GREENLINK INTERCONNECTOR LIMITED

Habitat Regulations Assessment

Greenlink Interconnector - Marine Wales

Greenlink - an interconnector between GB and the Republic of Ireland

P1975_R4710_RevF4 | October 2020

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GLOSSARY AND ACRONYMS

AA
Appropriate Assessment

An assessment carried out under Article 6(3) of the Habitats Directive of the implications of a plan or project, either individually or in combination with other plans and projects, on a European site in view of the site's conservation objectives.

ADD
Acoustic deterrent device

B Field
Magnetic field

Biodiversity
The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (UN Convention on Biological Diversity 1992).

Birds Directive
Council Directive 2009/14/EC on the conservation of wild birds.

Bryozoans
Also known as moss animals, are colonial animals that form encrustations or build bush-like structures resembling small corals.

CBRA
Cable burial risk assessment

CLB
Cable lay barge

CLV
Cable lay vessel

CHSR
Conservation of Habitats and Species Regulations 2017

CEMP
Construction Environmental Management Plan

CCW
Countryside Council for Wales

DP
Dynamic positioning

EMF
Electromagnetic field

EC
European Commission

The Commission of the European Communities.

EPS
European Protected Species
Under Article 12 of the EC Habitats Directive Member States are required to establish a system of strict protection for EPS, as listed in Annex IV across their entire range within the EU, both within and outside Natura 2000 Sites.

ES
Environmental Statement

EU
European Union

EUNIS
European Nature Information System

European Site
Collective term for Special Areas of Conservation, Special Protection Areas and Ramsar sites.

GB
Great Britain

GIL
Greenlink Interconnector Limited

GIS
Geographic Information System

Habitat
A habitat listed in Annex I of the Habitats Directive.

Habitats Directive
Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive).

HDD
Horizontal directional drilling

HRA
Habitat Regulations Assessment

Where competent authorities assess certain plans or projects which affect Natura sites. (The acronym HRA refers to a Habitat Regulations Assessment or a Habitat Regulations Appraisal).

HVDC
High voltage direct current

Hydroids
Colonial animals typically 5-500mm high or more, that branch.

iE field
Induced electric field

ICG-C
Intercessional Correspondence Group on Cumulative Effects

IROPI
Imperative reasons of overriding public interest

JNCC
Joint Nature Conservation Committee

JUB
Jack-up barge

KP
Kilometre Point

LSE
Likely significant effect

MBES
Multi-beam echo sounder

MCAA
Marine and Coastal Access Act 2009

MCZ
Marine Conservation Zone

Area designated under the Marine and Coastal Access Act 2009. They protect a range of nationally important marine wildlife, habitats, geology and geomorphology, and can be designated anywhere in English and Welsh territorial and UK offshore waters.

META
Marine Energy Testing Area

MHPA
Milford Haven Port Authority

MHWS
Mean high-water springs

MLW
Mean low water

MMO
Marine mammal observer

NPWS
National Parks & Wildlife Service (Ireland)

NRW
Natural Resources Wales

OMR
Conservation of Offshore Marine Habitats and Species Regulations 2017

OWEZ
Offshore Windfarm Egmond aan Zee

PAM
Passive Acoustic Monitoring

PCE
Potential cumulative effect

PCI
Project of Common Interest

PTS
Permanent threshold shift

QF
Qualifying Feature

RAMSAR Sites
Wetlands of international importance designated under the Ramsar Convention.

SAC
Special Area of Conservation

Are sites designated under European Communities Directive 92/43/EEC known as the 'Habitats Directive'. This requires the conservation of important, rare or threatened habitats and species (not birds, which are protected by Special Protection Areas) across Europe.

SBP
Sub-bottom profiler

Screening for Appropriate Assessment
The screening of a plan or project to establish if an appropriate assessment of the plan or project is required. Unless the screening assessment can establish that there is no likelihood of any significant effect on a European site, then an AA must be carried out.

SOPEPs
Shipboard oil pollution emergency plans

SPA
Special Protection Area

Are sites designated under the European Communities Directive 2009/14/EC, known as the 'Birds Directive', to conserve the habitats of certain migratory or rare birds.

SSS
Side Scan Sonar

SSSI
Site of Special Scientific Interest

Are nationally important areas of land and water (above mean low water) in Great Britain. SSSIs give legal protection to the best sites for wildlife and geology in England and Wales under the Wildlife and Countryside Act 1981 (as amended).

TEN-E Regulations
Trans-European Network for Energy

TJP
Transition joint pit

TTS
Temporary threshold shift

UXO
Unexploded Ordnance

1. Introduction

Revision F1 of this Habitats Regulations Assessment (HRA) for the Greenlink interconnector (Greenlink) was submitted by Greenlink Interconnector Limited (GIL) on 24 June 2019, accompanying a Marine Licence Application (MLA, reference CML1929). Its examination by Natural Resources Wales (NRW) is currently in progress.

On 24 February 2020, NRW issued a Request for Clarification/Further Information relating to the HRA and MLA and invited GIL to provide further evidence on the matters set out in regulations 64 and 68 of the Conservation of Habitats and Species Regulations 2017, namely:

- Whether there are any feasible alternative solutions to the project which are less damaging to the affected European site;
- Whether there are any imperative reasons of overriding public interest (IROPI) for the project to proceed;
- What compensatory measures are proposed to ensure that the overall coherence of the network of European sites is protected.

Revision F2 of this HRA, dated May 2020, has been prepared in response to the Request for Clarification. Section 6 provides evidence and information which demonstrates that NRW can be satisfied that there are no feasible alternative solutions to the Greenlink Interconnector and the application to use external cable protection (as a contingency) within Pembrokeshire Marine / Sir Benfro Forol SAC.

Section 7 confirms how Greenlink meets the IROPI test beyond the PCI status awarded to it.

Recital 28 of the TEN-E Regulation provides that: "Projects of common interest should be considered by competent authorities as being in the public interest. Authorisation should be given to projects which have an adverse impact on the environment, for reasons of overriding public interest, when all the conditions under Council Directive….are met".

Section 8 confirms that a Habitat Compensation Plan will be in place for Greenlink. This meets the conditions for the Council Directive.

For clarity, all new text added during Revision F2 is highlighted in yellow, with superseded text struck-through.

On 03 July 2020, NRW issued a Second Request for Clarification / Further Information in relation to the HRA and MLA and invited GIL to provide further evidence with respect to the following European sites:

- Pembrokeshire Marine / Sir Benfro Forol SAC (site code: UK0013116)
- West Wales Marine / Gorllwein Cymru Forol SAC (site code: UK0030397); and
- Bae Ceredigion / Cardigan Bay SAC (site code: UK0012712).

Most clarification requests relate to the assessment of the effects of underwater noise from unexploded ordnance disposal.

Revision F3 of this HRA, dated August 2020, has been prepared in response to the Request for Clarification. In view of the changes requested to West Wales Marine SAC, GIL have also made changes to the assessment for the Bristol Channel Approaches/ Dynesfeydd Môr Hafren SAC (site code: UK0030396).

Changes have also been made within Appendix A (Underwater Noise Modelling) and Appendix E (Marine Mammal Mitigation Plan) of this HRA. It has been agreed with NRW Marine Licensing that the requested changes to Appendix D (Habitats Compensation Plan) can be addressed post-marine licence consent decision as a condition of the marine license.

For clarity all new text added during Revision F3 is highlighted in blue.

1.1 Project Background

GIL is proposing to develop an electricity interconnector (Greenlink) linking the existing electricity grids in Great Britain (GB) and Ireland. The Greenlink project will consist of two converter stations, one close to the existing substation at Great Island in County Wexford (Ireland) and one close to the existing substation at Pembroke in Pembrokeshire (Wales). The converter stations will be connected by underground cables (onshore) and subsea cables (offshore). The Greenlink route is shown in Figure 1-1 (Drawing P1975-LOC-001).

The project is designated as a European Union Project of Common Interest (PCI), project number 1.9.1, under the provisions of European Union Regulation No. 347/2013 on guidelines for Trans-European Network for Energy (TEN-E Regulations) and has successfully applied for funding under the Connecting Europe Facility.

This HRA covers the Welsh Marine components of Greenlink from mean high-water springs (MHWS) at the Welsh landfall at Freshwater West, Pembrokeshire to the UK / Republic of Ireland median line. This is defined as the Proposed Development and comprises:

- Two high voltage direct current (HVDC) electricity power cables;
- A smaller fibre-optic cable for control and communication purposes;
- All associated works required to install, test, commission and complete the aforementioned cables; and
- All associated works required to operate, maintain, repair and decommission the aforementioned cables, including five repair events over the 40-year lifetime of Greenlink.

The location of the Proposed Development is illustrated in Figure 1-2 (P1975-CORR-001).

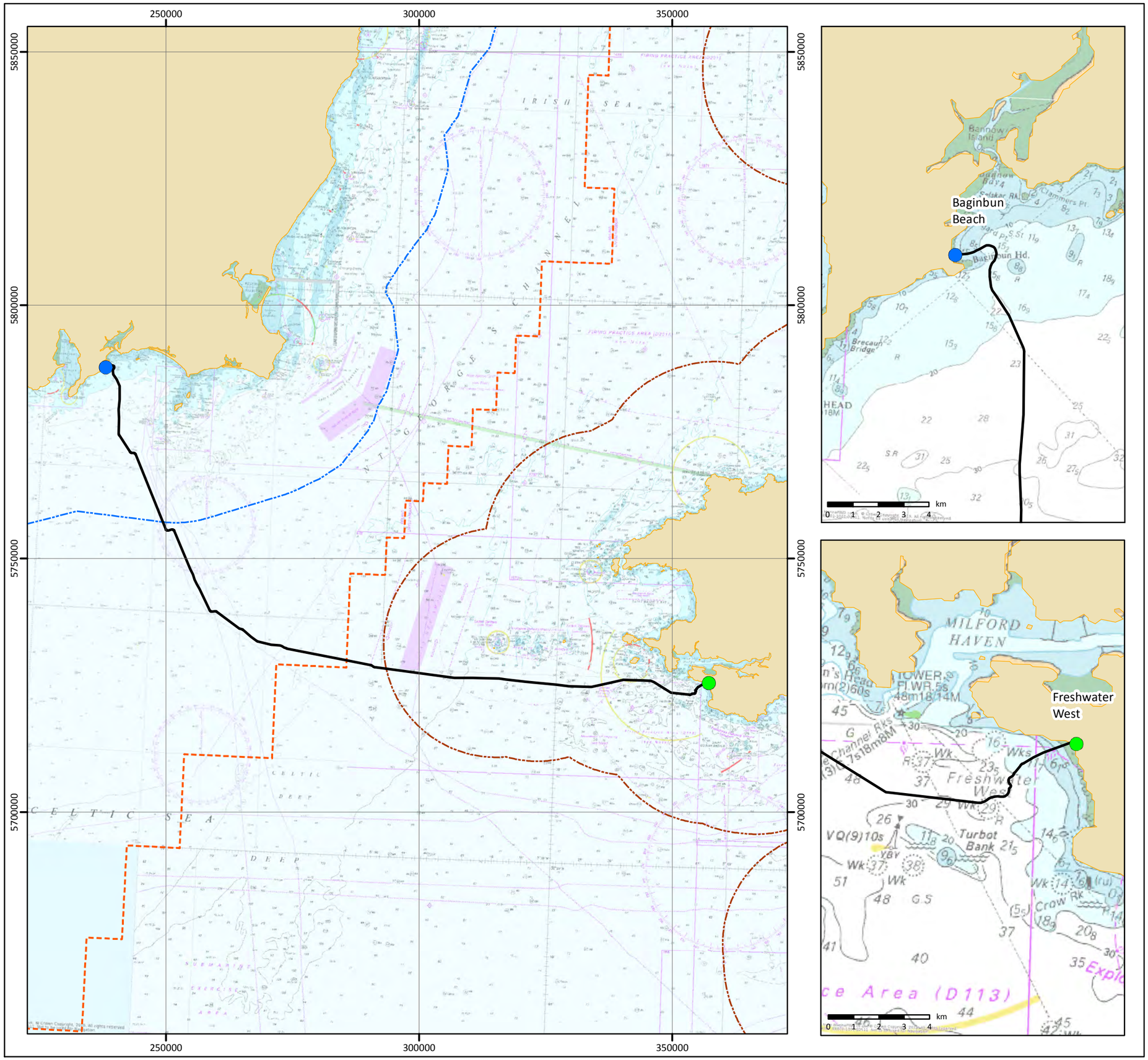
Separate HRAs / Natura Impact Statements will be prepared which cover individually the Welsh Onshore; the Irish Onshore; the Welsh Marine (the submarine

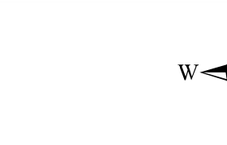
route from the Ireland/UK median line to MHWS at the Welsh landfall at Freshwater West, Pembrokeshire); and the Irish Marine (the submarine route from MHWS at the Irish landfall at Baginbun Bay, County Wexford to the 12nm limit) and Irish Offshore (the submarine route from the 12nm limit to the Ireland/UK median line). Once submitted these will be available online at www.greenlink.ie. The boundaries of the individual components described are shown in Figure 1-3.

GREENLINK INTERCONNECTOR

ROUTE OVERVIEW

Drawing No: P1975-LOC-001 | **A**





Legend

Landfall

- Baginbun Beach
- Freshwater West
- Greenlink Route Centreline (Indicative)

Administrative Boundaries

- ROI 12nm Territorial Sea Limit
- UK 12nm Territorial Sea Limit
- Median Line



NOTE: Not to be used for Navigation

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Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

Co-financed by the European Union Connecting Europe Facility

intertek

0 10 20 30 40 km

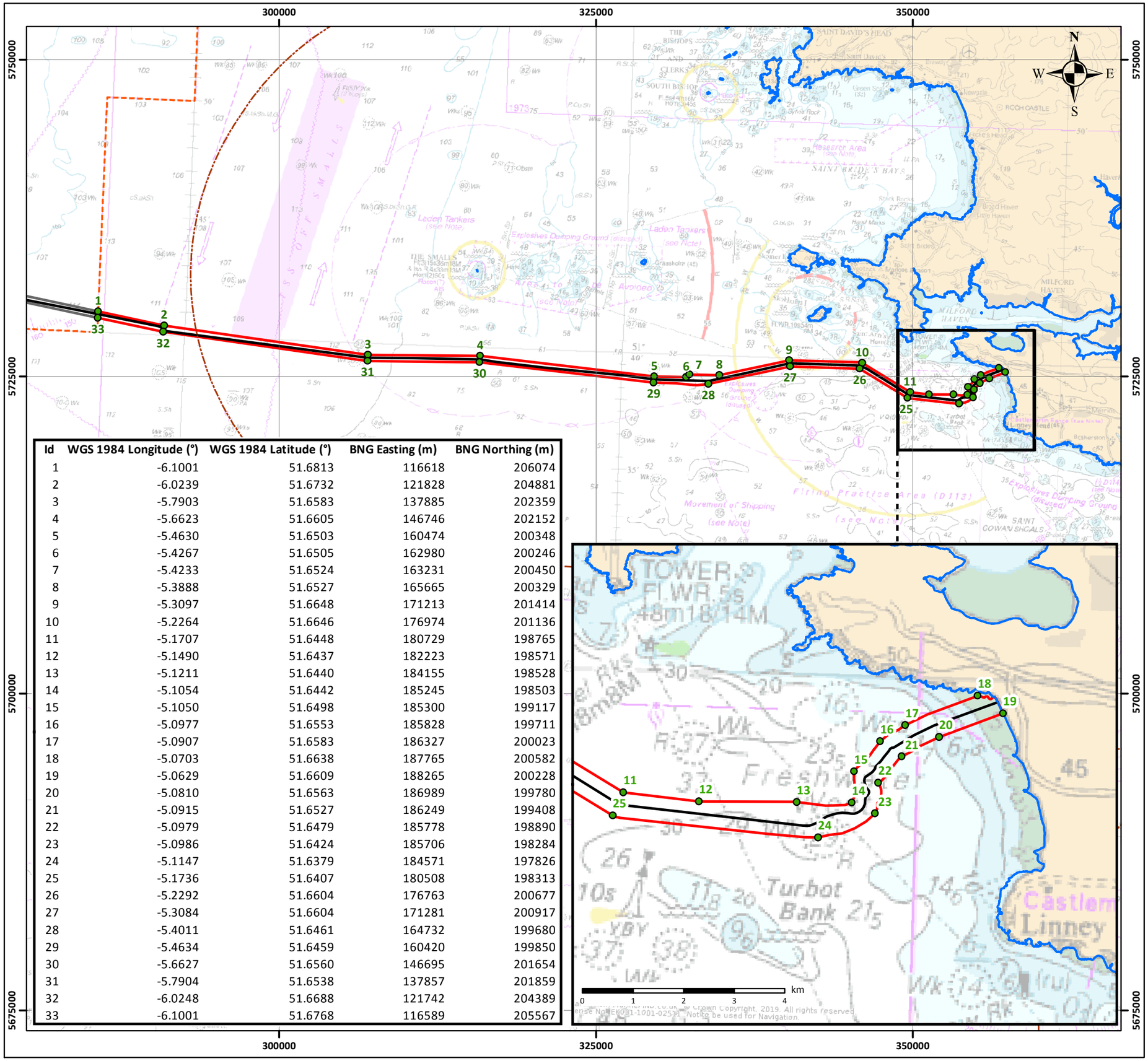
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GREENLINK INTERCONNECTOR

PROPOSED DEVELOPMENT
UK Waters

Drawing No: P1975-CORR-001 | **A**



Id	WGS 1984 Longitude (°)	WGS 1984 Latitude (°)	BNG Easting (m)	BNG Northing (m)
1	-6.1001	51.6813	116618	206074
2	-6.0239	51.6732	121828	204881
3	-5.7903	51.6583	137885	202359
4	-5.6623	51.6605	146746	202152
5	-5.4630	51.6503	160474	200348
6	-5.4267	51.6505	162980	200246
7	-5.4233	51.6524	163231	200450
8	-5.3888	51.6527	165665	200329
9	-5.3097	51.6648	171213	201414
10	-5.2264	51.6646	176974	201136
11	-5.1707	51.6448	180729	198765
12	-5.1490	51.6437	182223	198571
13	-5.1211	51.6440	184155	198528
14	-5.1054	51.6442	185245	198503
15	-5.1050	51.6498	185300	199117
16	-5.0977	51.6553	185828	199711
17	-5.0907	51.6583	186327	200023
18	-5.0703	51.6638	187765	200582
19	-5.0629	51.6609	188265	200228
20	-5.0810	51.6563	186989	199780
21	-5.0915	51.6527	186249	199408
22	-5.0979	51.6479	185778	198890
23	-5.0986	51.6424	185706	198284
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25	-5.1736	51.6407	180508	198313
26	-5.2292	51.6604	176763	200677
27	-5.3084	51.6604	171281	200917
28	-5.4011	51.6461	164732	199680
29	-5.4634	51.6459	160420	199850
30	-5.6627	51.6560	146695	201654
31	-5.7904	51.6538	137857	201859
32	-6.0248	51.6688	121742	204389
33	-6.1001	51.6768	116589	205567

Legend

- Proposed Development Points
- Greenlink Route Centreline (Indicative)
- Proposed Development
- Irish Offshore
- UK Mean High Water
- 12nm Limit
- Median Line



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Reviewed By	Emma Langley
Approved By	Anna Farley

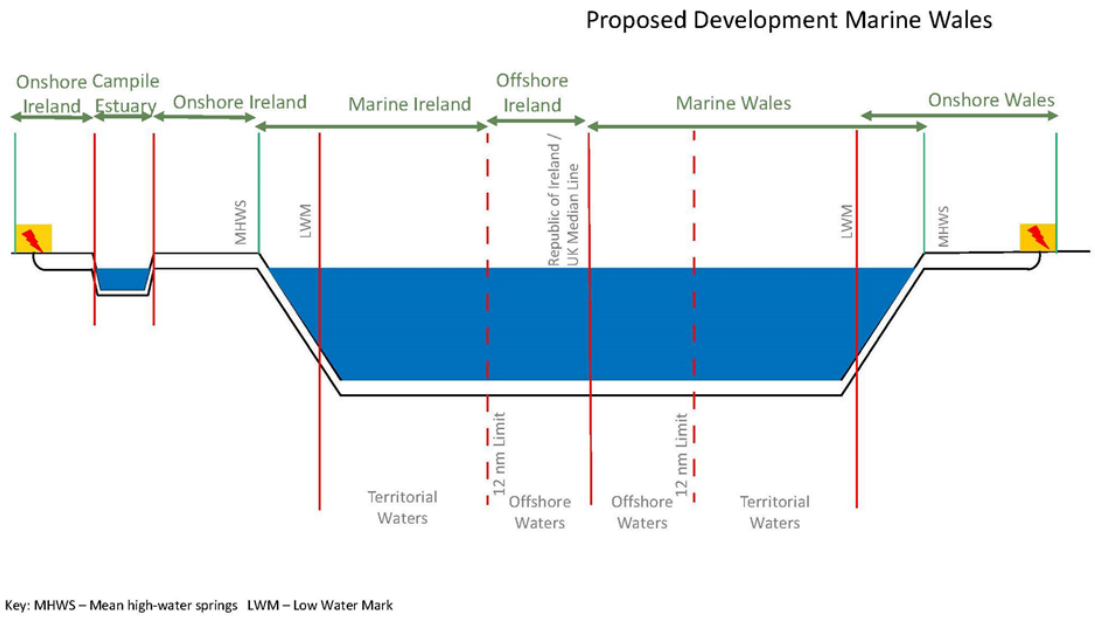
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Figure 1-3 Components of Greenlink



1.2 *Requirement for Habitat Regulations Assessment (HRA)*

The Birds Directive (2009/147/EC) and the Habitats Directive (92/42/EEC) put an obligation on European Union (EU) Member States to establish the Natura 2000 network of sites of highest biodiversity importance for rare and threatened habitats and species across the EU. The network comprises Special Areas of Conservation (SACs) designated under the Habitats Directive, and Special Protection Areas (SPAs) designated under the Birds Directive. SPAs and SACs are designated by the individual member states.

UK Government policy (ODPM Circular 06/2005) states that sites designated under the Convention on Wetlands (Ramsar, Iran 1971) known as the "Ramsar Convention"[1] are also included under the definition Natura 2000. The vast majority of Ramsar sites are also classified as SPAs.

Collectively, SPAs, SACs and Ramsar sites are referred to as European sites under UK Regulations.

A key protection mechanism under these directives is to consider the possible nature conservation implications of any plan or project on the European site network before any decision is made to allow that plan or project to proceed. Each plan considered for approval, must take into consideration the possible effects it may

[1] The Ramsar Convention is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance and to plan for the "wise use", or sustainable use, of all of the wetlands in their territories" (RAMSAR 2011).

have in combination with other plans and projects when going through the process known as the HRA process.

The obligation to undertake the HRA process derives from Article 6(3) and 6(4) of the Habitats Directive, and both involve a number of steps and tests that need to be applied in sequential order. Each step in the assessment process precedes and provides a basis for other steps. The results at each step must be documented so there is transparency of the decisions made.

The Proposed Development crosses the Pembrokeshire Marine / Sir Benfro Forol SAC (site code: UK0013116), the West Wales Marine / Gorllewin Cymru Forol SAC (site code: UK0030397), Skomer, Skokholm and the Seas off Pembrokeshire / Sgomer, Sgogwm a Moroedd Penfro SPA (site code: UK9014051) and the landfall is within the Castlemartin Coast SPA (site code: UK9014061) and the Limestone Coast of South West Wales / Arfordir Calchfaen de Orllewin Cymru SAC (site code: UK0014787). As the project is not directly connected with or necessary to the management of the European sites, under the Habitats Regulations it is necessary that the Proposed Development should be subject to the HRA process.

1.3 *Aim of this Report*

The purpose of this report is to inform the HRA process in determining whether the Proposed Development, both alone and in combination with other plans or projects, is likely to have a significant effect on any European site in the context of their conservation objectives and specifically on the habitats and species for which the sites have been designated.

