been applied to avoid or reduce potential significant effects as far as possible. These measures are described within the CEMP and compliance with these measures would be secured via conditions placed on the Marine Licence, as necessary.

3.9. Cable Emissions

The emissions that may occur during cable installation or operation are:

3.9.1. Electric and Magnetic Fields

The Proposed Development would use Direct Current (DC) technology which has a frequency of zero hertz (0 Hz) and would produce static electromagnetic fields (EMFs) when in operation.

Electric fields depend on the operating voltage of the equipment producing them and are measured in V/m (Volts per metre). As the proposed cables would be enclosed in a solid metal sheath, which screens the electric fields, they would not produce an external electric field. However, they would produce a magnetic field, which is not screened by the metal sheath, and seawater moves through the magnetic field, a small localised electric field is produced. This is known as an induced electric field.

Magnetic fields depend on the electrical currents flowing, which vary according to the electrical power requirement at any given time and are measured in μT (microtesla). Magnetic fields generated by the operational cables diminish rapidly with distance from the source.

The earth also produces its own DC magnetic field, which in the UK is around 50 μT, but this can vary due to geomagnetic material such as ferromagnetic rocks. Given the natural magnetic field, the background induced electric field could range between 5.0 and 61 μV/m in tidal velocities ranging between 0.1 m/s and 1.25 m/s.

The estimated magnetic fields for the Proposed Development have been calculated for two cable configurations: bundled HVDC cables, and HVDC cables separated by 15 m and buried to 25 m at landfall (HDD). All calculations were performed assuming the current maximum circuit separation and minimum burial depth, and 100 % load giving a worst-case scenario. The maximum magnetic field for each design option was calculated at vertical distances of 0 to 20 m from the seabed, and horizontal drop off along the seabed. A burial depth of 1 m was used for all calculations. The assessment is provided in **Appendix 3A: Electric and Magnetic Field Assessment.**

3.9.1.1. Magnetic Compass Deviation

Magnetic compasses, whether traditional magnetic needle designs or alternatives such as fluxgate magnetometers, operate from the Earth's magnetic field, and are susceptible to any perturbation to the Earth's magnetic field by other sources.

The Maritime and Coastguard Agency (MCA) in their response for the EGL 3 Non-Statutory Scoping Opinion stated that "*There must be no more than a 3-degree electromagnetic compass deviation for 95% of the cable route and for the remaining 5 % of the cable route there must be no more than a 5-degree electromagnetic compass deviation. If the MCA requirement cannot be met, a post installation actual electromagnetic compass deviation survey should be conducted for the cable in areas where compliance has not been achieved*."

The magnetic fields and compass deviation at the sea's surface were calculated for the Proposed Development for the same two design scenarios considered by the EMF calculations. The assessments were performed using cable orientation and depth from bathymetry data. The orientation of the cables to north, separation and depth, as well as the current flowing in the cable, will all impact the extent a compass is deviated from the Earth's magnetic north.

The compass deviation calculations assume that the cable would be buried 1 m below the seabed. The compass deviation calculation results are calculated at the sea surface. In practice, the draft of any vessel will limit the sea depth that applies, and the compass is likely to be situated above the water line, both of which will reduce the compass deviation that will be found in practice.

The calculations, presented in **Appendix 3A: Electric and Magnetic Field Assessment**, show that:

- When HVDC cables are bundled, the MCA thresholds are not exceeded.
- Where the HVDC cables are separated into individual ducts at the landfall, compass deviation would be > 5-degrees however water depths are very shallow in these areas.

3.9.2. Temperature increase

As well as EMF, cables generate heat as a by-product of transmitting electricity. The generated heat has the potential to raise the temperature of the seabed in proximity to the cables and consequently, alter the surrounding habitat, potentially resulting in impacts to benthic and fish species. The heat losses from the cables are related to the physical and thermal properties of the cables. Several scenarios were modelled to evaluate the thermal performance of the cables, including directly buried in a bundle to differing depths and contained within a duct at the landfall at various depths. The results presented in **Appendix 3C: EGL 3 Heat Calculations,** show that for cables operating at full power, temperature would be raised in the immediate vicinity of cables but reduces within increasing distance. The heat would be highly dependent on the depth of burial and the thermal resistance of the surrounding seabed. Temperature is likely to fluctuate as the cables would be unlikely to be operating at maximum capacity all the time or for extended periods of time (months/years).

3.9.3. Underwater Sound

The predominant noise generating activities during the installation and operations of the Proposed Development would be from:

- Geophysical survey equipment (e.g., side scan sonar, multi-beam echosounder, sub-bottom profiler and magnetometer);
- Cable trenching (vessel and equipment noise);
- Placement of external cable protection (vessel, equipment and rock placement noise);
- Investigation and clearance of potential UXO (note clearance is subject to a separate Marine Licence); and
- Movement of vessels.

UXO clearance would be consented via a separate Marine Licence and is therefore not assessed in detail, however a high-level assessment is provided to ensure a holistic view of the whole project.

The above activities include both impulsive and non-impulsive (continuous) anthropogenic sound sources.

- Impulsive sounds include pulses generated during geophysical surveys, which can be characterised by short duration pulses, broad bandwidth and have rapid rise and decay period with high peak pressures.
- Non-impulsive sounds include the continuous sounds from vessel movements, which can be characterised by low level sounds spread over a longer period of time that do not have a rapid rise and decay times or high peak pressures.

Underwater modelling has been undertaken for the Proposed Development with results included in **Appendix 10A: Underwater Noise Technical Assessment**.

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