The HRA provides a description of the Proposed Development (Section 3); identifies the European sites that could be affected by the plans (Section 4); and identifies the potential pressures that could arise from the planned activities on the sites (Section 4). It determines it there is any connectivity between the Proposed Development and any European sites (Stage 1 Appropriate Assessment Screening, Section 4) and considers the potential for adverse effects on the conservation objectives and qualifying feature(s) within the affected European site(s) (Stage 2 Information to Inform Appropriate Assessment, Section 5).

In February 2020, NRW invited GIL to provide further evidence on the matters set out in regulations 64 and 68 of the Conservation of Habitats and Species Regulations 2017, namely:

- Whether there are any feasible alternative solutions to the project which are less damaging to the affected European site;
- Whether there are any imperative reasons of overriding public interest (IROPI) for the project to proceed;
- What compensatory measures are proposed to ensure that the overall coherence of the network of European sites is protected.

This HRA was subsequently revised (Revision F2) to include a discussion of alternative solutions (Section 6); the case for IROPI (Section 7); and a Habitat Compensation Plan (Section 7.6 and Appendix D). Section 8 provides a summary and conclusions of the HRA process documented in this report.

This report has been prepared in accordance with current guidance, including:

- Managing Natura 2000 sites. The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC (European Commission, EC 2018a);
- Guidance on Energy Transmission Infrastructure and EU nature legislation (EC 2018b);
- The Planning Series 16 – Habitats Regulations Assessment (Welsh Government 2017);
- EU Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC (EC 2007); and
- Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC (EC 2002).

This document also presents a Marine Conservation Zone (MCZ) assessment and assessment of whether the Proposed Development has the potential to hinder the conservation objectives of Sites of Special Scientific Interest (SSSIs). The legislative requirement for these assessments is outlined in Section 2.

1.4 Consultation

Consultation has been undertaken with key statutory consultees and stakeholders and the public during key stages of project development. GIL has consulted with NRW throughout project design (cable routeing) to identify the ecological constraints and sensitivities of the habitats and species in the area. A scoping opinion from NRW was received on the broader Environmental Impact Assessment which has informed the HRA process.

Following the request for clarification in February 2020, GIL held consultation meetings with NRW Technical Experts in early March 2020 to discuss the specific points / concerns raised. The HRA has subsequently been updated considering these discussions.

Following the second request for clarification in July 2020, GIL held consultation meetings with NRW, JNCC and Cefas in July 2020 to discuss the points raised with respect to the assessment of the pressure underwater noise changes. The HRA has subsequently been updated considering these discussions.

2. Assessment Process

2.1 Habitats Regulations Assessment

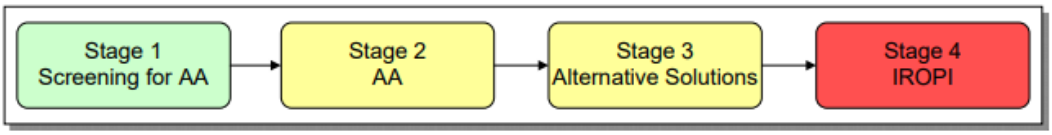
2.1.1 Legislative context

Under Article 6(3) of the EU Habitats Directive (Directive 92/43/EEC), any plan or project within or adjacent to a European site must be assessed with regard to their implications for the site conservation objectives. If the project is likely to have a significant negative effect on a European site, either alone or in combination with other plans or projects, it must undergo an Appropriate Assessment (AA) by the competent authority (those with decision making powers). Normally, the competent authorities cannot consent the plan / project without first having ascertained that it will not have an adverse effect on the integrity of the site concerned.

If an adverse negative effect is identified it may be possible to adjust the plan/project or introduce certain mitigation measures to avoid or pre-empt, remove or reduce effects to a non-significant level so that the plan/project may be approved (European Commission 2018b).

The European Commission's methodological guidance (EC 2002) outlines a four-stage approach to the AA process, where the outcome at each successive stage determines whether a further stage in the process is required. The four stages are shown in Figure 2-1 and described below. Collectively they make up what is referred to in the UK as the Habitat Regulations Assessment (HRA) process.

Figure 2-1 Stages of AA



The requirements for AA are transposed into UK statute through The Conservation of Habitats and Species Regulations 2017 (CHSR) for territorial waters (out to 12 nm); and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (OMR) for UK Exclusive Economic Zone waters. Collectively they are referred to as the 'Habitat Regulations'.

Whilst the obligation to undertake the AA is derived from Articles 6(3) and 6(4) of the Habitats Directive, it is Regulation 28(2) of the OMR and 63(1) of the CHSR that sets out procedural requirements. They require that the applicant provide such information as the component authority may reasonably require for the purposes of assessment or to enable them to determine whether an AA is required.

There is no statutory method for undertaking the HRA process, but Welsh Government (2017) guidance outlines the steps to be taken by the applicant at each Stage.

2.1.2 Stage 1 - Screening for Appropriate Assessment

Screening is the process that addresses and records the reasoning and conclusions in relation to the first two tests of Regulation 28 of the OMR and Regulation 63 of the CHSR:

- Whether a plan or project is directly connected to or necessary for the management of the site; and
- Whether a plan or project, alone or in combination with other plans and projects, is likely to have significant effects on a European site in view of its conservation objectives.

Where significant effects are likely, uncertain or unknown at screening stage, then the process must proceed to Stage 2 (AA). Screening should be undertaken without the inclusion of mitigation, unless potential impacts clearly can be avoided through the modification or redesign of the plan or project, in which case the screening process is repeated on the altered plan. The greatest level of evidence and justification will be needed in circumstances when the process ends at screening stage on grounds of no effect.

2.1.3 Stage 2 - Appropriate Assessment

If Stage 1 concludes that an AA is required, then the AA must be undertaken by the Competent Authority licensing the plan or project.

To inform the AA the developer must provide data and information on the project and on the European site. An analysis of potential effects on the site must be completed and presented as 'Information to Inform Appropriate Assessment'. This is a more detailed ecological assessment of the proposed activities and looks to answer two key questions:

- What are the likely effects of the proposed activity?
- How quickly could the Qualifying Feature recover from the effect, if at all?

The duty to undertake AA, having considered the 'Information to Inform AA', and to ensure that the stringent evaluation and decision-making procedure is applied correctly, lies with the competent authority, which for the Proposed Development is the Welsh Ministers. The AA will be a focused and detailed impact assessment of the implications of the plan or project, alone and in combination with other plans and projects, on the integrity of a European site in view of its conservation objectives.

If the assessment concludes that the plan or project will adversely affect the integrity of a European site, then the process must proceed to Stage 3, or the plan or project should be abandoned.

Any mitigation measures necessary to avoid, reduce or offset negative effects should be proposed at this stage.

2.1.4 Stage 3 – Alternative Solutions

This stage examines any alternative solutions or options that enable the plan or project to proceed without adverse effects on the integrity of a European site. The process must return to Stage 2 as alternatives will require AA in order to proceed. Demonstrating that all reasonable alternatives have been considered and assessed, and that the least damaging option has been selected, is necessary to progress to Stage 4.

2.1.5 Stage 4 - Imperative Reasons of Overriding Public Interest (IROPI)/Derogation

Stage 4 is the main derogation process of Article 6(4) which examines whether there are imperative reasons of overriding public interest (IROPI) for allowing a plan or project that will have adverse effects on the integrity of a European site to proceed in cases where it has been established that no less damaging alternative solution exists.

The extra protection measures for Annex I priority habitats come into effect when making the IROPI case. IROPI reasons that may be raised for sites hosting priority habitats are those relating to human health, public safety or beneficial consequences of primary importance to the environment. In the case of other IROPI, the opinion of the European Commission is necessary and should be included in the AA. Compensatory measures must be proposed and assessed. The European Commission must be informed of the compensatory measures. Compensatory measures must be practical, implementable, likely to succeed, proportionate and enforceable, and they must be approved by the Welsh Ministers.

2.2 *Marine Conservation Zone Assessment*

Marine Conservation Zones (MCZs) are designated under the Marine and Coastal Access Act 2009 (MCAA) to protect a range of important marine habitats, species and geological formations in English and Welsh territorial waters and offshore waters. In conjunction with other existing international and national designations these sites contribute to an ecologically coherent network of Marine Protected Areas (MPA) in the North East Atlantic.

Section 126 of the Marine and Coastal Access Act (MCAA 2009) places specific requirements on the public authority responsible for marine licensing, to determine if the licensable activity is capable of hindering the achievement of the conservation objectives stated for the MCZ.

The assessment process is similar to that required under the Habitats Regulations in that it follows a series of sequential steps as follows:

- **Screening** – Determine if the licensable activity is taking place within or near an area being put forward or already designated as an MCZ and whether the activity is capable of affecting (other than insignificantly) either (i) the protected features of an MCZ; or (ii) any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependant. If the answer is yes then proceed to Stage 1.
- **Stage 1 assessment** – Is the authority satisfied that there is no significant risk of the activity hindering the conservation objectives stated for the MCZ and can the authority exercise its functions to further the conservation objectives of the site. If the answer is no to either of these questions, then the authority has to consider whether there are other means of proceeding with the act which would create a substantially lower risk of hindering the achievement of the objectives. If the answer is still no then proceed to Stage 2.
- **Stage 2 assessment** – This stage looks at whether the benefit to the public clearly outweighs the risk of damage to the environment and seeks to satisfy the authority that the applicant can make arrangements to undertake measures of equivalent environmental benefit to the damage which the act will have on the MCZ.

2.3 *Sites of Special Scientific Interest (SSSI) Assessment*

Sites of Special Scientific Interest (SSSI) are nationally important areas of land and water (above mean low water) in Great Britain. SSSIs give legal protection to the best sites for wildlife and geology in England and Wales under the Wildlife and Countryside Act 1981 (as amended). SSSIs are protected by law and it is an offence for any person to intentionally or recklessly damage the protected natural features of a SSSI.

To undertake works within a SSSI a developer must demonstrate that they have given due consideration to the effects of the proposed activities on the features of special interest and that the conservation objectives of the site will not be hindered by the project. There is no formal method for undertaking this assessment and therefore SSSIs have been included within this document as best practice.

3. Description of the Project

3.1 Overview

Greenlink is a proposed subsea and underground electricity interconnector between the existing electricity grids in the Republic of Ireland and Great Britain with a nominal capacity of 500 megawatts (MW). Greenlink comprises subsea and underground cables and associated converter stations to connect EirGrid's Great Island transmission substation in County Wexford (Ireland) and National Grid's Pembroke transmission substation in Pembrokeshire (Wales). The power will be able to flow in either direction, depending on supply and demand in each country.

The converter stations will be connected by two HVDC cables under the Irish Sea. A fibre optic cable will also be laid for control and communication purposes.

The subsea cable system will be joined to the corresponding land cable system in a transition joint pit (TJP) located above MHWS, and therefore does not form part of the Proposed Development (the subject of this HRA).

The proposed landfall site is Freshwater West, Pembrokeshire. The total length of the Greenlink marine cables is 159.27km of which 73.8km forms the Proposed Development.

3.2 Development of the Project

The configuration of any interconnector project is influenced by the location of the existing network infrastructure, its ability to accommodate the required connection capacity, any requirement for network reinforcements, and other factors such as environmental constraints.

A full description of the alternatives considered and route development is provided in the Greenlink Marine ES – Wales, Chapter 3. Information previously provided in this section (as part of Revision F1) has now been moved to Section 6 and forms part of the information provided for Stage 3 – Alternative Solutions.

3.3 Submarine cable route description

The submarine cable corridor derived from preliminary cable route engineering, consultation with stakeholders and survey is shown in Figure 1-2 (Drawing P1975-CORR-001). Kilometre points (KPs) have been assigned to the route running from KP0 at MHWS, Freshwater West, Wales to KP159.27 at MHWS, Baginbun Beach. The Proposed Development therefore runs from KP0 (landfall) to KP73.8 (UK/Ireland median line).

The Proposed Development is generally 500m wide. The final cable configuration will only need a small part of this width for installation (of the order of 10-20m). It is proposed to finalise the precise position of the submarine cables within the corridor after permits are granted but before installation has commenced. This will

allow for optimisation of the final laid submarine cables to minimise engineering and environmental challenges.

It is likely that cables will be bundled together as a pair with no separation between the cables.

3.4 Project schedule

The programme for the commencement of installation has not yet been agreed but for a scheme of this size to be constructed it is expected to take approximately 36 months from start to finish. The Proposed Development is envisaged to commence on-site construction in late 2020 and be fully operational in 2023. Table 3-1 presents an indicative programme of marine works for Greenlink.

In general installation in European waters are undertaken in the summer season, broadly between April and October. This period is determined primarily by the high probability of adverse weather occurring outside of this period. The schedule will also be affected by factors such as, the availability of cable, the delivery of cable, other commitments of the installation contractor, and any Project Specific Mitigation proposed by the HRA and environmental impact assessment (EIA) process.

Table 3-1 Indicative programme for marine works

Activity	Duration (months)	2021				2022			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Landfall preparations - Ireland*	3								
Landfall preparations - Wales*	5								
Pre-lay survey	1								
Route preparation	1								
Cable lay & burial	3								
External cable protection installation	1								

* Sequencing of landfall preparation works may change

3.5 Pre-installation works

3.5.1 Survey requirements

Although detailed engineering surveys have been completed for the proposed submarine cable corridor (autumn 2018 – spring 2019), further surveys will be completed prior to the commencement of cable installation. This typically takes place 3-6 months ahead of installation.

The primary objective of these surveys is to confirm that no new obstructions have appeared on the seabed since the detailed engineering surveys, and to complete a unexploded ordnance (UXO) clearance survey. The survey will involve a range of

standard geophysical survey techniques such as multi-beam echosounder (MBES), side scan sonar (SSS), sub-bottom profiler (SBP) and magnetometer.

3.5.2 Route preparation

Prior to the start of marine cable installation, it is essential to ensure the proposed centreline is clear of obstructions that may hinder the installation works. A pre-lay grapnel (a wire with a string of specially designed hooks) will be towed along the entire route to remove any debris.

For areas with large stones and/or boulders along the route, there may be a requirement to move these objects out of the way (if they cannot be avoided) so that the marine equipment can operate. To prepare a clear path for the cable to be laid and buried, a plough will be towed across the seabed, pushing the boulders to both sides. A swathe of between 5 and 10m width will be cleared of surface boulders. Areas identified as potentially requiring boulder clearance are presented in Table 3-2.

Table 3-2 Indicative route lengths potentially requiring boulder clearance

Indicative KP	Approximate length (km)	EUNIS Biotope present	Annex I habitat present
KP11.3 to KP12	0.7	A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments	No
KP15 to KP22	7.0	A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	Annex I - Medium grade stony Reef
KP20.5	0.1	A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	Between two areas of Annex I - Medium grade stony Reef
KP24.9 to KP25.5	0.6	A5.142 - *Mediomastus fragilis*, *Lumbrineris spp.* and venerid bivalves in circalittoral coarse sand or gravel	No
KP34 to KP34.4	0.4	A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment	No
KP53 to KP53.5	0.5	A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment	No

Discrete areas of seabed will also require preparatory works known as pre-sweeping. A dredger or mass flow excavator will be used in areas of mobile sandwaves to remove a portion of the sandwave. This is to allow the cable to be buried relative to a non-mobile reference level below the lowest level of undulations; reducing the risk of the cable becoming exposed through sandwave movement.

No pre-sweeping will be required on the Turbot Bank; a Qualifying Feature of the Pembrokeshire Marine SAC. Table 3-3 presents indicative dimensions for the areas of pre-sweeping. The first location is within the Pembrokeshire Marine SAC, but the second is not within a European site.

Revision F3 – It has been agreed with NRW Technical Experts that the sandwaves at KP25.8 to KP26.4 will be avoided. Pre-sweeping will no longer be required at this location.

Table 3-3 Indicative pre-sweeping requirements

KP start	KP end	Length (m)	Maximum width (m)	Seabed footprint (m^2)	Maximum volume of sediment removed and re-deposited (m^3)
KP64	KP69	5000	20	100,000	400,000**
**Assumes that 4m of sand (3m trough to crest + 1m for cable burial) will need to be removed across the whole profile. In reality the removed sand volumes are likely to be less as the sand waves are not the quoted height across the entire length of the transect.					

3.5.3 Route preparation at subsea cable crossing

Greenlink crosses one in-service telecommunications cable, Pan European Crossing 2, within the Proposed Development at KP59.791. Greenlink will cross the cable on a 'bridge' comprised of either aggregate (rock) or concrete mattresses. This first layer of protective material that will be positioned during route preparation. Construction of the remainder of the crossing will occur once the cables are laid and will consist of a graded rock berm approximately 120m in length, up to 1.2m high, covering an area of 1009m^2. The crossing location lies in sandy sediments classified as EUNIS habitat A5.251 - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand.

3.5.4 UXO clearance

During route design a UXO desk top study was prepared (1st Line Defence 2018), which describes the risk of encountering UXO's along the cable route. The Proposed Development crosses the Castlemartin Firing Range, and it is extremely likely that UXO's will be found here, making this a high-risk area. Due to this risk, a UXO survey was undertaken of the cable route within the Castlemartin Firing Range, with the results being used to refine the indicative centreline of the cables within the Proposed Development.

If any significant UXO are identified the following decision-making process will be followed:

1. Avoid by micro-routeing the marine cables within the permitted corridor.
2. If it cannot be avoided, visual inspection confirms a UXO, and it is safe to do so, remove the UXO.
3. If it cannot be moved, detonate on site in accordance with Best Practice.

The design of the UXO clearance plan has been through three iterations and has resulted in the following revisions to this HRA:

- Revision F1 of this HRA the assessment assumed that as a worst-case a 794kg UXO could be detonated within the Proposed Development. This represented the largest explosive device to have been used historically in the region. It

should be noted that this size of magnetic anomaly has not been identified in the 2019 UXO data from Castlemartin Firing Range.

- Revision F2 - Consultation with JNCC, Cefas and NRW Technical Experts (TE) concluded that a more realistic scenario should be considered. Industry Best Practice is that a UXO over 50kg is detonated using deflagration (a low order detonation). Deflagration uses a small charge attached to the larger UXO, to burn out rather than blow up the UXO in effect neutralising the UXO. The assessment assumed all UXO over 50kg in size would not be detonated without this measure for health & safety reasons. As this would be part of the design for any UXO clearance scope it was assumed that the maximum charge to be detonated within the Proposed Development is 50kg.
- Revision F3 (this revision) JNCC has advised that Greenlink consider using deflagration for all UXO charge sizes requiring detonation (i.e. the explosive charge is burnt out rather than blown up). Having consulted with a UXO expert, GIL can commit to this process for all UXO that would require detonation. Deflagration of all UXO charges has been included as project specific mitigation in Stage 2 of this HRA assessment. Deflagration is a much less energetic process and studies (e.g. Cheong et al. 2020) have suggested that it is "quieter" than traditional high-order detonation. In order to model the potential impacts associated with deflagration a 1.54kg charge size has been assumed. Modelling has also been provided for the 794kg charge to demonstrate the efficacy of mitigation measures in Stage 2 of this HRA.

UXO detonation in the Proposed Development is deemed possible, and for the purposes of this assessment it is assumed that one UXO deflagration, will be required.

3.6 Cable installation

3.6.1 Installation vessels

The cable lay operation will be performed on a 24-hour basis. It is anticipated that the following vessel types will be required for cable installation:

- Cable lay vessel (CLV) - a specialist ship designed specifically to carry and handle long lengths of heavy power cables. CLV's are equipped with dynamic positioning (DP) systems.
- Jack-up barge (JUB) - a small platform that typically has four to eight legs. It may be used in water depths of less than 10m to support the pull-in of the cables. May be supported by a tug, which would tow it into position.
- Cable lay barge (CLB) – may be used in water depths of less than 10m instead of the CLV.
- Small work boats – support the CLV, CLB and JUB e.g. during cable pull-in operations.

- Guard vessel - where deemed necessary, the CLV, CLB or other vessel operations with restricted vessel manoeuvrability will be accompanied by a guard vessel(s).
- Rock placement vessel – will be used to deposit rock in areas where rock protection is required. Where there are strong currents fall-pipe vessels have a big advantage in that the rock can be more accurately placed.

3.6.2 Cable laying

Two cable installation techniques are being considered for the Proposed Development:

- Simultaneous lay and burial – in this operation the CLV may tow the burial equipment or it is deployed by another vessel navigating close behind, creating effectively a single large spread. The cables are fed into the burial equipment directly from above and the cables are buried as the spread progresses along the route.
- Post-lay burial – in this operation the CLV lays the cables on the seabed first. A post-lay burial vessel follows to bury the cables. The post-lay burial vessel may be some physical distance, or indeed some days, behind the lay vessel, so there are two discrete operations separated physically and in time.

It may be necessary to install the cables in two sections. The end of the installed section will be temporarily left on the seabed whilst the CLV picks up the new cable. Depending on the local situation (i.e. threat levels) the end of the cable may be temporarily buried into the seabed. A ground wire will be attached to the end of the cable to enable retrieval of the end of the cable to allow cable laying to continue.

Cable joints will be made on board the CLV and will take up to a week to complete per joint location. In this time the vessel is likely to anchor to maintain position. Once the cable joint has been made on board the vessel cable laying will continue as normal.

3.6.3 Cable burial and protection

The nature of the seabed varies along the cable route, ranging from fine sediments to stony reefs, consisting of pebbles and boulders and bedrock outcrops. Bedrock outcrops are predominantly found relatively close to the Pembrokeshire coastline. The choice of burial technique or protection method will depend upon the seabed conditions in each section. The preference is burial in the seabed as this provides the best protection. Where the seabed composition is not suitable for burial, external mechanical protection will be provided through rock placement or concrete mattresses.

There are three generic types of equipment for installing cables into the seabed:

- Jetting machines – use water jets to fluidise the seabed and allow the cable to sink into the seabed.

- Cable ploughs - like ploughs used in farming, a narrow blade (the plough 'share') is pulled through the seabed to create a furrow.
- Cutting - a trench is cut using a wheel or a driven chain cutter to break and move rock and hard sediments.

A typical trench is up to 1m wide. Although the installation tools can be up to 15m wide they typically move across the seabed on tracks or skids which may only leave temporary compression depressions of 1m width either side of the trench. However, as a precaution for the purposes of assessment, it has been assumed that the entire 15m width is disturbed by the machinery. Whilst jetting is considered to have the least effect on the environment because the footprint of the tool is smaller than other installation tools such as ploughs, the use of jetting tools does result in higher suspended sediment concentrations. However, in a review of seabed disturbance from various activities it was observed that disturbance resulting from jetting was largely restricted to fines and remained low in comparison with dredging and some fishing techniques (BERR 2008).

The recommended depth of lowering[2] along the cable length was determined in a detailed Cable Burial study (Intertek EWCS 2019b) using the Carbon Trust cable burial risk assessment (CBRA) methodology. This concluded the target burial depth is at least 0.6m, increasing to 0.75m for the entire Greenlink route. However, the target depth of burial has been set as between 1.0 and 1.5m.

A preliminary assessment of cable installation methods is presented in Table 3-4, and indicative locations where external cable protection may be required is shown in Figure 3-1 (Drawing P1975-INST-005).

Table 3-4 Potential installation method

Cable Protection Option	Length (km)
Burial in sediment (jetting or ploughing)	57.44
External cable protection only (crossing)	0.120
Potential burial in rock or external cable protection	16.34
Total	73.9

3.6.3.2 External cable protection

Approximately 16km of the cable route within the Proposed Development may require either cutting below the base of the sand unit to achieve the required burial depth or external cable protection such as rock or concrete mattresses. External cable protection will also be required at the third-party asset crossing location.

External cable protection is used to protect subsea cables by covering them in a continuous profiled berm of concrete mattresses, graded rock or a combination of the two. The particle size of the rock used will be driven by an assessment of the local seabed geology, metocean conditions, water depth and the nature of the external threat which is being protected against. Engineering design has not yet

[2] The minimum depth that the cables will be buried to.

been completed for the berms, but rock sizes are likely to be in the range of 2cm to 22 cm. A filter layer is sometimes required either to provide a stable base in soft sediment for the armour layer to be installed on and/or provide protection to the cable bundle from the impact of the installation of the armour layer. If used, the filter layer would be laid first comprising of smaller particle sizes, followed by larger layer designed to prevent segregation of sediments during placement. The final layer (i.e. the armour layer) covers the other two layers and is designed to provide protection against identified external threats (e.g. anchors and fishing gear) whilst also withstanding severe metocean events.

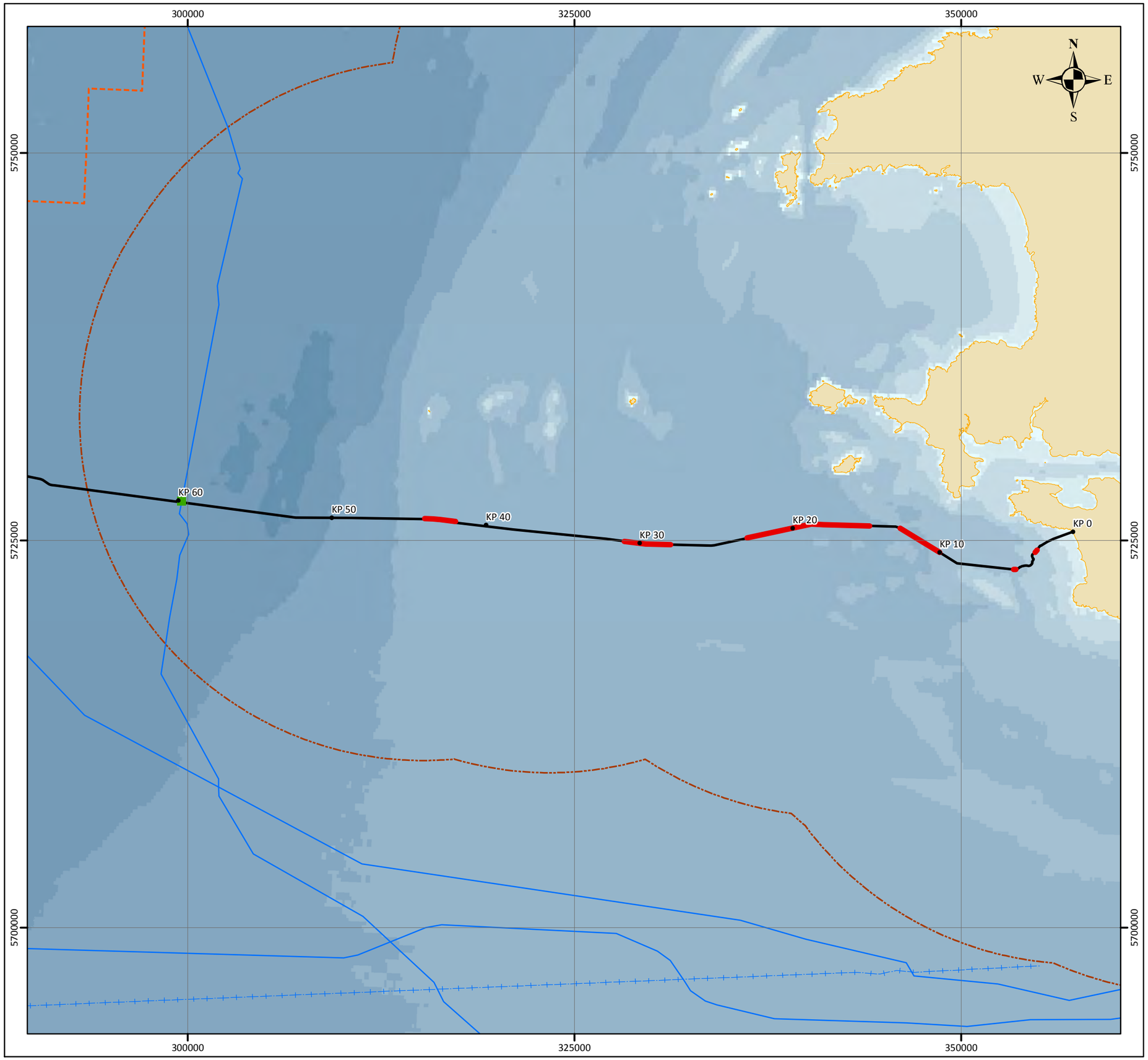
It has been assumed that the maximum height of the berm will be 1.5m, with a crest width of 1.0m. The side slopes of such a berm would be 1 vertical in 2.5 horizontal, which is the natural angle of repose of placed rock. The assessment assumes berms for external cable protection will have a maximum width of 10m.

The cable burial risk assessment (Intertek EWCS 2019b), informed by the geophysical and geotechnical survey data, has identified indicative locations where external cable protection may be required. Table 3-5 provides indicative locations where rock placement could be required due to ground conditions. These locations are shown on Figure 3-1.

Table 3-5 Indicative rock protection locations (due to ground conditions)

KP start	KP end	Distance (km)	Comment	Biotope	Presence of Annex I habitat
2.38	2.41	0.03	Outcrop within sandy channel. Likely to be too tight to route around.	Outcrop is A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock. Surrounding area is A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand.	Bedrock Reef
2.7	2.9	0.2	0.3-0.5m cover of sand. May be able to cut down into rock below sand. Protection likely to be 2-3m wide.	A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand. A5.25 - Circalittoral fine sand	
4.86	5	0.14	Small sand channel identified through bedrock reef confirmed by analysis of video transect data.	A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock	Bedrock Reef
10	13	3.0	0.4-0.9m layer of sand over hard ground. May be able to cut down into rock below sand.	A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	
15	23	8.0	~0.4 to ~1.2m layer of Sand/Gravel /Clay/Cobble over hard ground. May be able to cut down into rock below sand.	A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles A5.14 - Circalittoral coarse sediment	Medium grade Stony Reef

KP start	KP end	Distance (km)	Comment	Biotope	Presence of Annex I habitat
28	31	3.0	~0.3 to ~0.8m Layer of Sandy Gravel over hard ground. May be able to cut down into rock below sand.	A5.27 – Deep circalittoral sand	
42	44	2.0	Vibrocore refusal indicating thin layer of sediment over hard ground. Cone penetrometer test reached a depth of 0.8m	A5.611 - Sabellaria spinulosa on stable circalittoral mixed sediment A5.45 – Deep circalittoral mixed sediments	Potential Biogenic Reef between KP43.89 and KP44.0



GREENLINK INTERCONNECTOR

INSTALLATION

Indicative Rock Protection Requirements UK Waters

Drawing No: P1975-INST-005	A

Legend

- KP
- Telecom Cable
- Telecom Cable (Disused)
- 12nm Territorial Sea Limit
- Median Line

Assumed Installation Requirement

- Known Cable Crossing
- Potential External Protection Over Hard Ground
- Assumed Successful Depth of Burial

Bathymetry

Depth below LAT (m)

- -10 - 0
- -20 - -10
- -30 - -20
- -50 - -30
- -80 - -50
- -100 - -80
- -120 - -100
- -145 - -120



NOTE: Not to be used for Navigation

Date	Monday, April 29, 2019 14:06:44
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	KISORCA; UKHO; CDA; OSOD; EMODNET; ESRI
File Reference	J:\P1975\Mxd\15_INST\ P1975-INST-005.mxd
Created By	Chris Carroll
Reviewed By	Chris Goode
Approved By	Anna Farley

Co-financed by the European Union Connecting Europe Facility

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3.7 Cable landfall

The landfall is where the marine cables come ashore. In Wales, the landfall is located at Freshwater West, Pembrokeshire (illustrated in Figure 1-1 Drawing P1975-LOC-001).

Shore-crossings will be accomplished by horizontal directional drilling (HDD) which will exit seaward of the 0m lowest astronomical tide contour. There will be no works on Freshwater West between MHWS and MLWS.

The landfall will be prepared in advance of the arrival of the CLV, so that the vessel is not delayed in its operations. This will involve the digging of transition joint pits (TJPs) above MWHS and the installation of cable ducts using HDD from the TJP to an exit point below mean low water.

3.7.1 HDD compound and TJPs

The HDD compound, from which drilling will take place, will be sited above MHWS as shown in Figure 3-2.

The land cables will connect with the marine cables in a TJP, buried in the ground within the area used for the HDD compound. Up to two TJPs will be dug. Each bay will be 10-15m long, 2-3m wide and 2-3m deep below ground level; covering a maximum area of 45m^2 per TJP.

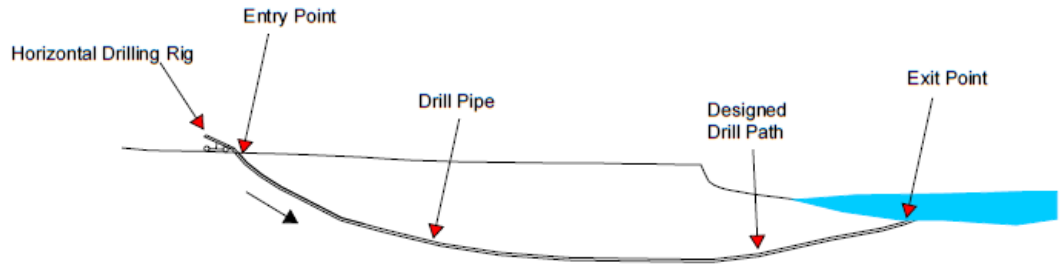
Figure 3-2 Indicative location of HDD compound – Freshwater West



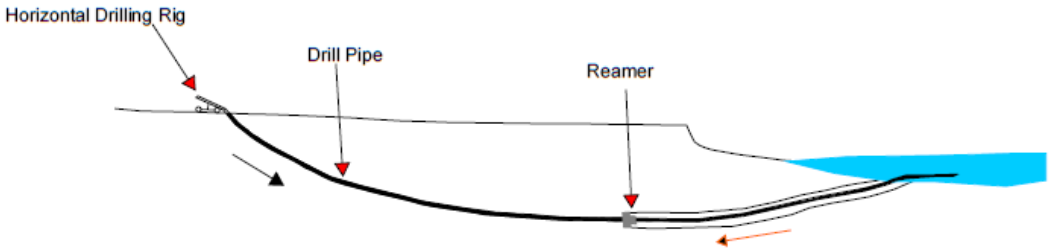
3.7.2 Installation of ducts - horizontal directional drilling (HDD)

HDD is a surface-launched process for boring a hole, under any sensitive features, to a point a suitable distance in the nearshore. A pipe is inserted into the drilled hole which is used as a duct into which the cables are installed. Figure 3-3 illustrates a typical shore to sea bore.

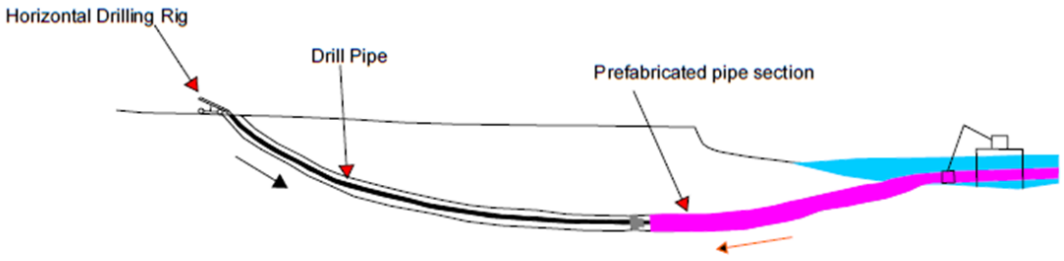
Figure 3-3 Typical HDD



A small diameter pilot hole is drilled from the entry point, under the sea bed, to the exit point.



Next, a reaming tool is pulled back through the pilot hole to enlarge the hole. More than one pass may be required to make the hole larger than the diameter of the pipe



Prefabricated pipe is attached to a swivel behind the Reamer and pulled into place under the beach

The cable ducts will pass approximately 10m below the beach.

Up to three ducts will be drilled; two for use and one as a spare. The fibre optic cable will be installed in a duct with one of the power cables. The ducts will fan out of the TJP to achieve exit points for the marine cables in the nearshore, with a separation distance of approximately 10m. From the exit point the cables will then merge back together, usually within 100m to form the bundle.

3.7.3 HDD exit point

Preliminary design of the HDD has been undertaken, but the final design will be completed by the Installation Contractor. Based on the geological conditions at Freshwater West, the HDD is likely to exit within the orange hatched box presented in Figure 3-4 (Drawing P1975-INST-001).

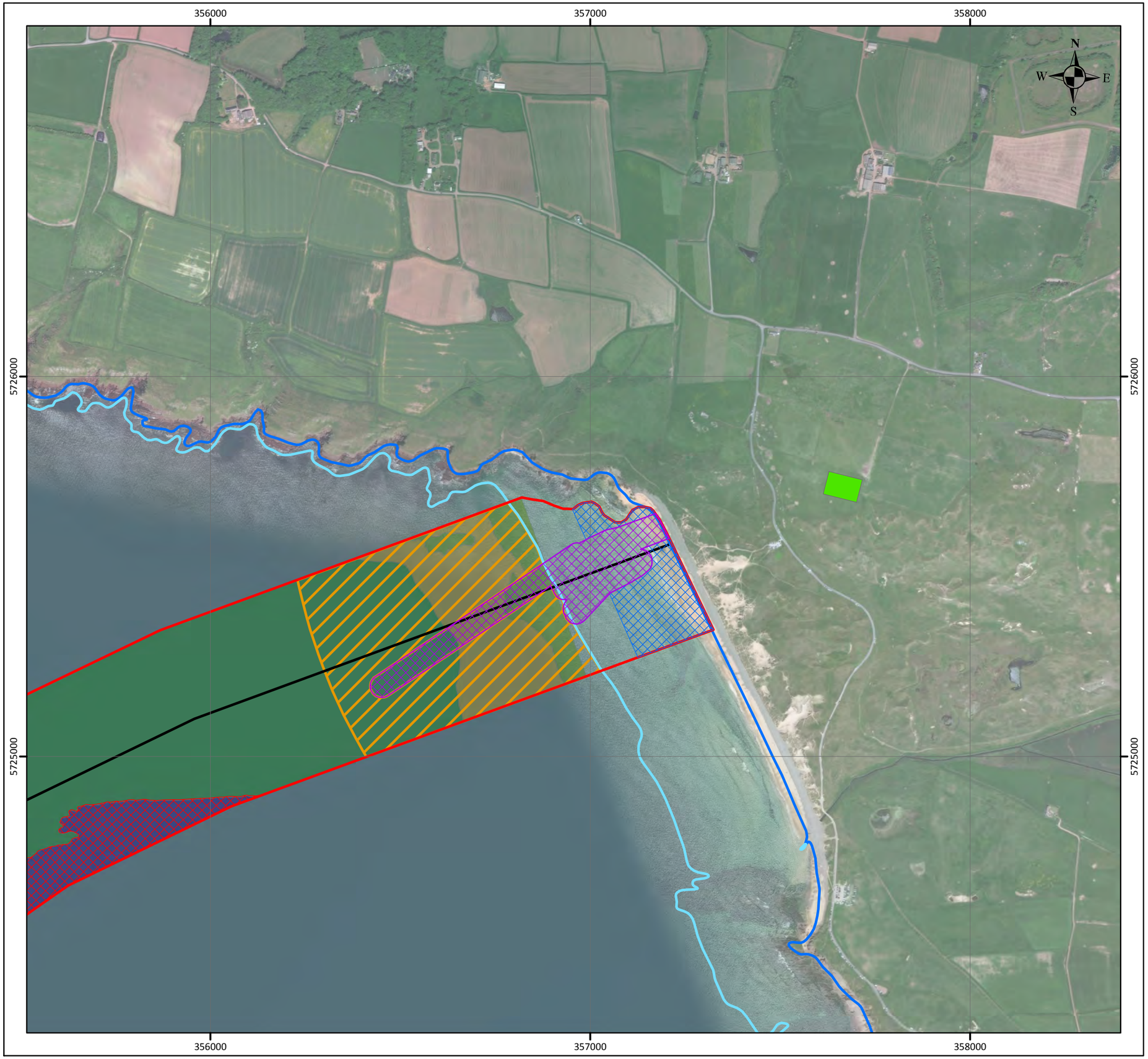
3.7.4 Marine cable installation at landfall

The installation sequence for each of the submarine cables and the fibre optic cable is likely to be similar and will be defined by the Installation Contractor. An indicative methodology is provided below:

- The end of the duct accepting the cable will be dug out using an excavator positioned on a jack-up barge or anchored barge.
- Material excavated will be left adjacent to the HDD exit point and refilled after the cable pull-in. The submarine cable would be floated to the exit point of the duct. Small work boats and divers would support this activity.
- The submarine cable would then be connected to the messenger wire pre-installed in the duct and winched from a position close to the TJP through the duct; whereupon it can be jointed to the onshore cables.
- The cable is then installed away from the beach either using a plough or trencher (as per the offshore installation section above).

No works would be required on the beach.

As marine operations are dependent on weather conditions, offshore and nearshore installation work will be conducted on a 24-hour basis.



GREENLINK INTERCONNECTOR

INSTALLATION

Indicative HDD Exit Point - UK Landfall

Drawing No: P1975-INST-001	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development
- High Water Mark
- Low Water Mark
- Decommissioned MOD Cable Avoidance Zone
- HDD Compound
- Indicative HDD Exit Point
- Trenching Exclusion Zone
- Annex I Habitat Exclusion Zone

EUNIS Habitat Classification

- A4.138
- A5.13
- A5.24
- A5.261

NOTE:

No trenching to be carried out in exclusion zones.



NOTE: Not to be used for Navigation

Date	Thursday, June 6, 2019 13:48:42
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OSOD; MMT; ESRI; Greenlink
File Reference	J:\P1975\Mxd\15_INST\ P1975-INST-001.mxd
Created By	Chris Goode
Reviewed By	Chris Carroll
Approved By	Anna Farley

Co-financed by the European Union Connecting Europe Facility

0 100 200 300 400 m

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3.8 Cable operation

3.8.1 Emissions

During operation of the cables emissions to the environment will consist of magnetic (B) and heat. The influence of Greenlink on the background geomagnetic field along the cable route has been calculated to be low with B fields dissipating to natural background levels within 2m of the cables.

Temperature increases in the upper sediments of the seabed over buried cables are not expected to emanate further than 1m from the cable or exceed 2°C.

3.8.2 Maintenance and repair

It is likely that routine inspection surveys using standard geophysical survey equipment and/or remotely operated vehicles to monitor buried depth and integrity of rock berms will be undertaken, particularly in the initial years of operation, and should the local environmental conditions change or be suspected as having changed.

Once installed, marine cables are not expected to require routine maintenance. If a cable fault is detected, usually as a consequence of damage cause by external interaction e.g. trawlers and commercial ship anchors, the relevant section of the cable will be located and retrieved to surface for inspection and replacement. It may be necessary to de-bury the cable prior to cable recovery. A repair will typically be carried out by a single vessel. A shallow water repair, in less than 10m of water, will typically be made using an anchored barge. In deeper water a dynamically positioned cable vessel will be used. As the fault location may be uncertain up to 1km has been allowed for as a replacement length. The extra length of a repaired short cable section means it cannot be returned to its exact previous alignment on the seabed. The excess cable will be laid on the seabed in a loop off to one side of the original route. The additional joints and the extra cable length will be buried, typically using jetting machines deployed from either the repair vessel itself or a separate specialised vessel.

The Proposed Development includes five discrete cable repairs, each 1km in length and assumes as a worst case that external cable protection up to 10m wide will be required to protect the new section of cables if they cannot be buried into the sediment.

3.9 Decommissioning

GIL recognise the importance of considering the decommissioning process at an early stage and should decommissioning be undertaken the operation will be conducted according to the standard industry protocol at the agreed time.

At the end of the cable's life the options for decommissioning will be evaluated.

The objectives during the decommissioning process will be to minimise both the short- and long-term effects on the environment whilst making the sea safe for others to navigate. Based on current regulations and available technology, the following level of decommissioning is proposed and has been assessed:

- Cables - to be either removed or to be left safely in-situ, buried to below the natural seabed level
- Mattresses - to be left in-situ
- Rock protection - to be left in-situ
- The HRA assesses the worst-case environmental effects which could either be full removal or leaving in-situ depending on the receptor.

3.10 Embedded mitigation

Greenlink has been developed through an iterative process that sought to avoid or reduce potential environmental effects. Steps taken to reduce environmental disturbance include:

- Sensitive environmental features were identified through a desk-based assessment that used publicly available datasets and survey data acquired from other developers in the region.
- Nearshore sections of the route in Wales were refined to follow identified sand channels through the bedrock reef habitat.
    - Three possible routes through the Pembrokeshire Marine SAC were designed for further investigation (see Section 3.2.3). NRW was consulted on the routes and survey strategy.
    - A reconnaissance survey was undertaken on two route options (Route A & Route E) through the SAC to identify areas of Reef habitat. NRW reviewed preliminary survey results.
    - In consultation with NRW, a new route option was engineered between Route A and Route E that sought to avoid a greater majority of the sensitive habitats in the area. This route is the Proposed Development.
- Geophysical survey was widened to investigate previously unknown sand channels and the route engineered to make use of this feature.

In addition to the route engineering that has taken place, the project will comply with international and national statute which is designed to avoid or abate negative environmental effects.

Embedded mitigation which forms part of the design of Greenlink and is considered the 'base case' is outlined in the Greenlink Marine Environmental Statement (ES). Table 3-6 presents extracts relevant to avoiding or reducing negative environmental effects on European sites. The ID column has been retained from the ES for cross-referencing purposes.

Table 3-6 Embedded mitigation

ID	Embedded mitigation measure	Project Phase		
		I	O	D
EM6	Ballast water discharges from Project vessels will be managed under the International Convention for the Control and Management of Ships' Ballast Water and Sediments standard.	■	■	■
EM8	The latest guidance from the GB non-native species secretariat (2015) will be followed and a Biosecurity Plan produced pre-installation.	■		
EM13	The preference is to use HDD for the cable landfalls to avoid disturbance of sensitive habitats (e.g. dune system) and disruption on beaches.	■		
EM14	Route engineering was undertaken during the marine survey to avoid sensitive habitats where possible or to reduce the distance the submarine cable corridor crosses a sensitive feature.	■		
EM15	Submarine cables will be bundled together, which reduces the seabed footprint of installation activities and the electromagnetic field generated during operation, thus minimising any potential compass deviation effects.	■	■	
EM18	Deployment of anchors/anchor chains on the seabed will be kept to a minimum in order to reduce disturbance to seabed.	■	■	■
EM19	Project vessels will not exceed 14 knots within the Proposed Development.	■	■	■
EM20	GIL will require that the appointed contractor(s) follows the 'JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys' (JNCC 2017a) (or subsequent amendments), appropriate to sub-bottom profiling and multi-beam and echo-sounder surveys respectively. In particular: • Establishing a 500m mitigation zone for marine mammal observation. • Provide non-dedicated marine mammal observers to implement the JNCC guidelines within the Pembrokeshire Marine / Sir Benfro Forol SAC and West Wales Marine / Gorllewin Cymru Forol SAC. • Undertake pre-survey search - On-board marine mammal observer will scan the waters surrounding the vessel for 30 minutes before operations start to determine whether any marine mammals are within 500m of the survey equipment. • Where possible, according to the operational parameters of the equipment concerned, its acoustic energy output shall commence from a lower energy start-up and thereafter be allowed to gradually build up to the necessary maximum output over a period of at least 15 minutes, with the duration from the start of the soft start until the start of the survey line being a maximum of 25 minutes. • If the device cannot be ramped up then it shall be switched on and off in a consistent sequential manner over a period of 20 minutes prior to commencement of the full necessary output.	■	■	■
EM21	A UXO survey will be undertaken less than 6 months prior to installation works commencing. If any significant UXO are identified the following decision making process will be followed: 1. Avoid by micro-routeing the marine cables. 2. If it cannot be avoided, consider whether it is safe to move. 3. If it cannot be moved, detonate on site.	■		

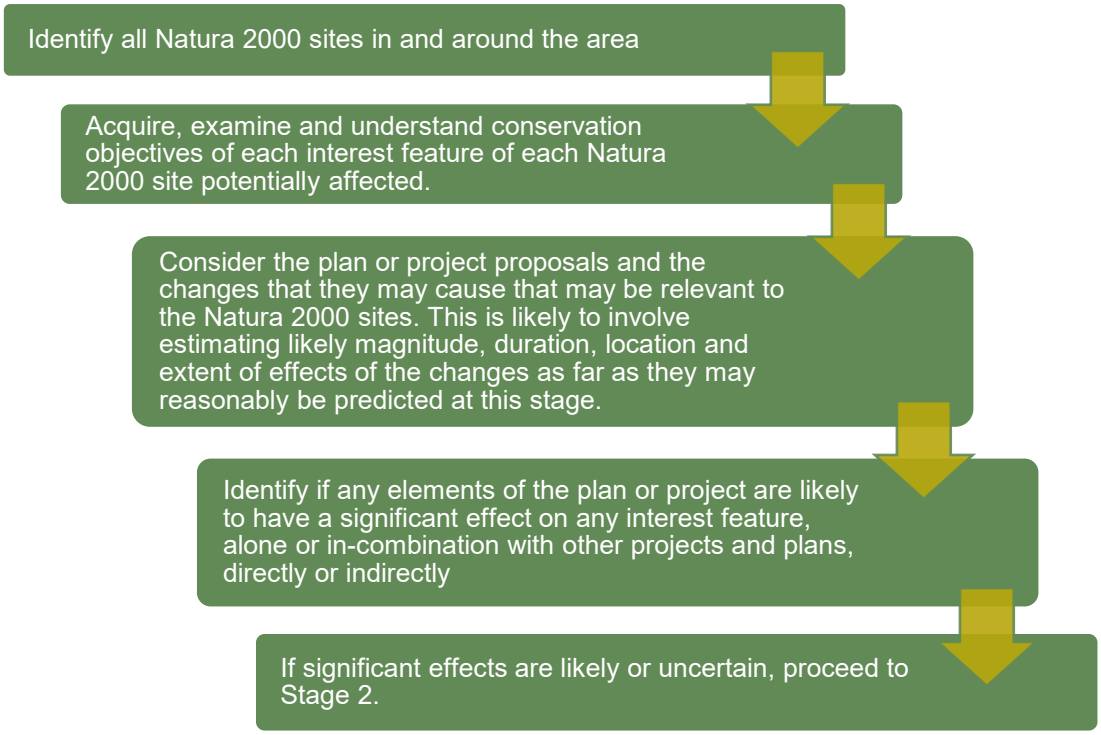
ID	Embedded mitigation measure	Project Phase		
		I	O	D
EM23	GIL will require that the appointed UXO contractor follows the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010, or as updated) including: • Establishing a default 1km mitigation zone for marine mammal observation, measured from the explosive source and with a circular coverage of 360 degrees. • Providing a trained marine mammal observer to implement the guidelines outlined in Section 2.1 to 2.4 e.g. pre-detonation search of mitigation zone. • Only commence explosive detonations during daylight hours and good visibility. • Accurately determine the amount of explosive required for the operation, so that the amount is proportionate to the activity and not excessive. • If necessary, plan the sequence of multiple explosive discharges so that, wherever possible, the smaller charges are detonated first to maximise the 'soft-start' effect.			
EM26	Post-installation inspection surveys will be conducted along the length of the cables on a regular basis.			
EM29	Rock and mattresses will only be deployed where adequate burial cannot be achieved. The footprint of the deposits will be the minimum required to ensure cable safety and rock berm stability.			
I = Installation; O = Operation (including repair & maintenance); D = Decommissioning				

4. Stage 1 – Appropriate Assessment Screening

4.1 Assessment Approach

This AA screening has been undertaken according to the process set out in Welsh Government (2017) guidance, as illustrated in Figure 4-1. It has taken into account all case law relevant to the Habitats Directive summarised in the recently issued EC Guidance (November 2018).

Figure 4-1 HRA Screening Process



4.2 Identification of relevant European sites

The potential for a European site to be significantly affected depends on whether receptors which are designating features of a European site:

a. Can come into contact with the Proposed Development; and

b. Are sensitive to the Proposed Development activities to the extent that the activity is likely to have an adverse effect on the conservation objectives for the features.

Identifying relevant European sites has therefore been achieved by applying the following steps:

1. Identify which receptors could be sensitive to the Proposed Development (Section 4.2.1.1);

2. Identify the potential pressures the Proposed Development could have on these receptors and what the zone of influence for these receptors is, i.e. the spatial extent over which effects could extend (Section 4.2.1.2)
3. Using the zones of influence as a guide define a search area within which European sites are screened for the relevant Qualifying Feature (Section 4.2.3.2); and
4. Screen SACs, SPAs, and Ramsar sites within the defined search areas to identify designating features and assess whether interest features of the site could be significantly affected by the Proposed Development (Section 4.2.3.3).

4.2.1.1 Identification of sensitive receptors

The receptors which could potentially be affected by the Proposed Development and could be the designating interest features of European sites are:

- Subtidal habitats;
- Fish;
- Birds; and
- Marine mammals (cetacean, pinniped and otter).

4.2.1.2 Defining a search area (identification of potential pressures and zone of influence)

The OSPAR Intercessional Correspondence Group on Cumulative Effects (ICG-C) pressure list and descriptions (OSPAR Commission 2011) have been used to describe the potential pressures expected from the Proposed Development. Listed in Table 4-1, these potential pressures may be direct or indirect, temporary or permanent, beneficial or harmful to the site, or a combination of these. The zone of influence – spatial extent over which effects may extend – has also been defined.

Repair and maintenance activities during the operational phase, where required, will result in similar pressures to those described in respect to installation activities, but on a smaller and more local scale. Therefore, they have been considered alongside installation pressures.

The zone of influence has been used to establish a search area within which European sites are screened for the relevant Qualifying Feature. Since mobile species from conservation sites further field may travel into the zone of influence, the zone of influence cannot be used alone as a distance to screen in relevant conservation sites. Therefore, search areas (distances from the Proposed Development) for each receptor group have been applied taking into consideration other information such as marine mammal management units and expert judgement to use for the initial screening of sites. Justification for the spatial extent of the search area is provided in Table 4-1.

Table 4-2 identifies the pressures that have been scoped out of the HRA and the reason for the exclusion. These pressures will not be discussed further.

Table 4-1 Potential pressures, zones of influence and European site search area

Receptor	Phase	Potential Pressure	Aspect of Proposed Development	Zone of influence	Search area and justification
Habitats	Installation (including repair & maintenance) Decommissioning	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Pre-sweeping	100m wide	Proposed Development Jetting and pre-sweeping will result in a brief, localised sediment plume. Levels of suspended sediments will be rapidly diluted within the Proposed Development and will be within the range of natural variation experienced after winter storm events in the region.
			Seabed preparation. Cable burial. Cable removal.	15m wide	
			Anchor placement	Proposed Development	
		Siltation rate changes, including smothering (depth of vertical sediment overburden)	Pre-sweeping. Cable burial. Cable removal.	100m wide	
		Hydrological changes (inshore/local)	External cable protection	Freshwater West	
		Physical change (to another seabed type)	External cable protection	10m wide	
Birds	Installation (including repair & maintenance) Decommissioning	Visual disturbance	Project vessels Welsh Onshore works e.g. at HDD compound	Radial distances 4km divers and sea ducks+ 2km all other species+	10km It is recognised that some seabirds from other SPAs will forage and loaf in zone of influence. However, disturbance will be limited in extent and duration and there is sufficient space in the surrounding environment for birds to temporarily relocate. Therefore, only sites within 10km of the Proposed Development have been screened.
Fish	Installation (including repair & maintenance) Decommissioning	Underwater noise changes*	Impulsive sound from geophysical survey	586m radial distance	40km As there is the potential that underwater sound changes could impede migration to and from rivers,
			Continuous sound from cable installation, cable removal and vessels	99m radial distance	
			Impulsive sound - UXO deflagration	1.8km radial distance	

Receptor	Phase	Potential Pressure	Aspect of Proposed Development	Zone of influence	Search area and justification
	Operation	Electromagnetic changes	Cables	2m radial distance	the search area has been extended to 40km.
Cetacean and otter	Installation (including repair & maintenance) Decommissioning	Underwater noise changes*	Impulsive sound from geophysical survey	756m radial distance	Management Unit** In recognition of the highly mobile nature of cetaceans the relevant species management unit will define the search area.
			Continuous sound from cable installation, cable removal and vessels	19km radial distance	
			Impulsive sound - UXO deflagration	40km radial distance	
	Operation	Electromagnetic changes	Cables	2m radial distance	
Pinniped	Installation (including repair & maintenance) Decommissioning	Underwater noise changes*	Impulsive from geophysical survey	756m radial distance	100km grey seal It is estimated that grey seal forage up to 100km from their haul out sites (DECC 2016) 50km harbour seal Harbour seal are not known to make trips greater than 50km from haul out sites (DECC 2016)
			Continuous sound from cable installation, cable removal and vessels	19km radial distance	
			Impulsive sound - UXO deflagration	40km radial distance	

* Zones of Influence for underwater noise changes have been taken from the Greenlink Marine ES – Wales Technical Appendix D – Underwater Sound Modelling Revision F3 (Intertek EWCS 2020) and are based on the calculated zones at which the onset of disturbance may occur.

** Most cetaceans are wide-ranging, and individuals encountered within Welsh waters form part of a much larger biological population whose range extends into adjacent jurisdictions. As a result, management units (MUs) have been outlined for seven of the common regularly occurring species following advice from the Sea Mammals Research Unit (DECC 2016) and the International Council for the Exploration of the Sea (ICES). These provide an indication of the spatial scales at which impacts of anthropogenic activities should be taken into consideration.

+ Based on the extent and potential consequences of seabird displacement from offshore wind farm developments published by the UK Joint Statutory Nature Conservation Bodies (JNCC 2017b).

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Table 4-2 Pressures scoped out and the reason for exclusion

Pressure Scoped Out of EIA	Receptor	Reason for Scoping Effect out of the ES
Hydrocarbon and PAH contamination	All receptors	Unplanned events (accidental oil or chemical spills) have been scoped out of the ES for the following reasons: • The likelihood of a large oil spill occurring from a Project vessel is extremely low and the risk is no greater than that for any other vessel in the Proposed Development area. • All Project vessels will have control measures and shipboard oil pollution emergency plans (SOPEP) in place and will adhere to MARPOL Annex I requirements. • A Construction Environmental Management Plan (CEMP) and an Emergency Spill Response Plan will be developed and implemented for the installation phase. Execution of these plans will ensure that the risks associated with an unplanned event will be effectively managed in line with relevant international and national statute.
Temperature changes - local	Habitats Fish	When cables are in operation, localised heating of the environment may occur surrounding the cables (i.e. sediments including interstitial water, where cables are buried, rock berms/concrete mattresses when cable protection employed). Seawater temperatures within the Celtic Sea vary seasonally and therefore are likely to accommodate minor localised variations in temperature associated with thermal losses. Impacts on seabed temperature will not have a significant effect. The indirect effects on fish and shellfish have therefore also been scoped out of the HRA.
Penetration and/or disturbance including abrasion	Intertidal habitats Intertidal birds	The preferred method of installation at the landfall is HDD. The HDD will exit below the low water mark and therefore intertidal habitats will not be affected and there will be no indirect effects on birds (e.g. temporary loss of food resource).
Visual disturbance	Fish	The effect could occur during cable installation, as a result of the presence of the installation vessels and equipment (and associated noise) within the vicinity of operations. This could result in the displacement of fish within the water column. The disturbance from installation operations will be short term, localised and not considered likely to be significant given existing background levels of noise and shipping in the St Georges Channel and around Milford Haven. Therefore, this effect has been scoped out of the HRA.
Siltation rate changes including smothering (depth of vertical sediment overburden)	Fish	There are three pathways for species to be smothered as a result of project activities: by displaced sediments during trenching; by the re-deposition of suspended sediment; and by cable protection material being placed on the seabed. The effect from displaced sediment will be very localised, only effecting species in the immediate vicinity of cable trenches. Suspended sediment settlement levels are expected to be minimal with any material deposited likely to be quickly re-suspended and distributed by natural hydrodynamic processes. Therefore, this aspect of the effect on fish and shellfish has been scoped out of the HRA. The suspension of sediments within the water column from cable installation may cause small, localised and temporary turbidity before being re-deposited on the seabed. A temporary reduction in the feeding capability of species relying on sight to locate their prey may occur. Most species are likely to be tolerant to any changes in turbidity levels (likely to be equivalent

Pressure Scoped Out of EIA	Receptor	Reason for Scoping Effect out of the ES
		to those experienced during storm events) and the significance of the effect is likely to be negligible. Therefore, this aspect of the effect on fish and shellfish has also been scoped out of the HRA. The effects of depositing cable protection material will be assessed.
Death or injury by collision	Marine mammals	Although shipping collision is a recognised cause of basking shark and marine mammal mortality worldwide, the key factor influencing the injury or mortality caused by collisions is ship size and speed. Ships travelling at 14 knots or faster are most likely to cause lethal or serious injuries. Although the presence of the cable lay vessels and support vessels will marginally increase the level of vessel activity within the area for the duration of the marine works, none of the Proposed Development's vessels will be travelling at speeds exceeding 14 knots. Cable lay vessels move along the cable route at the rate of cable installation, approximately 100-300m per hour depending on sediment conditions, resulting in a low likelihood of collision. Given that vessels will be operating at less than 14 knots, the effect is scoped out of the HRA as it is not likely to be significant.
Light	Birds	NRW Scoping Opinion SC1816 noted "Consideration should be given to the impacts of lighting at any stage of the project on Manx shearwater, a feature of the Skomer, Skokholm and the Seas off Pembrokeshire SPA." The necessity of scoping in the pressure was queried on the grounds that: • The Proposed Development lies 3.13km south of Skokholm. Where the Proposed Development is close to the islands it is within an area of moderate to high shipping density. This is the main route for the Pembroke to Rosslare ferry amongst other vessels transiting to and from Milford Haven. • The Proposed Development is to the south of the known rafting areas of manx shearwater. • Both manx shearwater and puffin score low for susceptibility to disturbance on the Joint SNCB Interim Displacement Advice Notice (2017). • The cable lay vessel will be progressing very slow along the route; effectively stationary in terms of bird displacement. it is a 24-hour continuous operation and would progress through the SPA. • The introduction of the cable lay vessel will be within the day-to-day variation of ship numbers in the area. Birds in the region are habituated to the shipping levels and the cable lay vessel will not significantly increase this. NRW agreed that the pressure could be scoped out on the grounds that "The Conservation Objectives for the SPA call for "The breeding population of Manx shearwater should be stable or increasing with no measured decrease in numbers (based on a population count of 150,968), based on annual study plots. The current population for Manx shearwater is estimated at just under 300,000 individuals. This is the lowest conservative estimate (there are differences in counting methods). Therefore, the population is doing well and we [NRW] don't consider that the presence of one ship, carrying out the activities proposed …, has the potential to have a significant effect on population numbers." (Pauls, L. 04/04/2019 [email])

4.2.1.3 Screening of European sites

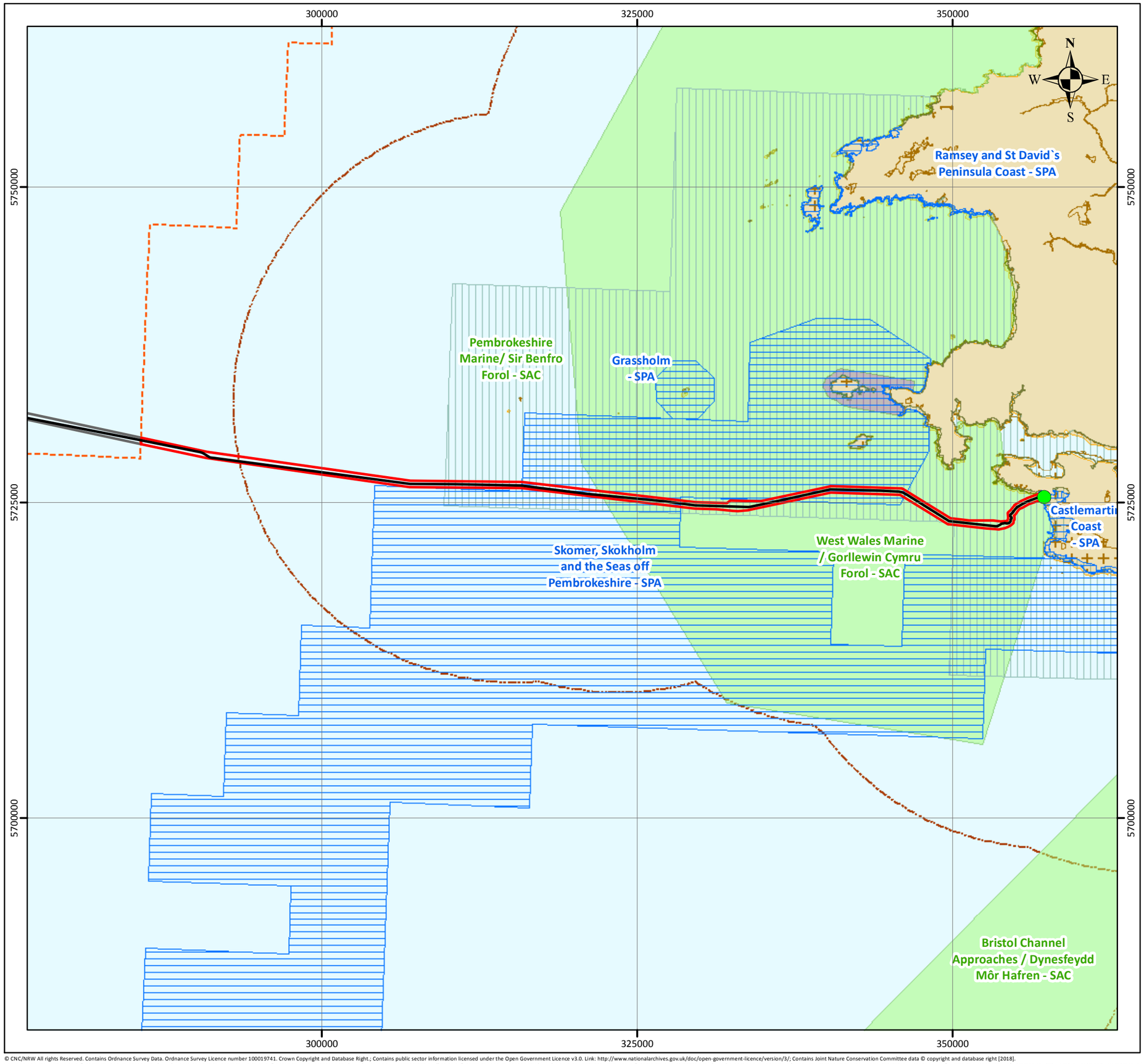
A geographic information system (GIS) was used to map the boundaries of European sites in relation to the Proposed Development. All conservation sites with marine components which are within the defined search area distance for identified receptors have been listed along with their qualifying features. Figure 4-2 (Drawing (P1975-PROT-001) shows the sites crossed by the Proposed Development.

A total of 12 European sites were screened in this assessment and are shown in Table 4-3. In addition, 12 SSSIs and 1 MCZ were also screened and are shown in Table 4-4.

For each site it was determined whether there is the potential for an interaction between the Proposed Development and the Qualifying Features i.e. whether there is a pressure-receptor pathway. This is determined by comparing information such as the extent of the zone of influence with information regarding the conservation feature e.g. species foraging distances, spatial extent of habitats etc. The interactions were defined as follows:

- Yes: A pathway between the Proposed Development and the Qualifying Feature can be identified that is likely to result in an effect; or
- No: Either a pathway between the Proposed Development and the Qualifying Features cannot be identified or a pathway exists but there is no physical overlap of the pressure and the Qualifying Feature.

For all Qualifying Features where it is determined that there is a possible interaction, the likely significance of the effect is assessed in light of the conservation objectives for the site in Section 4.4.



GREENLINK INTERCONNECTOR

PROTECTED SITES
UK Waters

Drawing No: P1975-PROT-001	A

Legend

- Freshwater West
- Proposed Development
- Irish Offshore
- UK 12nm Territorial Sea Limit
- Median Line

Environmental Designations

- SAC
- SAC - Harbour Porpoise
- SPA
- MCZ
- SSSI



NOTE: Not to be used for Navigation

Date	Monday, April 8, 2019 12:00:50
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	NRW; JNCC; DCCAE; UKHO; CDA; GEBCO; Greenlink
File Reference	J:\P1975\Mxd\08_PROT\ P1975-PROT-001.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

Co-financed by the European Union Connecting Europe Facility

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Table 4-3 Initial screening for relevant European sites

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
Pembrokeshire Marine / Sir Benfro Forol SAC UK0013116	Within	Estuaries Coastal lagoons Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) Submerged or partially submerged sea caves Large shallow inlets and bays Shore dock *Rumex rupestris*	No pressure-receptor pathway	**Screened out** as the Qualifying Features are not within the Proposed Development
		Reefs	Penetration and/or disturbance including abrasion	**Yes** - Cable installation techniques are intrusive and therefore have the potential to disturb the Qualifying features of the site that the Proposed Development crosses.
			Physical change (to another seabed type)	**Yes** – External cable protection will be required within this Qualifying Feature.
			Siltation rate changes	**No** – Seabed preparation, cable burial and cable removal will cause a brief, localised increase in suspended sediment in the water column with subsequent re-deposition of sediment on surrounding habitats. Calculations presented in Greenlink Marine ES – Chapter 6, indicate that deposition of sand and gravel will be restricted to the footprint of the cable trench equipment (<15m). Although silt will be deposited over a larger area (up to 7.6km from the trench) the layer of deposition will be less than 1mm thick and therefore not measurable above natural levels of turbidity and sediment deposition.
			Hydrological changes	**No** – Use of external cable protection will cause localised change in seabed topography but due to water depths and distances offshore there will be no effect on coastal processes.
		Sandbanks which are slightly covered by seawater all the time	Penetration and/or disturbance including abrasion	**Yes** - Cable installation techniques are intrusive and therefore have the potential to disturb the Qualifying features of the site that the Proposed Development crosses.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
			Physical change (to another seabed type)	**Screened out** as external cable protection will not be used within this Qualifying Feature.
			Siltation rate changes	**No** – Seabed preparation, cable burial and cable removal will cause a brief, localised increase in suspended sediment in the water column with subsequent re-deposition of sediment on surrounding habitats. Calculations presented in Greenlink Marine ES – Chapter 6, indicate that deposition of sand and gravel will be restricted to the footprint of the cable trench equipment (<15m). Although silt will be deposited over a larger area (up to 4.5km from the trench) the layer of deposition will be less than 1mm thick and therefore not measurable above natural levels of turbidity and sediment deposition.
Pembrokeshire Marine / Sir Benfro Forol SAC UK0013116	Within	Sandbanks which are slightly covered by seawater all the time	Hydrological changes	**Screened out** – External cable protection will not be used within this Qualifying Feature and therefore there is no pathway for hydrological changes
		Mudflats and sandflats not covered by seawater at low tide	Physical change (to another seabed type)	**Screened out** as external cable protection will not be used within this Qualifying Feature.
			Siltation rate changes	**Screened out** as there will be no intrusive works within the intertidal area.
			Hydrological changes	**Yes -** Installation of external cable protection has the potential to affect coastal processes effecting the beach at Freshwater West.
		• Grey seal Halichoerus grypus • Otter Lutra lutra	Underwater noise changes	**Yes** – Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.
			Disturbance (visual)	**Yes -** Disturbance will be limited to that initiated by the movement of the project vessels.
		• Allis shad *Alosa alosa* • Twaite shad *Alosa fallax*	Underwater noise changes	**Yes** - Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could disturb / cause temporary injury or disturbance.
			Electromagnetic changes	**No** – effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration to or from rivers.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
		• Sea lamprey Petromyzon marinus • River lamprey Lampetra fluviatilis	Underwater noise changes	**No** – Sea lamprey are not hearing specialist fish species and it is unlikely that they will be effected by underwater noise changes.
			Electromagnetic changes	**No** – Effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration to or from rivers.
Skomer, Skokholm and the seas off Pembrokeshire /Sgomer, Sgogwm a moroedd Penfro SPA UK9014051	Within	Breeding birds: • Red-billed chough Pyrrhocorax pyrrhocorax • European storm petrel *Hydrobates pelagicus* • Migratory species (breeding): • Lesser black-backed gull *Larus fuscus* • Manx shearwater Puffinus puffinus • Atlantic Puffin Fratercula arctica • Seabird assemblages - Regularly supports at least 20,000 seabirds in any season.	Disturbance	**Yes** – It is possible that breeding and migratory birds from this site could be disturbed by cable installation activities.
		• Short-eared owl *Asio flammeus*	No pressure-receptor pathway	**Screened out**
West Wales Marine / Gorllewin Cymru Forol SAC UK0030397	Within	• Harbour porpoise *Phocoena phocoena*	Underwater noise changes	**Yes -** Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.
			Changes to supporting habitat	**No** – Important prey species for harbour porpoise is herring and sandeel. The interaction of the Proposed Development with potential spawning habitat of these

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
			and prey availability	species was investigated in the Greenlink Marine ES Wales – Technical Appendix E; and the effects of the cable installation on herring and sandeel was assessed in Section 8 of the ES. The assessment concluded that the residual effect of the installation activities on herring and sandeel species is Minor and Not significant. As such, the Proposed Development will not have a significant effect on the condition of supporting habitats or prey availability at this site.
Castlemartin Coast SPA UK9014061	Within	Breeding bird and over winter: • Red-billed Chough	Disturbance	**Yes** - Disturbance is predicted to be limited to that initiated by the movement of the project vessels. Although chough are terrestrial birds and do not use the marine environment for foraging, they nest in the sea cliffs along this stretch of coast and may forage close to the landfall area.
Limestone Coast of South West Wales Arfordir Calchfaen de Orllewin Cymru SAC UK0014787	Within	• Dune grassland • Caves (terrestrial and sea) • Dry heaths • Early gentian Gentianella anglica • Petalwort Petalophyllum ralfsii • Greater horseshoe bat • Dry grasslands and scrublands on chalk or limestone • Vegetated sea cliffs	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
Grassholm SPA UK9014041	8.55	• Regularly occurring migratory species (breeding): • Gannet Morus bassanus	Disturbance	**Yes -** Disturbance is predicted to be limited to that initiated by the movement of the project vessels. It is possible that the qualifying species of this site could forage within the vicinity of the Proposed Development.
Bristol Channel Approaches/	20	• Harbour porpoise	Underwater noise changes	**Yes** - Site is within the Celtic and Irish Seas (CIS) Management Unit. Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
Dynesfeydd Môr Hafren SAC UK0030396			Electromagnetic changes	**No** - Effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration.
			Changes to supporting habitat and prey availability	**No** – The Proposed Development does not overlap with the European site boundary and therefore there is no direct effect on the supporting habitat with the European site. However, it is recognised that harbour porpoise are mobile species and forage outside of the European site. Important prey species for harbour porpoise is herring and sandeel. The interaction of the Proposed Development with potential spawning habitat of these species was investigated in Greenlink Marine ES Wales – Technical Appendix E; and the effects of the cable installation on herring and sandeel was assessed in Section 8 of the ES. The assessment concluded that the residual effect of the installation activities on herring and sandeel species is Minor and Not significant. As such, the Proposed Development will not have a significant effect on the prey availability for the species.
North Anglesey Marine / Gogledd Môn Forol SAC UK0030398	170	• Harbour porpoise	Underwater noise changes	**Yes** - Site is within the Celtic and Irish Seas (CIS) Management Unit. Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.
			Electromagnetic changes	**No** - Effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration.
			Changes to supporting habitat and prey availability	**No** – The Proposed Development does not overlap with the European site boundary and therefore there is no direct effect on the supporting habitat with the European site. However, it is recognised that harbour porpoise are mobile species and forage outside of the European site. Important prey species for harbour porpoise is herring and sandeel. The interaction of the Proposed Development with potential spawning habitat of these species was investigated in Greenlink Marine ES Wales – Technical Appendix E; and the effects of the cable installation on herring and sandeel was assessed in Section 8 of the ES. The assessment concluded that the residual effect of the installation activities on herring and sandeel species is Minor and Not significant. As such, the Proposed Development will not have a significant effect on the prey availability for the species.
North Channel SAC UK0030399	279	• Harbour porpoise	Underwater noise changes	**Yes** – Site is within the Celtic and Irish Seas (CIS) Management Unit. Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
			Electromagnetic changes	**No -** effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration.
			Changes to supporting habitat and prey availability	**No** – The Proposed Development does not overlap with the European site boundary and therefore there is no direct effect on the supporting habitat with the European site. However, it is recognised that harbour porpoise are mobile species and forage outside of the European site. Important prey species for harbour porpoise is herring and sandeel. The interaction of the Proposed Development with potential spawning habitat of these species was investigated in Greenlink Marine ES Wales – Technical Appendix E; and the effects of the cable installation on herring and sandeel was assessed in Section 8 of the ES. The assessment concluded that the residual effect of the installation activities on herring and sandeel species is Minor and Not significant. As such, the Proposed Development will not have a significant effect on the prey availability for the species.
Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd SAC UK0020020	29	• Sea lamprey • River lamprey	Underwater noise changes	**No** – Sea lamprey are not hearing specialist fish species and it is unlikely that they will be effected by underwater noise changes.
			Electromagnetic changes	**No** – effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration to or from rivers.
		• Twaite shad • Allis shad	Underwater noise changes	**Yes** - Greenlink Marine ES Wales - Technical Appendix D concluded that underwater could disturb cause temporary injury or disturbance.
			Electromagnetic changes	**No** – effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration to or from rivers.
		• Sandbanks which are slightly covered by seawater all the time • Estuaries • Mudflats and sandflats not covered by seawater at low tide	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
		• Large shallow inlets and bays • Salicornia and other annuals colonizing mud and sand • Atlantic salt meadows (Glauco-Puccinellietalia maritimae) • Otter		
Bae Ceredigion / Cardigan Bay SAC UK0012712	72	• Bottlenose dolphin *Tursiops truncatus*	Underwater noise changes	**Yes** – Site is within the Offshore Channel and SW England (OCSW) Management Unit. Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.
			Electromagnetic changes	**No** - Effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration.
			Changes to supporting habitat and prey availability	**No** – The Proposed Development does not overlap with the European site boundary and therefore there is no direct effect on the supporting habitat with the European site. However, it is recognised that bottlenose dolphin are mobile species and forage outside of the European site. Important prey species for harbour porpoise is herring and sandeel. The interaction of the Proposed Development with potential spawning habitat of these species was investigated in Greenlink Marine ES Wales – Technical Appendix E; and the effects of the cable installation on herring and sandeel was assessed in Section 8 of the ES. The assessment concluded that the residual effect of the installation activities on herring and sandeel species is Minor and Not significant. As such, the Proposed Development will not have a significant effect on the prey availability for the species.
		• Grey seal	Underwater noise changes	**Yes** – Site is within the same grey seal Management Unit (South and West England and Wales Management Unit) as the Pembrokshire Marine/Sir Benfro Forol SAC. In addition, the Proposed Development is within the 100km foraging range of this species. Therefore, it is likely that the two SACs are connected. Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
			Electromagnetic changes	**No** - Effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration.
		• Sea lamprey • Grey seal • River lamprey	Underwater noise changes	**Screened out** as site is outside of the search area for fish species.
		• Sandbanks which are slightly covered by sea water all the time • Reefs • Submerged or partially submerged sea caves	No pressure-receptor pathway identified	**Screened out** as site is outside of the search area for habitats.
Pen Llyn a'r Sarnau / Lleyn Peninsula and the Sarnau SAC UK0013117	124	• Bottlenose dolphin	Underwater noise changes	**Yes** – Site is within the Offshore Channel and SW England (OCSW) Management Unit. Greenlink Marine ES Wales - Technical Appendix D concluded that underwater noise could cause temporary injury or disturbance.
			Electromagnetic changes	**No** - Effects of EMF will be not be measurable above natural background levels within 2m of the cables. The slight elevation in field strength will not inhibit migration.
			Changes to supporting habitat and prey availability	**No** – The Proposed Development does not overlap with the European site boundary and therefore there is no direct effect on the supporting habitat with the European site. However, it is recognised that bottlenose dolphin are mobile species and forage outside of the European site. Important prey species for harbour porpoise is herring and sandeel. The interaction of the Proposed Development with potential spawning habitat of these species was investigated in Greenlink Marine ES Wales – Technical Appendix E; and the effects of the cable installation on herring and sandeel was assessed in Section 8 of the ES. The assessment concluded that the residual effect of the installation activities on herring and sandeel species is Minor and Not significant. As such, the Proposed Development will not have a significant effect on the prey availability for the species.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
		• Otter • Sandbanks which are slightly covered by sea water all the time • Estuaries • Coastal lagoons • Large shallow inlets and bays • Reefs • Mudflats and sandflats not covered by seawater at low tide • Salicornia and other annuals colonizing mud and sand • Atlantic salt meadows (Glauco-Puccinellietalia maritimae) • Submerged or partially submerged sea caves	No pressure-receptor pathway identified	**Screened out** as site is outside of the respective search areas and species unlikely to travel to Proposed Development.

Table 4-4 Initial screening for relevant SSSI and MCZ sites

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
Broomhill Burrows SSSI 1136	Within	• Red-billed Chough Pyrrhocorax pyrrhocorax • Lapwing Vanellus vanellus	Disturbance	**Yes -** Disturbance is predicted to be limited to that initiated by the movement of the project vessels. Although chough are terrestrial birds and do not use the marine environment for foraging, they nest in the sea cliffs along this stretch of coast and may forage close to the landfall area. Lapwings breed in the dune slacks at the back of Freshwater Bay.
Arfordir Penrhyn Angle / Angle Peninsula Coast SSSI 0923	0.06	• Red-billed Chough	Disturbance	**Yes** – Disturbance is predicted to be limited to that initiated by the movement of the project vessels. Although chough are terrestrial birds and do not use the marine environment for foraging, they nest in the sea cliffs along this stretch of coast, may forage close to the landfall area and NRW has requested the chough of this site are considered.
		Intertidal species • Reef habitat • Submerged or partially submerged sea caves • Peregrine falcon *Falco peregrinus* • Greater horseshoe bat Rhinolophus ferrumequinum • Lesser horseshoe bat *R. hipposideros*	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
Castlemartin Range SSSI 0140	0.54	• Red-billed Chough	Visual disturbance	**Screened out -** Site is within Castlemartin Coast SPA which lists red-billed chough as a Qualifying Feature. The assessment for these features has therefore been undertaken within the screening for the SAC.
		• Breeding seabirds (guillemot, razorbill, kittiwake, fulmar, lesser-black-backed gull, herring gull, shag)	Disturbance	**Yes -** It is possible that breeding birds from this site could be disturbed by cable installation activities.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
		• Grey seal • Otter	Disturbance Underwater noise changes	**Screened out** - Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists grey seal and otter as a Qualifying Feature. The assessment for these features has therefore been undertaken within the screening for the SAC.
		• Rare and scarce plants and invertebrates • Coastal geology • Greater horseshoe bat • Lesser horseshoe bat	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
Castlemartin Corse SSSI 0242	0.71	• Cliff and foreshore rock outcrops • Sand dune system • Grassland • Insects, lichen and reptiles. • Lapwing	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
Milford Haven Waterway SSSI 0282	1.44	• Geology • Ancient woodland • Rare and scarce maritime plants • Greater horseshoe bat • Lesser horseshoe bat	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
	1.44	• Otter	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists otter as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
		Over-wintering wildfowl and waders including:	Disturbance	**No** – these birds will be found feeding in the intertidal area. Therefore, given the distance of this SSSI (as the cross flies across land) to the Proposed Development, it is considered unlikely that these birds will be disturbed.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
		• Eurasian teal *Anas crecca* • Eurasian widgeon *Anas penelope* • Eurasian curlew *Numenius arquata* • Little grebe Tachybaptus ruficollis • Dunlin Calidris alpine • Common shelduck *Tadorna tadorna*		
Dale and South Marloes Coast SSSI 0585	3.22	• Rocky and sandy shore communities • Nationally scarce green and red algal communities • Maritime grassland, maritime heath, maritime cliff crevice and ledge vegetation, coastal scrub • Shore dock • Golden hair lichen Teloschistes flavicans • Scaly cricket Pseudomogoplistes vicentae	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
		• Red-billed chough	Disturbance	**No** - Appendix B indicates that disturbance is predicted to be limited within a few hundred metres of foraging birds. During the most sensitive season (breeding) birds

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
				stay within 100-300m of nests. Therefore, given the distance of the site it is unlikely that birds will be disturbed.
		• Grey seal	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists otter as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
Skokholm SSSI 0297	3.15	• Manx shearwater • Atlantic puffin • Atlantic storm petrel • Razorbill • Guillemot • Lesser-black backed gull • Fulmar • Herring gull • Greater black-backed gull	Disturbance	**Screened out -** Site is within Skomer, Skokholm and the seas off Pembrokeshire /Sgomer, Sgogwm a moroedd Penfro SPA which lists the bird species as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SPA.
		• Grey seal	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists grey seal as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
Grassholm / Ynys Gwales SSSI 0594	8.55	• Gannet Morus bassanus	Disturbance	**Screened out -** Site is within Grassholm SPA which lists gannet as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SPA.
		• Grey seal	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists grey seal as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
		• Intertidal communities	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
Skomer Island and Middleholm SSSI 0953	6.83	Breeding birds: • Manx shearwater, • Atlantic puffin • Atlantic storm petrel • Razorbill • Guillemot • Lesser black-backed gull • Kittiwake • Red-billed chough	Disturbance	**Screened out -** Site is within Skomer, Skokholm and the seas off Pembrokeshire /Sgomer, Sgogwm a moroedd Penfro SPA which lists the bird species as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SPA.
		• Grey seal	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists grey seal as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
		• Short-eared owl • Reef communities • Sea caves • Skomer vole Clethrionomys glareolus skomerensis • Rare and scare plants and lichens • Maritime grassland and cliff crevice communities	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
Marloes Mere SSSI 0464	6.82	• Scare plant and insect communities and wintering wildfowl	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.

Site Name & Code	Distance	Qualifying feature	Potential Pressure	Likelihood of interaction
De Porth Sain Ffraid / St Bride's Bay South SSSI 0342	7.66	• Rocky and sandy shore communities • Ancient sessile oak woodland • Geology	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
		• Grey seal	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists grey seal as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
Stackpole SSSI 0024	9.08	• Rocky and sandy shores • Limestone sea cliffs • Wooded valleys • Rare plant and invertebrate species	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.
		• Red-billed chough • Breeding seabirds (kittiwake, razorbill, guillemot, Atlantic puffin, fulmar)	Disturbance	**No -** Site is outside of zone of influence for disturbance for breeding birds. Although individuals may be use the Proposed Development for feeding and loafing there is sufficient available habitat in the wider region for birds which are briefly displaced by the presence of vessels.
		• Otter	Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists otter as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
Skomer MCZ	7.55	• Grey seal	Underwater noise changes / Disturbance	**Screened out -** Site is within Pembrokeshire Marine / Sir Benfro Forol SAC which lists grey seal as a Qualifying Feature. The assessment for this feature has therefore been undertaken within the screening for the SAC.
		• Pink seafan • Sponge communities • Eelgrass • Algal communities	No pressure-receptor pathway identified	**Screened out** as Proposed Development will not interact with these features.

4.3 Assessment of Likely Significant Effects (LSE)

A likely effect is defined as one that cannot be ruled out on the basis of objective information. The test is a 'likelihood' of effects rather than a 'certainty' of effects. Where the Proposed Development is likely to undermine the site's conservation objectives, it must be considered likely to have a significant effect on the site. The assessment of that risk must be made in light, amongst other things, of the characteristics and specific environmental conditions of the site concerned. If the screening presented in Table 4-3 or Table 4-4 identified that an interaction between the Proposed Development and the Qualifying Feature(s) is possible, the potential for a likely significant effect (LSE) on the conservation objectives has been considered in the sections below.

To support the assessment, two Appendices have been provided. Appendix A presents the findings of an underwater noise assessment conducted on the Proposed Development's activities; and Appendix B provides information to support the assessment of red-billed chough.

4.3.1 Pembrokeshire Marine / Sir Benfro Forol SAC

The Proposed Development crosses this site from KP0 to approximately KP50. The SAC covers an area of 1380.69km^2. Primary and Qualifying Features are outlined in Table 4-3.

4.3.1.1 Conservation objectives

Habitats

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status.

- Range - The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing.
- Structure and function - The physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include; geology; sedimentology; geomorphology; hydrography and meteorology; water and sediment chemistry; and biological interactions.
- Species - The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include: species richness; population structure and dynamics; physiological health; reproductive capacity; recruitment; mobility; and range.

Species

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives

are not met restoration measures will be needed to achieve favourable conservation status.

- Populations - The population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements include: population size; structure, production; condition of the species within the site.
- As part of this objective it should be noted that for otter and grey seal contaminant burdens derived from human activity are below levels that may cause physiological damage, or immune or reproductive suppression.
- For grey seal and otter, populations should not be reduced as a consequence of human activity.
- Range - The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future.
- As part of this objective it should be noted that for otter and grey seal:
    - Their range within the SAC and adjacent inter-connected areas is not constrained or hindered.
    - There are appropriate and sufficient food resources within the SAC and beyond.
    - The sites and amount of supporting habitat used by these species are accessible and their extent and quality is stable or increasing
- Supporting habitats and species - The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include; distribution; extent; structure; function and quality of habitat; and prey availability and quality.

4.3.1.2 Assessment against conservation objectives – Reefs

Screening identified a possible pressure-receptor pathway for the pressures 'penetration and/or disturbance including abrasion' and 'physical change (to another seabed type)'.

The seabed within the direct zone of influence of the installation will be temporarily disturbed. The actual cable installation is a one-off event, but the seabed along the cable centreline could be disturbed on two to three discrete occasions within approximately a three month period. The first occasion will be for any seabed preparation works e.g. boulder clearance, pre-sweeping; the second occasion will be the pre-lay grapnel run; and the third occasion will be the cable lay and burial or deposit of external cable protection. These activities will be within the same zone of influence. When assessing the significance of the effect the assessment has considered the culmination of these activities.

Cable installation is an intrusive activity involving burying the cable in the seabed. Although the footprint of the disturbance is relatively small (15m ~~20m~~ wide) the Proposed Development crosses reef sub-types: Bedrock Reef; Stony Reef; and Biogenic Reef.

Stony Reef and Bedrock Reef can be of high environmental value, as they may contain more delicate species such as rugose squat lobsters, ascidians and sponges that take longer to re-colonise hard substrata and grow to adult size. Recoverability of such habitats is expected to take longer, and therefore the overall magnitude of effect from cable installation could be higher in Reef habitat.

Although much of the Bedrock Reef within the Proposed Development can be avoided through careful routeing, there are small sections (totalling 170m in length) where the outcropping rock could be crossed, and external cable protection may be required.

In addition, medium grade Stony Reef has been identified between KP15 and KP23. It may be possible to bury the cables in this area, but some boulder clearance may be required. Where this is needed large cobbles and boulders would be pushed to either side of the centreline. However, it has also been identified that burial in seabed may not be feasible in this 8km section and external cable protection would be required. There are also small areas of biogenic reef habitat where either cable burial will be required or if sediments are not suitable for burial external cable protection may be required.

Although the potential effects are highly localised, abrasion is likely to have short-term effects on the species inhabiting the Reef habitat. This Reef is high in diversity and predominantly dominated by ascidians and hydrozoans. Other taxa identified include poriferans and bryozoans. There is also the potential that the use of external cable protection will reduce the range (extent) of the habitat within the site.

The assessment concludes that there is the potential for a likely significant effect.

Screening Conclusion: Potential for LSE. Appropriate Assessment is required.

4.3.1.3 Assessment against conservation objectives - Sandbanks which are slightly covered by sea water all the time

The Qualifying Feature is reported to cover 414.12km^2 of the SAC; of which the Turbot Bank covers approximately 19.10km^2.

The Proposed Development crosses the Turbot Bank for approximately 5km between KP5 and KP10. The cable route survey identified that two habitat classifications are present within the Proposed Development on this Qualifying Feature; A5.25 Circalittoral fine sand; and A5.44 Circalittoral mixed sediment. The habitats contain various species of infauna, such as the molluscs *Goodallia triangularis, Asbjornsenia pygmaea, A. prismatica, T. ovata, Kurtiella bidentata* and the polychaete *Nephtys*

cirrosa, *O. borealis*, *Lumbrineris cingulate*, *Glycinde nordmanni* and different amphipods which may be affected by seabed disturbance.

Burial in seabed will be achievable in this area without the need for pre-sweeping or external cable protection.

The Turbot Bank is exposed to wave action, suggesting that epifauna and infauna present will be characteristic of moderately strong tidal currents, and given the dominance of sand and coarse sediments, can be viewed as adaptable to physical disturbance. Many infaunal species may live at depths where they will be protected from surface disturbance and in areas where direct loss occurs, it is likely that adjacent areas will act to replenish communities rapidly as most infaunal species are mobile and the zone of influence is narrow. Bivalves are likely to take longer than polychaetes to re-colonise areas but even considering this it is unlikely to exceed months (MarLIN 2019).

The zone of influence of the installation (15m) represents a very small area (0.075km^2) when compared to the extent of the habitat in the site. The Proposed Development will temporarily affect 0.39% of the Turbot Bank and 0.09% of the wider Qualifying Feature. However, it will not change the physical characteristics of the seabed, meaning that once installation activities have ceased the seabed will still be suitable for recolonization from the surrounding area. As the range, structure, function and species of the habitat will not be affected other than temporarily there will be no likely significant effects on the conservation objectives.

Screening conclusion: No potential for LSE. AA is not required

4.3.1.4 Assessment against conservation objectives – Mudflats and sandflats not covered by seawater at low tide

The presence of external cable protection in the offshore region may cause very localised changes in water flows. This in turn could cause localised scour. Scour will only occur in areas of sediment where bottom current either already exceeds the critical bedload parting velocity, or where external cable protection results in an increase in current velocity to above the critical bedload parting velocity. Given that current speeds within the Proposed Development are relatively low, particularly near the seabed due to frictional effect, high scour is unlikely to be a significant issue.

The description of this pressure also includes sediment transport considerations e.g. whether the installation of the rock berms could affect transport of sediment to and from the beach at Freshwater West.

Depth of closure is an important concept used in coastal engineering. The depth of closure is a theoretical depth along a beach profile where sediment transport is very small or non-existent (USACE 2019), or basically the furthest distance offshore at which there is no significant sediment transport between the nearshore and offshore. Depth of closure has been conservatively estimated, using a mean significance wave

height of 1.63m, as 14.5m below lowest astronomical tide for Freshwater West. Beyond this depth, there will be theoretically little effect on beach processes.

This calculation was based on the simplified Hallermeier approach. In discussion with NRW TE, it was agreed that the inner and outer depth of closure should be re-calculated based on the more detailed Hallermeier (1978) approach and the US Army Corps of Engineers (Brutsché et al. 2015) approach, respectively, to provide assurance that the depth of closure provided was representative of high waves and longer wave periods.

The calculations are provided in document CML1929 – Response to Second Phase of Consultee Comments (Intertek reference: P1975_R5130_Rev0). They conclude that the inner depth of closure is 16.2m and the outer depth of closure is 18.5m. These calculations account for significant wave height, wave periods and, for the outer dept of closure, sediment type.

The shallowest point of the rock in the vicinity of the proposed external cable protection locations at KP2.38 is approximately 22.1m below LAT; and therefore below the inner and outer closure depths.

It is concluded that there will be no effects on sediment transport pathways at Freshwater West.

Screening conclusion: No potential for LSE. AA is not required

4.3.1.5 Assessment against conservation objectives – Grey seal

The site overlaps between mean low water (MLW) and MHWS with the following SSSIs and MCZ which list grey seal as a Qualifying Feature. The below assessment therefore also applies to these sites.

- Castlemartin Range SSSI
- Dale and South Marloes Coast SSSI
- Grassholm / Ynys Gwales SSSI
- Skomer Island and Middleholm SSSI
- De Porth Sain Ffraid / St Bride's Bay SSSI
- Skomer MCZ

Table 4-1 identified that there is a possible pressure-receptor pathway between grey seal and activities which generate underwater noise.

The underwater noise assessment provided in Appendix A, concluded that:

- Continuous noise generated by vessels and cable installation will not injure grey seal. Grey seal may be subject to disturbance within 19km.
- Geophysical survey will generate noise levels sufficient to temporarily injure grey seal within 11m, and may disturb animals within 756m, of the sound source.

- If UXO disposal is required, there is the potential for grey seal within 6.2km of the UXO location to be injured and the onset of temporary behavioural disturbance within 40km.

Grey seal densities in the water within the Proposed Development are estimated to be approximately 0.4 individuals per km^2 [1] (Jones et al. 2013).

Animals within the SAC are part of the South and West England and Wales Management Unit. They are not thought to form a discrete population within the SAC but are part of the wider SW Wales population. This population extends to SW England and SE Ireland. The SW Wales population is approximately 5000 individuals. They range throughout the open coast areas of the site and predominantly confined to a few favoured locations (e.g. Stack Rock). The closest haul-out is Linney Head[2], approximately 3.5km south of the Proposed Development.

Continuous noise

Modelling suggests that animals could only be exposed to injurious effects within 2m of the installation vessels. However, to put this into context the threshold for onset of injurious effects assumes that the animal must be present within the area for 24-hours for the noise to cause effects. It is implausible that animals will stay within 2m of the installation vessels for 24-hours and therefore it is concluded that there is no risk of the installation causing injurious effects.

With respect to disturbance effects, the large zone of influence (19km for DP vessel noise) suggests that behavioural impacts to grey seal from project-related vessel noise can be expected. However, disturbance effects will be temporary as vessels will transit through the SAC rather than remain in one location; will not be severe; and will not be biologically significant.

The activities that will generate continuous noise are rock placement, cable trenching and vessel engines/thrusters. Rock placement will not be a continuous activity over 24-hours. If rock berm is required for external cable protection (due to ground conditions preventing burial in seabed) within the SAC it is possible that rock placement activities would take a couple of days. However, it is likely the actual deposition would be sporadic rather than continuous, with breaks in the activity as vessel(s) would require re-loading and positioning. Cable trenching and vessel engines will be a continuous source, but activity will progress through the SAC. According to the Navigation Risk Assessment cable lay is anticipated to progress at approximately 230m/hr; equivalent to 5.5km/day. The cable lay is therefore anticipated to take 5 days within the SAC. Project vessels will be present for longer e.g. carrying out survey, route preparation or cable pull-in, but this will not be consistent activity over long periods.

It is important to place the results for disturbance effects in the context of the baseline noise environment. The background noise levels in the region are likely to

[1] Estimated upper 95% confidence interval of total estimated usage of grey seal around the UK. Average number of seals is up to 10 per 5x5km grid in the region of the Proposed Development.
[2] http://pembrokeshiremarinesac.org.uk/english/special/seal_c.htm

be in range of 91 to 127 db re 1 µPa (rms) due to the presence of other vessels and natural source levels. It is important to note that the exceedance of the threshold for the onset of disturbance does not mean that disturbance will occur. It is also worth noting that the activities and noise sources modelled are temporary and transitory. The cable installation will progress along the centreline, with the zone of influence constantly moving. Animals may actively avoid the area for a short period of time but will return once the vessels have passed through.

Screening conclusion: No potential for LSE. AA is not required.

Impulsive noise – Geophysical survey

Grey seal in water are vulnerable to sound generated by the geophysical survey. For geophysical survey it is best practice to follow the JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys' (JNCC 2017a). Adherence to the guidelines constitutes best practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels. Adherence to the guidelines has been incorporated into the Proposed Development as embedded mitigation EM20.

The underwater noise changes associated with a geophysical survey and therefore the associated potential for disturbance is generally acknowledged as small when compared to activity such as use of air guns during 2D and 3D seismic and wind farm piling (BEIS 2018). It is possible that a geophysical survey will be undertaken ahead of installation, with further inspection surveys completed every 3-5 years post-installation.

For all distances calculated for injurious effects (PTS and TTS) animals will be able to move away from the area where injurious noise levels could be experienced, within seconds; avoiding all injurious effects. With respect to disturbance effects, animals will be able to swim out of the 756m zone of influence in under 5 minutes; assuming a swim speed of 2.7m/s (6 miles per hour, Oceanwide Expeditions 2020). Based on this, animals present within the ZOI will temporarily be disturbed by the geophysical survey. However, considering the spatially limited zone of influence and temporary nature of the geophysical survey, animals will be able to return to the area immediately after geophysical survey has ceased and the effect is therefore not significant.

The proposed activities will be restricted in duration and will progress slowly along the cable centreline through the Proposed Development, with the zone of influence constantly moving. Assuming an average survey speed of 3.6km/hour the 50km route length within the SAC would be surveyed in approximately 14 hours. During the 14 hour period approximately 75.6km^2 of the SAC will experience a brief increase in underwater noise; equivalent to 5.5% of the site.

Animals may actively avoid the activity, but will return to the area once the vessels have passed through. The Proposed Development will not reduce the population, hinder the range (other than briefly) or effect the supporting habitats and species that grey seal rely on.

Screening conclusion: No potential for LSE. AA is not required.

Impulsive noise – UXO deflagration (if required)

It is unknown how many, if any, UXO detonations will be required within the Proposed Development. The Proposed Development passes through the Castlemartin Firing Range, so it is plausible that UXO will be encountered.

Should UXO be found which require clearance by detonation there will be a relatively large release of impulsive sound energy, creating high amplitude shock waves (von Benda-Beckmann et al. 2015). The precise injury effect range cannot be stated in advance of information on the nature and quantity of explosive material potentially involved, which will not be known until a UXO is identified.

Underwater noise modelling of a UXO detonation or deflagration has been undertaken based on certain assumptions. Provided as Appendix A to this HRA (Revision 3) it concludes the level of risk depends on the size, location and season of the deflagration / detonation. In all scenarios modelled, there is the risk that without mitigation there could be significant effects to grey seal from blast injury, auditory injury and temporary auditory disturbance.

As animals could be physically injured, and the application of mitigation cannot be considered at this stage of the HRA process it is concluded that there is the potential for a LSE on the population structure, and Appropriate Assessment is required.

Screening Conclusion for UXO detonation: Potential for LSE / AA is required.

4.3.1.6 Assessment against conservation objectives – Otter

The site overlaps between MLW and MHWS with Stackpole SSSI and Milford Haven Waterway SSSI which list otter as a Qualifying Feature.

Otter are known to use a narrow zone close to shore (<100m) for foraging. The known locations of otter at Freshwater West are to the south of the Proposed Development. Significant numbers are not expected to use the waters of the Proposed Development. Any disturbance of otter will be localised, temporary and minor in nature.

Screening conclusion: No potential for LSE / AA is not required

4.3.1.7 Assessment against conservation objectives – Allis shad and Twaite shad

Table 4-1 identified there is a possible pressure-receptor pathway between shad and activities which generate underwater noise. An underwater noise assessment provided in Appendix A, concluded that:

- As hearing specialist fish, twaite shad and allis shad (members of the clupeid family) individuals are sensitive to underwater noise changes.
- There is no direct evidence of permanent injury to fish species from shipping and other continuous noise (such as cable installation).

- Geophysical survey could cause noise levels sufficient to cause temporary injury within 586m of the noise source.
- If required, UXO deflagration, could generate noise levels sufficient to cause a temporary threshold shift within 1.8km of the disposal location.

Continuous noise

Modelling has indicated that noise levels sufficient to cause recoverable injury in hearing sensitive fish species may be experienced within 99m of Installation vessels. However, this assumes that the animal will spend 24-hours within this zone of influence. This is highly implausible given that fish are mobile species and the installation vessels will be continually moving. Therefore, the risk of injurious effects from continuous noise sources in negligible.

Screening conclusion: No potential for LSE / AA is not required

Impulsive noise – geophysical survey

For geophysical works, modelling has indicated that fish may be exposed to noise levels sufficient to cause temporary injury within 586m of the survey vessel. However, the potential zone of influence is transient as it moves slowly in a constant direction along the principal survey line orientation. It is expected that fish will avoid the area once operations have started and are extremely unlikely to move towards the sound source.

The works will not lead to any long-term displacements as they are transient and temporary. Individuals would be expected to be able to return once the operation had passed through. However, it should be noted that the ability of small fish to take avoiding action may be limited, and temporary displacement may not therefore occur.

Temporary displacement of mobile species in the marine environment is not expected to result in significant adverse effects for the individuals concerned unless it interferes with a critical lifecycle activity such as spawning. The Proposed Development is not a spawning ground for Allis or Twaite Shad. However, juvenile shad are known to forage in the nearshore environment, so some interaction may be possible.

Any disturbance effects from noise associated with operations will be localised, temporary and transient. There will be no effect on the distribution of the species. In addition, the Proposed Development will not effect the population structure, range (spawning extent or habitat extent) or structure of supporting habitats and prey species. Considering the extent of inshore habitat available the likely effect on shad has been assessed as not significant.

Screening conclusion: No potential for LSE / AA is not required

Impulsive noise – UXO deflagration (if required)

It is unknown how many, if any, UXO deflagrations will be required within the Proposed Development. The Proposed Development passes through the Castlemartin Firing Range, so it is plausible that UXO will be encountered.

In line with embedded mitigation EM21 a decision-making process will be followed for any potential UXO whereby the target is first avoided, then removed and if neither previous option is feasible, deflagration is undertaken.

Should UXO be found which require clearance by deflagration it is assumed that there would be a relatively large release of impulsive sound energy, creating high amplitude shock waves (von Benda-Beckmann et al. 2015).

Twaite shad are likely to be sensitive to such disturbance. However, the explosion will be brief, with the shock waves attenuating rapidly in the water column, thus resulting in a restricted lethal zone (Continental Shelf Associates, Inc 2004). Although there is the potential that individuals will be killed the activity, if required, is unlikely to affect the viability of the population. It will not affect the range or supporting habitats and species.

Screening conclusion: No potential for LSE / AA is not required

4.3.2 Skomer, Skokholm and the seas off Pembrokeshire / Sgomer, Sgogwm a moroedd Benfro SPA

The Proposed Development crosses this site between KP13 and KP23 and between KP31 to KP43.5. It then runs adjacent to the site boundary until KP55. The SAC covers an area of 1,668km^2. Component SSSIs include Skokholm SSSI and Skomer Island and Middleholm SSSI.

4.3.2.1 Conservation objectives

The protected features covered by the conservation objectives are the qualifying marine species of the SPA: breeding populations of storm petrel, lesser black-backed gull, Manx shearwater, and Atlantic puffin as well as the breeding seabird assemblage. For each of these features there are four conservation objectives:

- The size of the population should be stable or increasing, allowing for natural variability, and sustainable in the long term.
- The distribution of the population should be being maintained, or where appropriate increasing.
- There should be sufficient habitat, of sufficient quality, to support the population in the long term.
- Factors affecting the population or its habitat should be under appropriate control".

4.3.2.2 Assessment against conservation objectives

The islands of Skomer and Skokholm support the largest concentrations of breeding seabirds in England and Wales; the breeding seabird assemblage totals over 394,000

birds. The islands support the largest breeding colony of Manx shearwater in the world (316,000 pairs) and one of the largest colonies of lesser-black-backed gull in Britain (over 10,000 occupied nests).

The SPA boundary includes waters vital for essential ecological requirements (preening, bathing, displaying, loafing/ resting at sea) for Manx shearwater and Atlantic puffin (as individually qualifying features) as well as common guillemot and razorbill (as component species of the seabird assemblage).

To set the boundaries for the SPA, JNCC undertook analysis of seabird densities to identify concentrations or 'hotspots' of birds offshore. Density maps presented in NRW (2015) show important foraging areas for Manx shearwater and Atlantic puffin. During design (routeing) of the Proposed Development, the position of the SPA boundary was taken into consideration and the length of cable route within the site boundary was minimized where possible. Figure 4-3 (Drawing P1975-BIRD-001) below shows starting from Freshwater West the Proposed Development initially follows the bottom boundary of the northern section of the SPA which is identified as important for Atlantic puffin. The Proposed Development then takes the shortest route through the larger area identified as important for Manx shearwater before the route continues just above the northern boundary of the SPA.



Table 4-1 identified that there is the potential pressure-receptor pathway for the pressure disturbance. Disturbance is predicted to be limited to that initiated by the movement of the project vessels. Birds may take evasive action, but a single disturbance event does not have any immediate effect on the survival or productivity of an individual bird. Repeated disturbance, or disturbance over an extended period, can however affect survival and productivity.

The Proposed Development passes >2km south of the islands of Skokholm and Skomer (i.e. outside of the zone of influence for disturbance). It is therefore unlikely that nesting birds will be disturbed by the presence of the project vessels should any activities temporally overlap with the breeding season. Therefore, the discussion below focuses on the effects of displacement.

Atlantic Puffin

Puffin arrive at breeding colonies in March and April and leave again by the beginning of August. Sensitivity to displacement differs considerably between seabird species. The Joint SNBC Interim Displacement Advice Notice (JNCC 2017b) provides a scoring system to help assist in the assessment of species, susceptibility to disturbance by windfarm structures, ship and helicopter traffic. This metric gives an indication of which species are expected to be most susceptible to displacement effects. As a general guide any species scoring 3 or more should be considered further. Atlantic puffin has a score of 2 for disturbance susceptibility which suggests it is unlikely to

be sufficiently disturbed by the presence of the vessel to be displaced for a significant period.

In addition, shipping activity along the Proposed Development is expected to be moderate due to the presence of shipping routes to Milford Haven, and the presence of a traffic separation zone to the north of the Proposed Development through which ships transit in and out of the Irish Sea. Against this level of activity, the introduction of the project vessel(s) is unlikely to have any significant effect. Any disturbance caused by the project will be temporary in nature and limited in extent. Given the Proposed Development is at the southern limit of the area important for puffin, any disturbance is likely to be not significant. The project vessels will move continuously through the Proposed Development and therefore their presence in any one location will be brief allowing any disturbed birds to return within a short period of time.



Manx shearwater

Manx shearwater score 1 for disturbance susceptibility and therefore would not normally require further assessment. However as Manx shearwater is a qualifying feature of the 4km marine extension around Skomer and Skokholm they are considered further here.

During the breeding season (April to August) prior to dusk, adult Manx shearwaters assemble in flocks or 'rafts' on the surface of the sea 1-10 km from the colony. When darkness falls, these 'rafting' birds, of up to 10,000 individuals in some locations, fly to their burrows to feed their chicks (McSorley et al. 2008). Radio-telemetry tracking of breeding Manx shearwater was undertaken at Skomer island from May to August in 2003 (McSorley et al. 2008). The results of the tracking indicated that overall the birds formed rafts most often to the north of the island and no rafts were formed before 19:00. Birds moved significantly closer to the colony as the evening progressed.

Figure 4-3 (Drawing P1975-BIRD-001) shows the locations of rafting Manx shearwater from the 2003 tracking data in relation to the proposed cable corridor. The closest rafting Manx shearwater were located at least 5.96km to the north of the Proposed Development. Should rafting Manx shearwater be present within the vicinity of the Proposed Development during cable installation, any disturbance will take place within the context of existing sources of disturbance, such as commercial shipping, commercial fishing and recreational vessels in the area. Figure 4-3 shows that there are high densities of shipping present along the Proposed Development, south of Skokholm island within the SPA. It is therefore likely that the Manx shearwater will be habituated to vessel noise, lights and physical presence and the addition of the project vessel(s) is unlikely to be noticeable against natural variation in shipping levels.

The magnitude of the effect will depend on the degree of disturbance. The most disruptive activities are those that are sudden, noisy or fast. As such, helicopters and speedboats usually cause the greatest disturbance (Natural England and Suffolk Coast and Heaths 2012). Vessels travelling at faster speeds cause a greater level of disturbance in terms of the proportion of birds flushing and at further distances (Bellefleur et al. 2009; Ronconi and St Clair 2002). The project vessels will be slow moving, only between 100 – 300 m / hour, which is slower than walking speed (generally assumed to be 5 km / hour). At such slow speeds, the vessels are effectively stationary in terms of bird displacement. Studies have shown that slow moving vessels cause little disturbance to birds and birds may habituate to frequent and relatively benign events and noises (Hill et al. 1997). It is therefore concluded that any disturbance will be temporary and localised and will not result in any likely significant effects on Manx shearwater.

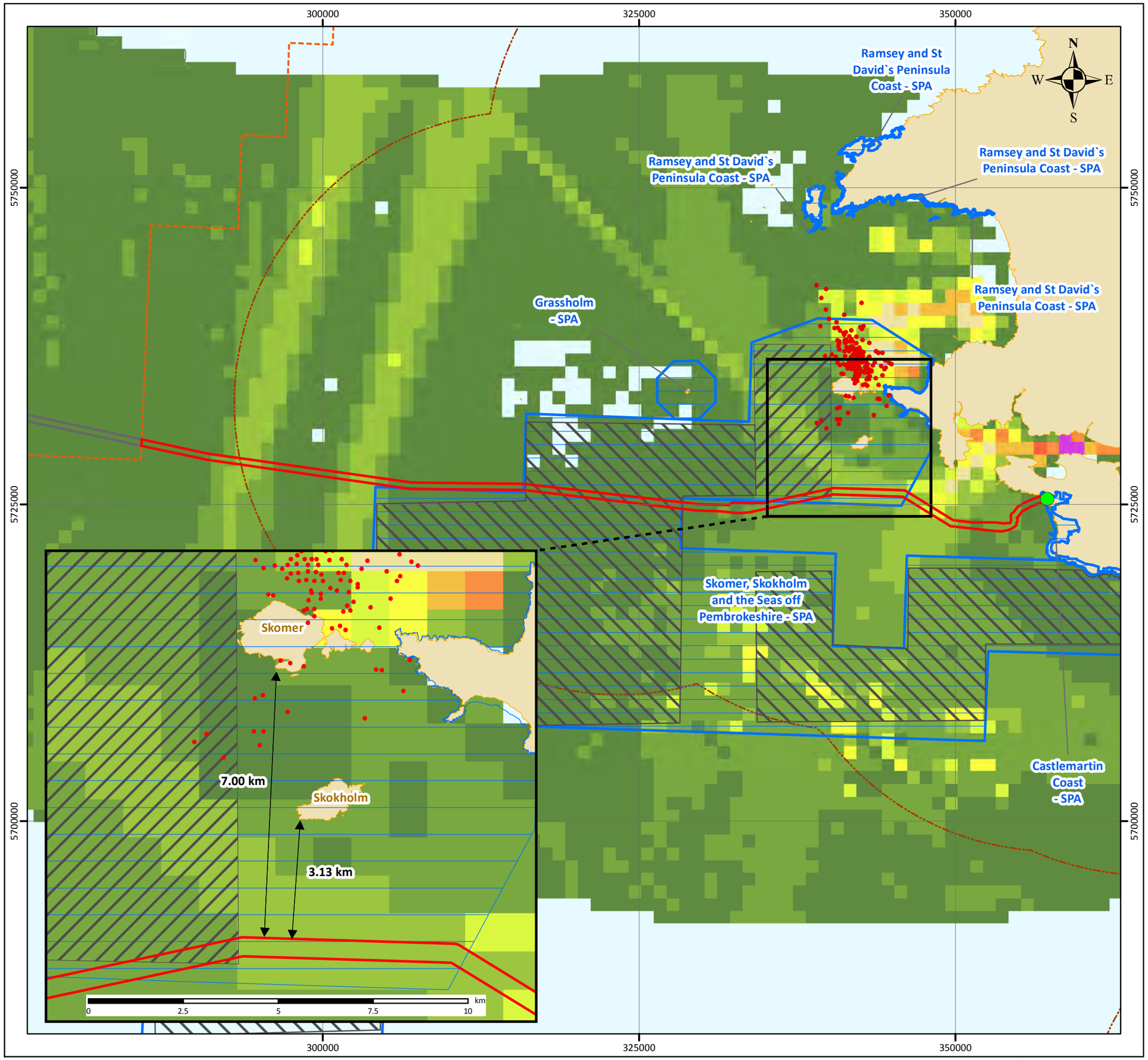
Screening conclusion: No potential for LSE / AA is not required

GREENLINK INTERCONNECTOR

BIRD ACTIVITY

Locations of Rafting Manx Shearwater (after McSorley et al 2008) in Relation to the Proposed Development and Existing Shipping Activity

Drawing No: P1975-BIRD-001	A



Legend

- Manx Shearwater Rafting Location
- Freshwater West
- Proposed Development
- Irish Offshore
- UK 12nm Territorial Sea Limit
- Median Line

Protected Site

- SPA
- Important Area - Atlantic Puffic
- Important Area - Manx Shearwater



NOTE: Not to be used for Navigation

Date	Wednesday, May 8, 2019 08:12:04
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	UKHO; CDA; OSOD; JNCC; Ocenaeering; Greenlink; Intertek
File Reference	J:\P1975\Mxd\13_BIRD\ P1975-BIRD-001.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Co-financed by the European Union Connecting Europe Facility

0 2.5 5 7.5 10 km

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4.3.3 West Wales Marine / Gorllewin Cymru Forol SAC

The Proposed Development crosses this site from KP0 to KP37. The SAC covers an area of 7,376km^2.

4.3.3.1 Conservation objectives

To avoid deterioration of the habitats of harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status (FCS) for the UK harbour porpoise.

- To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:
- The species is a viable component of the site.
- There is no significant disturbance of the species.
- The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

4.3.3.2 Assessment against conservation objectives

Marine cable installation, operation and decommissioning will generate underwater sound from a number of sources:

- Continuous sound sources e.g. vessel movements, cable laying, rock placement, geophysical survey; and
- Impulsive sound sources e.g. UXO detonation (if required).

The Conservation Objectives and Advice on Operations published by the JNCC (2019) for the SAC suggests…

"noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoises from more than

1. 20% of the relevant area of the site in any given day, and

2. An average of 10% of the relevant area of the site over a season."

An underwater noise assessment presented in Appendix A, considers the potential for injury and disturbance from the Proposed Development. It concludes:

Continuous sound – cable installation

The frequency of sound generated by DP vessels and cable trenching is outside of the sensitivity range of harbour porpoise. Therefore, it is unlikely that the species will experience any hearing loss or disturbance from these activities.

Modelling, presented in Appendix A, concluded that rock placement has the potential to cause injurious effects if animals are within 210m of the activity for 24-hours. Assuming a swim speed of 1.5m/s (Otani et al. 2000, Lepper et al. 2012) harbour porpoise will be able to move away from the zone of influence in under 3 minutes.

This is a conservative estimate as there is data (Kastelein et al. 2018) to suggest that animals will flee at much higher speeds (1.9m/s) at least initially. Therefore, the risk of actual injurious effects from any of the continuous noise sources is negligible.

With respect to disturbance effects, behavioural effects from continuous noise can be expected but would not be extensive or severe. Short-term responses such as behaviour disruptions to localised groups or individuals (e.g. animals moving away from vessels), and temporary disruption of communication or echolocation from auditory masking could be expected. This is more likely to be observed within 8km of the vessel engaged in rock placement; although it should be noted that animals will have to be within 8km of the rock placement activity for 24-hours for the onset of significant disturbance effects. Rock placement will not be a continuous activity over 24-hours. If rock berm is required for external cable protection (due to ground conditions preventing burial in seabed) within the SAC it is possible that rock placement activities would take a couple of days. However, it is likely the actual deposition would be sporadic rather than continuous, with breaks in the activity as vessel(s) would require re-loading and positioning.

It is important to place the results for disturbance effects in the context of the baseline noise environment. The background noise levels in the region are likely to be in range of 91 to 127 dB re 1 µPa (rms)[3] due to natural sources such as breaking waves, rain and marine life, and anthropogenic noise such as shipping. It is important to note that the exceedance of the threshold for the onset of disturbance does not mean that disturbance will occur. It is also worth noting that the activities and noise sources modelled are temporary and transitory.

In conclusion, there will be temporary disturbance to harbour porpoise but it will not be significant under the criteria set out in the conservation objectives and therefore Appropriate Assessment is not required.

Screening Conclusion for continuous sound: No potential for LSE / AA is not required

Impulsive sound - geophysical survey

Harbour porpoise (high-frequency cetacean) are vulnerable to sound generated by the multi-beam echosounder, sidescan sonar and sub-bottom profilers with the largest zone of influence being from the multibeam echosounder. Permanent injury could occur within 36m and temporary injury within 85m of the multi-beam echosounder.

For geophysical survey it is best practice to follow the JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys' (JNCC 2017a). Adherence to the guidelines constitutes best practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels. Adherence to the guidelines has been incorporated into the Proposed Development as embedded mitigation EM20.

[3] See Greenlink Marine ES Technical Appendix D revision F2 - Section 1.2.1.

Disturbance could occur up to 756m radial distance (1.8km^2) from the survey vessel. Evidence of the effects of geophysical surveys on cetaceans is limited but BEIS (2018) summarises the results of a study carried out in the Moray Firth. It observed responses to a 10-day 2D seismic survey which exposed a 200km^2 area to noise throughout that period. A relative decrease in density of harbour porpoise within 10km of the survey vessel was reported, but effects were brief with animals returning to the area within 19 hours of cessation of activities.

The underwater sound changes associated with the geophysical survey, and therefore the associated potential for disturbance is generally acknowledged to be lower when compared to an activity such as use of air guns during 2D and 3D seismic and wind farm piling. Animals will have sufficient time to avoid the survey vessels, and it is unlikely that they will swim over operating equipment.

The proposed activities will be restricted in duration and will progress slowly through the Proposed Development, with the zone of influence constantly moving. Assuming an average survey speed of 3.6km/hour the 37km route length within the SAC would be surveyed in approximately 10.5 hours. During the 10.5 hour period approximately 55.9km^2 of the site would experience a brief increase in underwater noise; equivalent to 0.8% of the site. Animals may actively avoid the activity but will return to the area once the vessels have passed through. The Proposed Development will therefore not act as a barrier to movement or cause significant short or long-term disturbance.

Screening Conclusion for geophysical survey: No potential for LSE / AA is not required

Impulsive sound – UXO deflagration (if required)

It is unknown how many, if any, UXO deflagration will be required within the Proposed Development. The Proposed Development passes through the Castlemartin Firing Range, so it is plausible that UXO will be encountered. The Greenlink UXO desk-based assessment (1st Line Defence 2018) also identified a high-risk area in the St Georges Channel; a former WWII sea mine ground. The area has previously been comprehensively searched and cleared by the Navy since WWII, but taking a precautionary approach, the potential remains for some UXO to be encountered. GIL has therefore applied for one UXO deflagration within Welsh waters, as a precaution; and the effect of this deflagration has been assessed.

Should UXO be found which require clearance by detonation it is assumed that there would be a relatively large release of impulsive sound energy, creating high amplitude shock waves (von Benda-Beckmann et al. 2015). The precise injury effect range cannot be stated in advance of information on the nature and quantity of explosive material potentially involved, which will not be known until a UXO is identified.

Underwater noise modelling of a UXO detonation or deflagration has been undertaken based on certain assumptions. Provided as Appendix A to this HRA (Revision 3) it concludes the level of risk depends on the size, location and season of the deflagration / detonation. In all scenarios modelled, there is the risk that without

mitigation there could be significant effects to harbour seal from blast injury, auditory injury and temporary auditory disturbance.

As animals could be physically injured, and the application of mitigation cannot be considered at this stage of the HRA process it is concluded that there is the potential for a LSE on the population structure. In addition, there is the potential that a deflagration / detonation would disturb an area that exceeds 20% of the SAC within a given day. Appropriate Assessment is required.

Screening Conclusion for UXO detonation: Potential for LSE / AA is required.

4.3.4 Castlemartin Coast SPA

The intertidal area of the Proposed Development form KP0 to approximately KP0.33 is within the site. The SPA covers an area of 11.22km^2 as a linear strip along the coastline. Component SSSIs include Broomhill Burrows and Castlemartin Cliffs and Dunes, Stackpole and Stackpole Quay.

4.3.4.1 Conservation objectives

The conservation vision for Red-billed chough is:

- A breeding chough population will occur along the limestone coast, between Freshwater West and Barafundle Bay.
- This population will be maintained at a minimum of 12 breeding pairs (representing 3.5% of the GB population, at the 1993 SPA designation level)
- Choughs will continue to, feed, roost and breed successfully, unhindered by human recreational activities (e.g. climbing).
- The majority of pairs will rear young each year, with an annual average productivity of at least two young per occupied territory.
- Choughs will continue to have access to large amounts of optimal feeding habitat (open areas with very short grassland and heath vegetation <1cm to <3cm in height) within all cliff-top management units and within dune grassland management units at Broomhill Burrows, Brownslade and Linney Burrows and on Stackpole Warren.
- Yellow ant-hills, an important summer food resource, will occur in coastal turf, throughout the SPA, at densities up to approximately 550 ant-hills per ha.
- A non-breeding chough population (variable in number between 10 and 50 birds) made up largely of juvenile and sub-adult birds will occur at any season.

4.3.4.2 Assessment against conservation objectives

Around 4% of the UK population of chough occur within the SPA. There is regular interchange of the chough from this site and those from the adjacent Angle Peninsula Coast SSSI. In addition a number of other SSSIs within close proximity to the Proposed Development also list chough as a Qualifying Feature.

Appendix B provides background information on the species and the surveys which have been undertaken by GIL to inform assessment of effects. This information has been used to draw the following conclusions:

- The only area that is likely to be utilised by chough is within the Wales Onshore component of Greenlink; the HDD compound above Freshwater West.
- Chough were not recorded during a breeding bird survey of the compound.
- The wintering bird survey results indicated that a maximum of four red-billed chough were observed in the compound area at any given time (assumed to be two pairs) which represents 8% of the wintering Castlemartin Coast SPA population (cited as 24 pairs).
- The preliminary Onshore HRA (Arup 2018) concluded that there would be no likely significant effects on red-billed chough taking into account the distance from individual territories, the limited area affected by the works in relation to the available feeding habitat, combined with the temporary nature of the cable installation works, the subsequent reinstatement of the construction area and maintenance of the existing land management regime post-installation.
- The two closest chough territories to the Proposed Development landfall site (Parsons Quarry Bay on the Angle Peninsula and Furzenips on Freshwater West) are both approximately 1.5km from the Proposed Development.
- During the most sensitive time (breeding season) chough are likely to spend most of their time foraging between 100m to 300m from the nest, over 1km from the Proposed Development.
- Most disturbance occurs when people come within 35m of foraging chough.

In conclusion, the Proposed Development will not disturb foraging chough given the distance to the closest chough territories.

Screening conclusion: No potential for LSE / AA is not required

4.3.5 Grassholm SPA

4.3.5.1 Conservation objectives

The Qualifying Feature is Gannet. The vision for the feature is for it to be in a favourable conservation status, where all of the following conditions are satisfied:

- The population will not fall below 30,000 pairs in three consecutive years.
- It will not drop by more than 25% of the previous year's figures in any one year.
- There will be no decline in this population significantly greater than any decline in the North Atlantic population as a whole (CCW 2008).

4.3.5.2 Assessment against conservation objectives

Disturbance is predicted to be limited to that initiated by the movement of the project vessels. Birds may take evasive action, but a single disturbance event does not have any immediate effect on the survival or productivity of an individual bird. Repeated disturbance, or disturbance over an extended period of time, can affect survival and productivity. Activities such as geophysical survey or cable installation will be discrete events, with the project vessel passing slowly through the Proposed Development following the cable centreline. Individual activities will typically be separated in time by a period of weeks, or months.

Gannet forage over large distances; Thaxter et al. (2012) estimate a maximum range of 590km during the breeding season. However, the Joint SNCB Interim Displacement Advice Note (2017) note that although their disturbance susceptibility score is 2, suggesting displacement is not of concern, there is empirical studies suggesting that they are sensitive to displacement. However, the Proposed Development will take place against moderate shipping activity in the region due to the presence of shipping routes to Milford Haven, and the presence of a traffic separation zone to the north of the Proposed Development through which ships transit in and out of the Irish Sea. Against this level of activity, the introduction of the project vessel(s) is unlikely to have any significant effect. Any disturbance caused by the Proposed Development will be temporary in nature and limited in extent.

In addition, the Proposed Development passes >8.5km south of the island of Grassholm (i.e. outside of the zone of influence for disturbance).

Screening Conclusion: No potential for LSE/ AA is not required

4.3.6 Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC

4.3.6.1 Conservation objectives

The conservation objectives for the SAC is:

To avoid deterioration of the habitat of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise.

To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:

1. The species is a viable component of the site.
2. There is no significant disturbance of the species.
3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

4.3.6.2 Assessment against conservation objectives

The SAC lies 20km to the south of the Proposed Development within the same management unit (Celtic and Irish Sea MU). It is therefore possible that harbour porpoise from the site may be observed in the Proposed Development.

Impulsive noise (geophysical survey) and continuous noise

The zone of influence of disturbance from geophysical survey is small (<1km) and therefore will not overlap with the SAC. For continuous noise sources, the noise from DP vessels and trenching is outside the sensitivity range of harbour porpoise and the risk of effects is negligible. It has been calculated that the threshold for the onset of disturbance from rock placement is exceeded at 8km from the Proposed Development and therefore will also not overlap with this SAC.

In conclusion, noise generated from cable installation and geophysical survey will not result in significant disturbance to harbour porpoise within the European site. In addition, noise generated from cable installation and survey operations will not affect harbour porpoise habitat or prey items and harbour porpoise will still be a viable component of these sites.

Screening Conclusion for geophysical survey & continuous noise: No potential for LSE / AA is not required

Impulsive noise - UXO deflagration

It is unknown how many, if any, UXO detonations will be required within the Proposed Development. The Proposed Development passes through the Castlemartin Firing Range, so it is plausible that UXO will be encountered.

Should UXO be found which require clearance by detonation there will be a relatively large release of impulsive sound energy, creating high amplitude shock waves (von Benda-Beckmann et al. 2015). The precise injury effect range cannot be stated in advance of information on the nature and quantity of explosive material potentially involved, which will not be known until a UXO is identified.

Underwater noise modelling of a UXO detonation or deflagration has been undertaken based on certain assumptions. Provided as Appendix A to this HRA (Revision 3) it concludes the level of risk depends on the size, location and season of the deflagration / detonation. However, it concludes that the onset of significant disturbance could be 40km from the UXO location. This zone would therefore overlap with the SAC and there is the potential that harbour porpoise within the SAC could be disturbed. The conservation objectives for the site (JNCC 2019) state that:

"Noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoises from more than:

1. 20% of the relevant area of the site in any given day, and

2. an average of 10% of the relevant area of the site over a season".

As there is the potential that disturbance from UXO detonation could affect more than 20% of the relevant area of the site in any given day AA is required.

Screening Conclusion for UXO detonation: Potential for LSE/ AA is required

4.3.7 North Anglesey Marine/ Gogledd Môn Forol SAC and North Channel SAC

4.3.7.1 Conservation objectives

The conservation objectives for the two sites are the same:

To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise.

To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:

1. The species is a viable component of the site.
2. There is no significant disturbance of the species.
3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

4.3.7.2 Assessment against conservation objectives

It is possible that harbour porpoise from these sites may be observed in the area given that the Proposed Development is in the same management unit as these sites (Celtic and Irish Sea MU).

North Anglesey Marine / Gogledd Môn Forol SAC and North Channel SAC are located 170km and 279km from the Proposed Development, respectively. The zone of influence of disturbance from geophysical survey is small (<1km) and therefore will not overlap with the European sites. For continuous noise sources, the noise from DP vessels and trenching is outside the sensitivity range of harbour porpoise and the risk of effects is negligible. It has been calculated that the threshold for the onset of disturbance from rock placement is exceeded at 8km from the Proposed Development and therefore will also not overlap with these European sites.

The zone of influence for UXO deflagration, whilst large (40km radial distance) will not overlap with the sites. Therefore there will no significant disturbance of the species within the SAC. Harbour porpoise will still remain a viable component of the site following detonation. In addition, the detonation would not significantly effect harbour porpoise habitat or prey items.

In conclusion, noise generated from the Proposed Development will not result in significant disturbance to harbour porpoise from the European sites, will not affect harbour porpoise habitat or prey items and harbour porpoise will still be a viable component of these sites.

Screening Conclusion: No potential for LSE/ AA is not required

4.3.8 Cardigan Bay / Bae Ceredigion SAC

4.3.8.1 Conservation objectives – grey seal and bottlenose dolphin

The conservation objectives for the sites are to achieve and maintain in the long-term favourable conservation status for the species features. With respect to grey seal and bottlenose dolphin this means:

- Populations:
  - The population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements include population size; structure, production; and condition of the species within the site;
  - Grey seal populations should not be reduced as a consequence of human activity;
- Range:
  - The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future;
  - Their range within the SAC and adjacent inter-connected areas is not constrained or hindered;
  - There are appropriate and sufficient food resources within the SAC and beyond; and
  - The sites and amount of supporting habitat used by these species are accessible and their extent and quality is stable or increasing.
- Supporting habitats and species: The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include distribution; extent; structure; function and quality of habitat; and prey availability and quality.

4.3.8.2 Assessment against conservation objectives – bottlenose dolphin

The initial screening (Table 4-3) concluded that there was a possible pressure-receptor pathway between the Proposed Development and the bottlenose dolphin Qualifying Feature of this site.

Bottlenose dolphin don't form a discrete site-based population within the SAC but are part of the wider Channel and SW England management unit. Dolphins associated with the Cardigan Bay SAC move into and through the Pen Llyn a'r Sarnau SAC. Bottlenose dolphin have been observed within the Proposed Development (at densities of 0.06 animals per km^2), and as the species is highly mobile it is possible that animals from the site might be present during the planned activities.

Bottlenose dolphin are classed as very high frequency cetaceans. The noise assessment presented in Appendix A concluded that the zone of influence of disturbance for very high frequency cetaceans is 8km for cable installation and <1km for geophysical survey. This European site is located 72km from the Proposed Development. Therefore, noise generated from cable installation and geophysical survey will not result in significant disturbance to bottlenose dolphin at this site. In addition, as there is no spatial overlap between the Proposed Development and the site, noise generated from cable installation and survey operations will not affect bottlenose dolphin habitat or prey items and bottlenose dolphin will still be a viable component of these sites.

If UXO deflagration ~~detonation~~ is required within the Proposed Development there is the potential that animals from the site could be present within the zone of influence for disturbance (40km radial distance). The disturbance will be a brief one-off event (less than a day) and will not overlap with the site boundary. The numbers of animals likely to be affected will be very small. Therefore, bottlenose dolphin will still remain a viable component of the site following deflagration. In addition, the deflagration would not significantly affect bottlenose dolphin habitat or prey items.

Screening Conclusion: No potential for LSE/ AA is not required

4.3.8.3 Assessment against conservation objectives - grey seal

Table 4-1 identified that there is a possible pressure-receptor pathway between grey seal and activities which generate underwater noise. This is because the Cardigan Bay / Bae Ceredigion SAC are located within the same management unit for grey seal (South and West England and Wales Management Unit). In addition, the Proposed Development is located within the foraging range of this species. It is therefore likely that these two SACs are connected. An underwater noise assessment provided in Appendix A, concluded that:

- Continuous noise generated by vessels and cable installation will not injure grey seal. Grey seal may be subject to disturbance within 19km.
- Geophysical survey will generate noise levels sufficient to temporarily injure grey seal within 11m, and may disturb animals within 756m, of the sound source.
- If UXO disposal is required, there is the potential for grey seal within 6.2km of the UXO location to be injured and the onset of temporary behavioural disturbance within 40km.

Grey seal densities in the water within the Proposed Development are estimated to be approximately 0.4 individuals per km^2 [1] (Jones et al. 2013).

Animals within the SAC are part of the South and West England and Wales Management Unit. They are not thought to form a discrete population within the SAC but are part of the wider SW Wales population. This population extends to SW England and SE Ireland. The SW Wales population is approximately 5000

[1] Estimated upper 95% confidence interval of total estimated usage of grey seal around the UK. Average number of seals is up to 10 per 5x5km grid in the region of the Proposed Development.

individuals. They range throughout the open coast areas of the site and predominantly confined to a few favoured locations (e.g. Stack Rock). The closest haul-out is Linney Head[2], approximately 3.5km south of the Proposed Development which is located outside of the Cardigan Bay SAC.

Continuous noise

Modelling suggests that animals could only be exposed to injurious effects within 2m of the installation vessels. However, to put this into context the threshold for onset of injurious effects assumes that the animal must be present within the area for 24-hours for the noise to cause effects. It is implausible that animals will stay within 2m of the installation vessels for 24-hours and therefore it is concluded that there is no risk of the installation causing injurious effects.

With respect to disturbance effects, the large zone of influence (19km for DP vessel noise) suggests that behavioural impacts to grey seal from project-related vessel noise can be expected. However, disturbance effects will be temporary as vessels will transit through the SAC rather than remain in one location; will not be severe; and will not be biologically significant.

It is important to note that the zone of influence for continuous noise does not overlap with the Cardigan Bay SAC, however individuals foraging outside of the SAC may swim into the zone of influence for the Proposed Development.

The activities that will generate continuous noise are rock placement, cable trenching and vessel engines/thrusters. Rock placement will not be a continuous activity over 24-hours. If rock berm is required for external cable protection (due to ground conditions preventing burial in seabed) within the SAC it is possible that rock placement activities would take a couple of days. However, it is likely the actual deposition would be sporadic rather than continuous, with breaks in the activity as vessel(s) would require re-loading and positioning. Cable trenching and vessel engines will be a continuous source, but activity will progress through the SAC. According to the Navigation Risk Assessment cable lay is anticipated to progress at approximately 230m/hr; equivalent to 5.5km/day. The cable lay is therefore anticipated to take 5 days within the SAC. Project vessels will be present for longer e.g. carrying out survey, route preparation or cable pull-in, but this will not be consistent activity over long periods.

It is important to place the results for disturbance effects in the context of the baseline noise environment. The background noise levels in the region are likely to be in range of 91 to 127 dB re 1 µPa (rms) due to the presence of other vessels and natural source levels. It is important to note that the exceedance of the threshold for the onset of disturbance does not mean that disturbance will occur. It is also worth noting that the activities and noise sources modelled are temporary and transitory. The cable installation will progress along the centreline, with the zone of influence constantly moving. Animals may actively avoid the area for a short period of time but will return once the vessels have passed through.

[2] http://pembrokeshiremarinesac.org.uk/english/special/seal_c.htm

Screening conclusion: No potential for LSE. AA is not required.

Impulsive noise – Geophysical survey

Grey seal in water are vulnerable to sound generated by the geophysical survey. For geophysical survey it is best practice to follow the JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys' (JNCC 2017a). Adherence to the guidelines constitutes best and common practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels. Adherence to the guidelines has been incorporated into the Proposed Development as embedded mitigation EM20 and is considered part of the design of the project.

The underwater noise changes associated with a geophysical survey and therefore the associated potential for disturbance is generally acknowledged as small when compared to activity such as use of air guns during 2D and 3D seismic and wind farm piling (BEIS 2018). It is possible that a geophysical survey will be undertaken ahead of installation, with further inspection surveys completed every 3-5 years post-installation.

For all distances calculated for injurious effects (PTS and TTS) animals will be able to move away from the area where injurious noise levels could be experienced, within seconds; avoiding all injurious effects. With respect to disturbance effects, animals will be able to swim out of the 756m zone of influence in under 5 minutes; assuming a swim speed of 2.7m/s (6 miles per hour, Oceanwide Expeditions 2020).

The proposed activities will be restricted in duration and will progress slowly along the cable centreline through the Proposed Development, with the zone of influence constantly moving. The zone of influence does not overlap with the Cardigan Bay SAC, therefore there will be no changes in underwater noise within the SAC.

Animals foraging outside of the SAC may actively avoid the activity, but there is sufficient habitat available in the wider region that temporary displacement will not affect animal condition. Animals will return to the area once the vessels have passed through. The Proposed Development will not reduce the population, hinder the range (other than briefly) or effect the supporting habitats and species that grey seal rely on.

Screening conclusion: No potential for LSE. AA is not required.

Impulsive noise – UXO deflagration (if required)

It is unknown how many, if any, UXO deflagration will be required within the Proposed Development. The Proposed Development passes through the Castlemartin Firing Range, so it is plausible that UXO will be encountered.

Should UXO be found which require clearance by deflagration it is assumed that there would be a relatively large release of impulsive sound energy, creating high amplitude shock waves (von Benda-Beckmann et al. 2015). The precise injury effect range cannot be stated in advance of information on the nature and quantity of explosive material potentially involved, which will not be known until a UXO is identified.

Underwater noise modelling of a UXO detonation or deflagration has been undertaken based on certain assumptions. Provided as Appendix A to this HRA (Revision 3) it concludes the level of risk depends on the size, location and season of the deflagration / detonation. In all scenarios modelled, there is the risk that without mitigation there could be significant effects to grey seal from blast injury, auditory injury and temporary auditory disturbance.

The zone of influences calculated for the UXO detonation will not overlap with the SAC. However, as there is a large interchange of animals throughout the management unit; there is interconnection between Pembrokeshire Marine SAC and Cardigan Bay SAC; and animals foraging outside of the SAC could swim into the zone of influence, there is the potential for a LSE on the population structure as a consequence of injurious effects or disturbance, and Appropriate Assessment is required.

Screening Conclusion for UXO detonation: Potential for LSE / AA is required.

4.3.9 Pen Llyn a'r Sarnau / Lleyn Peninsula and the Sarnau SAC

4.3.9.1 Conservation objectives – bottlenose dolphin

The conservation objectives for the site are to achieve and maintain in the long-term favourable conservation status for the species features. With respect to bottlenose dolphin this means:

- The population is maintaining itself on a long-term basis as a viable component of its natural habitat;
- The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future;
- The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and population dynamics of the species within the site and population beyond the site is stable or increasing

4.3.9.2 Assessment against conservation objectives – bottlenose dolphin

Bottlenose dolphin do not form a site-based population within the SAC but are part of the wider Channel and SW England management unit. Dolphins associated with the Cardigan Bay SAC move into and through the Pen Llyn a'r Sarnau SAC. Bottlenose dolphin have been observed within the Proposed Development (at densities of 0.06 animals per km^2), and as the species is highly mobile it is possible that animals from the Pen Llyn a'r Sarnau SAC might be present during the planned activities.

Despite this, the noise assessment presented in Appendix A concluded that the zone of influence for disturbance of high frequency cetaceans is 8km for cable installation and <1km for geophysical survey. The Lleyn Peninsula and the Sarnau SAC is located 124km from the Proposed Development, therefore there is considered to be sufficient distance for there to be no overlap between the SAC and zone of influence and therefore no significant disturbance to bottlenose dolphin within the site.

Furthermore, noise from the Proposed Development will not affect bottlenose dolphin habitat or prey items and bottlenose dolphin will still be a viable component of these sites.

If UXO detonation is required, the zone of influence is 40km radial distance. Any disturbance will be a brief, one-off event that will not overlap with the site boundary. Therefore, the number of individuals affected will be small and bottlenose dolphin will still remain a viable component of the site following detonation. In addition, the detonation would not significantly affect bottlenose dolphin habitat or prey items.

Screening Conclusion: No potential for LSE/ AA is not required

4.3.10 Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd SAC

4.3.10.1 Conservation objectives

Species - Twaite shad and Allis shad

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status.

- Populations - The population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements include: population size; structure, production; condition of the species within the site.
- Range - The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future.

As part of this objective it should be noted that:

- Their range within the SAC and adjacent inter-connected areas is not constrained or hindered.
- There are appropriate and sufficient food resources within the SAC and beyond.
- The sites and amount of supporting habitat used by these species are accessible and their extent and quality is stable or increasing
- Supporting habitats and species - The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include; distribution; extent; structure; function and quality of habitat; and prey availability and quality.

4.3.10.2 Assessment against conservation objectives

Twaite shad and Allis shad are members of the herring family, Clupeidae. Adults spend most of their time at sea in coastal waters but return to rivers in late spring (April – June) to spawn. Clupeids are high sensitivity hearing species are therefore will react to changes in underwater noise levels.

Marine cable installation, operation and decommissioning will generate underwater sound from a number of sources:

- Continuous sound sources e.g. vessel movements, cable laying, rock placement; and
- Impulsive sound sources e.g. geophysical survey, UXO detonation (if required).

The underwater noise assessment prepared for the Greenlink Marine ES (Technical Appendix D) is presented in Appendix A. It considers the potential for injury and disturbance from the Proposed Development.

Continuous sound

Modelling has indicated that noise levels sufficient to cause recoverable injury in hearing sensitive fish species may be experienced within 99m of Installation vessels. However, this assumes that the animal will spend 24-hours within this zone of influence. This is highly implausible given that fish are mobile species and the installation vessels will be continually moving.

The presence of several vessels and continued noise with 24-hour operations means it is likely that the most hearing specialist fish will demonstrate temporary avoidance behaviour from early on in and remain outside the zone influence of operations for the duration of the installation activities. The works will not lead to any long-term displacements as they are transient and temporary. Individuals would be expected to be able to return once the operation had passed through.

The site is not within the zone of influence for the pressure and therefore there will be no direct effects on the conservation objectives e.g. activities will not reduce the range, populations or supporting habitats within the site.

The site has been screened as clupeids are mobile species and therefore individuals from the site could travel into the zone of influence. However, given the distance to the site (29km), and the large areas of available habitat, it is unlikely that significant numbers of individuals will be present. It is extremely unlikely that fish will experience a significant effect other than brief displacement from the immediate area surrounding the continuous noise source. Disturbance will therefore not affect the population.

Screening conclusion for continuous sound: No potential for LSE/ AA is not required

Impulsive sound – Geophysical survey and UXO deflagration (if required)

The zone of influence for geophysical surveys has been calculated as 586m. The works will not lead to any long-term displacements as they are transient and

temporary. Individuals would be expected to be able to return once the operation had passed through.

If UXO deflagration is required within the Proposed Development there is the potential that fish from the European site could be present within the zone of influence for a temporary threshold shift (1.8km radial distance). The pressure change will be a brief one-off event (less than a day) and will not overlap with the site boundaries. The numbers of animals likely to be affected will be very small. Therefore, Twaite shad and Allis shad will still remain a viable component of the site following detonation. In addition, the detonation would not cause any significant effects to habitat or prey items.

Screening conclusion for impulsive sound: No potential for LSE/ AA is not required

4.3.11 Broomhill Burrows SSSI

The site covers 2.01km^2 and includes the intertidal area at Freshwater West down to the low water mark. The Proposed Development lies within the site from KP0 to KP0.33.

4.3.11.1 Conservation objectives

To maintain, conserve or restore biodiversity, natural heritage, habitats, species or landscapes with legal protection status.

4.3.11.2 Assessment against conservation objectives

Table 4-2 concluded that there was possible pressure-receptor pathway between the Proposed Development and two bird species listed as Qualifying Features of the site; red-billed chough, and lapwing.

The site is a component feature of the Castlemartin SPA. The assessment against the conservation objectives for the Castlemartin SPA in relation to chough concluded that there is no potential for LSE.

Lapwing breed in the dune system above MHWS; outside of the Proposed Development. As there will be no works between MHWS and the low water mark it is unlikely that vessels in the nearshore area will disturb nesting birds.

Screening conclusion: Conservation objectives will not be hindered

4.3.12 Angle Peninsula Coast SSSI

The SSSI covers an area of 1.34km^2 and is approximately 60m NW of the Proposed Development at the Freshwater West landfall.

4.3.12.1 Conservation objectives

To maintain, conserve or restore biodiversity, natural heritage, habitats, species or landscapes with legal protection status.

4.3.12.2 Assessment against conservation objectives

Table 4-4 concluded that there was possible pressure-receptor pathway between the Proposed Development and the Qualifying Feature red-billed chough.

The SSSI supports a small breeding population (usually one to two pairs a year), and roosting areas for a significant proportion of the South Pembrokeshire non-breeding population of chough. There is a communal roost in the Whitedole/South Studdock area within the SSSI which is regularly occupied by up to 15 chough and there are a number of available nest sites along the cliffs, one or two of which are occupied each year. There is regular interchange of the chough from this site and those from the neighbouring Castlemartin Coast SPA.

Appendix B provides background information on the species and the surveys which have been undertaken by Greenlink Interconnector Limited to inform assessment of effects. This information has been used to draw the following conclusions:

- The only area that is likely to be utilised by chough is within the Wales Onshore component of Greenlink; the HDD compound above Freshwater West.
- Chough were not recorded during a breeding bird survey of the compound.
- The wintering bird survey results indicated that a maximum of four red-billed chough were observed in the compound area at any given time (assumed to be two pairs) which represents 8% of the wintering Castlemartin Coast SPA population (cited as 24 pairs).
- The preliminary Onshore HRA (Arup 2018) concluded that there would be no likely significant effects on red-billed chough taking into account the distance from individual territories, the limited area affected by the works in relation to the available feeding habitat, combined with the temporary nature of the cable installation works, the subsequent reinstatement of the construction area and maintenance of the existing land management regime post-installation.
- The two closest chough territories to the Proposed Development landfall site (Parsons Quarry Bay on the Angle Peninsula and Furzenips on Freshwater West) are both approximately 1.5km from the Proposed Development.
- During the most sensitive time (breeding season) chough are likely to spend most of their time foraging between 100m to 300m from the nest, over 1km from the Proposed Development.
- Most disturbance occurs when people come within 35m of foraging chough.

In conclusion, the Proposed Development will not disturb foraging chough given the distance to the closest chough territories.

Screening conclusion: Conservation objectives will not be hindered

4.3.13 Castlemartin Range SSSI

This site is a component part of the Castlemartin Coast SPA. It covers an area of 20.89km^2 and lies 0.54km from the Proposed Development.

At this site, an open cliff top with grazed pasture supports 15-20 pairs of chough at one of its main breeding locations in west Wales.

4.3.13.1 Conservation objectives

To maintain, conserve or restore biodiversity, natural heritage, habitats, species or landscapes with legal protection status.

4.3.13.2 Assessment against conservation objectives

Table 4-4 concluded that there was possible pressure-receptor pathway between the Proposed Development and two Qualifying Features red-billed chough and breeding seabirds.

The site is a component feature of the Castlemartin SPA. The assessment against the conservation objectives for the Castlemartin SPA in relation to chough concluded that there is no potential for significant effects.

With respect to the Qualifying Feature breeding seabirds, the coastal cliffs within the site support the largest concentration of breeding seabirds on the Pembrokeshire mainland, with about 12,000 – 16,000 individual guillemots (*Uria aalge*), and 800 – 1,100 razorbills (*Alca torda*), mainly nesting at Stack Rocks. Other smaller colonies are scattered along the cliffs opposite the Stacks, and elsewhere on the Range, at locations such as Mewsford Point. A small (currently declining) number of kittiwakes (*Rissa tridactyla*) also breed, along with a few puffins (*Fratercula arctica*). Other breeding seabirds include fulmar (*Fulmarus glacialis*), lesser black-backed gull (*Larus fuscus*), herring gull (*L. argentatus*) and shag (*Phalacrocorax aristotelis*).

Although the Proposed Development lies 0.54km from the SSSI, the coastal cliffs are approximately 2.9km at the closest point (Brimstone Rock) from the Proposed Development. Stack Rocks, where the greatest concentration of seabirds are, is further south around the coast, approximate 8km distant (in a straight line across land) from the Proposed Development. Mewsford Point is 9.5km from the Proposed Development.

It is possible that birds will use the Proposed Development e.g. for foraging, loafing, bathing, flying across. However, given the distances to the sea cliffs, nesting birds within the site will not be disturbed. Any disturbance caused by project vessels will be temporary in nature and limited in extent. Birds will be able to return to the area shortly after the vessels have passed through. The area is subject to moderate levels of shipping, fishing and recreational activity and against this baseline the addition of a few vessels is unlikely to be noticeable within the normal day-to-day and seasonal changes in activity levels.

Screening conclusion: Conservation objectives will not be hindered

4.4 Possible in-combination effects

The Habitats Directive requires that plans or projects are assessed alone and in-combination with other plans or projects to determine whether a likely significant effect to European sites could occur. Only plans or projects that would increase the likelihood of significant effects should be considered.

The nature of a linear interconnector cable project mean that the majority of potential pressures result in short term and localised effects. Most effects, as a result of the Proposed Development, will be restricted to a zone within 10km either side of the Proposed Development. An initial area of search of 10km has therefore been applied either side of the Proposed Development to identify plans and projects for inclusion within this assessment.

Known types of projects and plans considered include:

- Renewable energy projects i.e. offshore wind farms;
- Sites for marine aggregate dredging and disposal;
- Cables and pipelines;
- Oil and gas exploration and development;
- Carbon Capture and Storage; and
- Military Practice Areas.

Projects and plans have been identified through desktop review of published information[4] and through consultation with stakeholders e.g. NRW, The Crown Estate, Marine Energy Wales, Bombora Wave Power and Ministry of Defence.

Commercial fisheries, shipping interests and recreational use has been scoped out of the list of projects as they are considered to represent baseline conditions, and are not considered as projects and plans.

Table 4-5 identifies known developments situated within 10km of the Proposed Development.

Table 4-5 Projects and Plans within 10km of the Proposed Development

Project Category	Name / Type of Project	Status	Operator/Owner/ Other Details	Distance*
Disposal sites	Milford Haven (LU170)	Closed	Milford Haven Port Authority (MHPA)	0.25km
	Milford Haven Three (LU169)	Open	MHPA	8km
	St Ann's Head (LU180)	Closed	MHPA	2km
	Neyland (LU190)	Open	MHPA	10km
	Munitions dump sites (two delineated)	Disused	MOD	1.2km 4km

[4] Data sources included: UKDEAL; National Infrastructure Planning website; Natural Resources Wales website; Marine Energy Wales website; The Crown Estate Website, Oil and Gas Authority activity maps.

Project Category	Name / Type of Project		Status	Operator/Owner/ Other Details	Distance*
Cables	Pan European Crossing 2 (Telecom)		Active	Century Link (Level 3)	0km
	Submarine cables in the estuary (Milford Haven)		Unknown	Unknown	5km
Dredging	Maintenance dredging		Active	MHPA	3km
Military Practice area	Castlemartin Firing Range		Active	MOD	0km
Marine energy	Marine energy test area (META)	Site 8	Proposed	Marine Energy Wales	0km
		Site 7			6km
		Site 1-5			8km
	Bombora Wave Power Seacam device (linked to META 8)		Prospective	Bombora Wave Power	0km
	Wave Dragon Test Site		Prospective	Wave Dragon Wales Ltd	3.5km
Scientific Surveys	Marker buoy deployment		Installed	Bombora Wave Power	0km
	Bangor University Scientific Research Surveys		Licence	Bangor University	0.5km
	Deposit of scientific experiment and marker buoys		Licence	University College of Swansea	0.5km
	MacroBioCrude project		Uncertain (Licence until 2018)	Swansea University	8-10km
	Marine Benthic Invertebrate / Sediment Grab Sampling		Proposed	Natural Resources Wales	2.2km
Oil and Gas	Seismic survey		Prospective	ENI UK	2km
	Wellhead 50/10-1		Disused	Mobil	9.5km
Construction	Milford Haven Port Development		Prospective	Milford Haven Port Authority	7km
	Neyland Yacht Haven Marina (Piling works)		Active	Neyland Yacht Haven Ltd	10km
	Salvaging of anchors and chains		Licence	Mr J Middleton	4 km
	Jetty Maintenance		Licence	Puma Energy (UK) Ltd	5 km
	Deposit of a temporary trackway and jetty		Licence	REM Engineering Limited	4.5km
* Closest distance to Proposed Development					

For there to be a potential cumulative effect (PCE) the Proposed Development and another project or plan there must be a common pressure-receptor pathway which overlaps spatially and temporally. A screening exercise has been undertaken, presented below, to determine if any of the projects or plans identified have:

a. A common-pressure receptor pathway with the Proposed Development (Section 4.4.1.2);

b. Activities, the effects of which overlap spatially with the Proposed Development (Section 4.4.1.3); and

c. Activities, the effects of which overlap temporally with the Proposed Development (Section 4.4.1.4).

4.4.1.2 Common pressure-receptor pathway assessment

The projects fall into eight categories. An activity / pressure/ receptor matrix for these eight categories has been developed (Table 4-6) to define the common pressures associated with the project types, and which receptors can be effected. Where pressures where identical the categories have been grouped together for presentation purposes. If there is no common pressure-receptor pathway the project pressure is screened out.

Table 4-6 Activity / pressure / receptor matrix for identified projects

Category	Phase	Pressure	Receptors			
			Habitats	Fish	Birds	Marine Mammals
Disposal sites Dredging	Operation	Siltation rate changes	■			
		Disturbance			■	
		Underwater noise changes		■		■
		Physical change (to another seabed type)	■			
Cables Marine Energy Scientific surveys	Installation and Repair	Penetration and/or disturbance including abrasion	■			
		Siltation rate changes	■			
		Hydrological changes (inshore/ local)	■			
		Physical change (to another seabed type)	■			
		Disturbance			■	
		Underwater noise changes		■		■
Military Practice Area Oil and gas	Operation	Disturbance			■	
		Underwater noise changes		■		■
Construction	Installation	Penetration and/or disturbance including abrasion	■			
		Siltation rate changes	■			
		Physical change (to another seabed type)	■			
		Disturbance			■	
		Underwater noise changes		■		■

4.4.1.3 Spatial overlap assessment

Of the projects listed in Table 4-6, Milford Haven (LU170), St Ann's Head (LU180), the two munitions dump sites, and well head 50/10-1 have been screened out from

further consideration. All sites are closed or decommissioned and no further activities that could affect the environment will be associated with them.

For there to be a potential cumulative effect (PCE) the effects from the Proposed Development and other plans and projects must overlap spatially. If there is no spatial overlap between the pressures, the pressure from the plan or project can be screened out at this stage. Table 4-7 presents an assessment of the projects to determine if spatial overlaps exist with the Proposed Development.

Table 4-7 Spatial overlap assessment

Key	Screened out – No common pressure-receptor pathway	Screened out – Common pressure receptor pathway but outside Proposed Development zone of influence	Screened in – Common pressure receptor pathway and within Proposed Development zone of influence

Project		Distance*	Greenlink pressures and zone of influence (km)					
			Penetration and/or disturbance including abrasion	Siltation rate changes	Hydrological changes (inshore/ local)	Physical change (to another seabed type)	Disturbance	Underwater noise changes
			0.02	0.10	0.00	0.01	4.00	2.60
Milford Haven Three (LU169)		8						
Neyland (LU190)		10						
Pan European Crossing 2 (Telecom)		0						
Submarine cables in the estuary (Milford Haven)		5						
MHPA Maintenance dredging		3						
Castlemartin Firing Range		0						
Marine energy test area (META)	Site 8	0km						
	Site 7	6km						
	Site 1 - 5	8km						
Bombora Wave Power SEACAM device (linked to META 8)		0						
Wave Dragon Test Site		3.5						
Marker buoy deployment		0						
Bangor University Scientific Research Surveys		0.5						
Deposit of scientific experiment and marker buoys		0.5						
MacroBioCrude project		8-10						
Marine Benthic Invertebrate / Sediment Grab Sampling		2.2						
Seismic survey		2						
Milford Haven Port Development		7						

Key	Screened out – No common pressure-receptor pathway	Screened out – Common pressure receptor pathway but outside Proposed Development zone of influence	Screened in – Common pressure receptor pathway and within Proposed Development zone of influence

Project	Distance*	Greenlink pressures and zone of influence (km)					
		Penetration and/or disturbance including abrasion	Siltation rate changes	Hydrological changes (inshore/ local)	Physical change (to another seabed type)	Disturbance	Underwater noise changes
		0.02	0.10	0.00	0.01	4.00	2.60
Neyland Yacht Haven Marina (Piling works)	10						
Salvaging of anchors and chains	4						
Jetty Maintenance	5						
Deposit of a temporary trackway and jetty	4.5						

4.4.1.4 Temporal overlap assessment

Although Table 4-7 has determined that there is a spatial overlap between twelve projects and the Proposed Development, the effects must overlap temporally as well as spatially for there to be a PCE. If there is no temporal overlap between projects the project is screened out.

Table 4-8 presents the results of the temporal overlap assessment.

Table 4-8 Temporal overlap assessment

Name / Type of Project	Status	Conclusion
Pan European Crossing 2 (Telecom)	Installed	Cable is installed so any repairs will be on an ad hoc basis. No confirmed schedule – Screened out
MHPA Maintenance Dredging	Active	License active until 2022 – Potential for temporal overlap
Castlemartin Firing Range	Active	Range is active with ongoing exercises – Potential for temporal overlap
Bombora Wave Power Seacam device (META8)	Proposed	Consultation with Bombora Wave Power indicates deployment of advice is expected in 2020 for a duration of 6-12 months – Potential for temporal overlap
Wave Dragon	Proposed	No confirmed schedule for the project – Screened out
Marker buoy deployment	Installed	License active until 2019 – No temporal overlap – Screened out
Bangor University Scientific Research Surveys	Licensed	License is valid until 2021 but there is no confirmed schedule – Screened out
Deposit of scientific experiment and marker buoys	Licensed	License expires in 2019 – No temporal overlap – Screened out
Marine Benthic Invertebrate / Sediment Grab Sampling	Renewal license	License expires in 2021 - Potential for temporal overlap

Name / Type of Project	Status	Conclusion
Seismic survey	Proposed	No confirmed schedule for the project – Screened out
Salvaging of anchors and chains	Licensed	License expires in 2021 – No temporal overlap – Screened out

4.4.1.5 Potential for cumulative effects

Five projects have been screened in to be assessed for PCE. The potential for the projects to increase the likelihood of the Proposed Development having a LSE on a European site is discussed below.

MHPA Maintenance Dredging

The common pressure receptor-pathway between this project and the Proposed Development is disturbance to birds. The project and the Proposed Development are set against a background of moderate shipping activity associated with the shipping routes to, from and within Milford Haven. The two projects will only contribute an additional one or two vessels to this background level at any one time, which is within the seasonal and daily fluctuations experienced in the area. Therefore, there is no potential for a PCE.

Castlemartin Firing

The common pressure-receptor pathway between this activity and the Proposed Development is disturbance to birds and underwater noise changes effecting fish and marine mammals. The Castlemartin Firing Range is an active military exercise area. However, grey seal and seabirds still use the coastline of the range for breeding. This suggests that they are habituated to the noise levels and activities associated with the range. Screening of the Proposed Development identified that there is the potential for LSE on grey seal and harbour porpoise from the detonation of UXO (if required). The detonation will be a brief one-off event. As there will not be continued disturbance it will not accumulate with the activities associated with the Castlemartin Firing Range. There is no potential for PCE.

Bombora Wave Power SEACAM Device (META Site 8)

Six common pressure-receptor pathways were identified between the Bombora Wave Power project and the Proposed Development.

The Bombora Wave device will be a temporary gravity based structure (i.e. it will not require intrusive anchoring or piles to keep it in place), installed at the 10m water depth contour. It will have a footprint of approximately 75m x 16m (1200m^2). The location of the device will be in sandy sediments which are not a Qualifying Feature of the Pembrokeshire Marine SAC.

Bombora Wave Power are currently considering the possibility of connecting the device to land via a data cable. There are several options for the cable protection and route. It is expected the cable would be surface laid and protected with clam

shells. It is possible that rock protection may be used but this could not be confirmed during the HRA process.

Based on the information available and in the absence of information regarding a possible cable route or external cable protection Table 4-9 presents the assessment of the likelihood of PCE.

Table 4-9 Assessment of PCE between Bombora Wave Power and Proposed Development

Pressure	Justification	Conclusion
Penetration and/or disturbance including abrasion	The footprint of the structure and the Proposed Development installation will both temporarily disturb habitat defined as EUNIS habitat 'A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment'. MarLIN (2019) class this habitat as having low sensitivity to the pressure. The habitat is therefore expected to recover quickly following disturbance. Given the small footprints of both the Proposed Development and the Bombora Wave Power device in this area and the fact that the habitat is not a Qualifying Feature of the Pembrokeshire SAC the assessment concludes no PCE.	No PCE
Siltation rate changes	The Proposed Development will only have a brief effect on suspended sediment concentrations. Similarly, the Bombora Wave Power device is likely to have a brief effect on suspended sediment concentrations during installation. However, both effects will be within the natural background range experienced in the region (e.g. after storm events).	No PCE
Hydrological changes (inshore/ local)	The Proposed Development will not have an effect on the hydrology at Freshwater West and therefore there is no potential for a PCE with the Bombora Wave Power device	No PCE
Physical change (to another seabed type)	The Proposed Development will cause localised physical changes to seabed conditions where external cable protection is required. It has been identified that there will be LSE on the Pembrokeshire Marine SAC Qualifying Feature Reef. The Bombora Wave Power device gravity structure will also change the seabed type; from sand to an artificial structure. However, this will be a short-term change and when the gravity base foundations are removed, the habitat will return to pre-installation conditions. The structure is not within a Qualifying Feature of the Pembrokeshire Marine SAC. Given the small size of the change and the fact that the Bombora Wave power device will not affect the conservation objectives for the Qualifying Feature Reef it is concluded there will be no PCE. It is unknown whether there will be external cable protection and therefore this aspect cannot be assessed.	No PCE
Disturbance	The Stage 1 Screening assessment concluded that there was no LSE on the Bird Qualifying Features of any of the European sites that the Proposed Development crosses or is close to. There is limited information available on the Bombora Wave Power project, but it is assumed that installation will require the temporary presence of one of more vessels, similar to cable installation. The device will be installed ahead of the Proposed Development installation and therefore it is unlikely that there will be temporal overlap of activities. If there is, then there is the potential that birds will be disturbed by two sets of nearshore activities. However, the significance of this will be negligible with no long-term effects on populations.	No PCE

Pressure	Justification	Conclusion
Underwater noise changes	Bombora Wave Power confirmed that they will not be applying for consent to detonate UXO.	Not assessed

Marine Benthic Invertebrate / Sediment Grab Sampling

The common pressure-receptor pathway between this project and the Proposed Development is disturbance to birds and underwater noise changes. Stage 1 Screening concluded that the Proposed Development will not have a LSE on birds or marine mammals from the presence of the project vessels or the generation of continuous noise. There is limited information available on the survey but it is assumed that it would involve the presence of one or more vessels generating underwater noise levels similar to a standard vessel. Therefore, there will be no PCE.

4.4.1.6 Conclusion

The assessment has screened projects within 10km of the Proposed Development. It has concluded that there will be no PCEs between the Proposed Development and any other known project, plan or activity.

4.5 *Screening Statement and Conclusions*

To determine whether the Proposed Development is likely to have a significant effect on any European sites, either individually or in-combination with other plans or projects, AA screening was carried out.

The screening assessed twelve European sites that were either within the direct zone of influence of the Proposed Development or contain mobile Annex II species which could potentially travel into the Proposed Development. In addition, twelve SSSIs and one MCZ was also screened.

A review of the Proposed Development identified seven pressures that could be exerted on Qualifying Features during installation, maintenance, repair, operation and decommissioning. These were:

- Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion
- Siltation rate changes, including smothering (depth of vertical sediment overburden)
- Hydrological changes (inshore/local)
- Physical change (to another seabed type)
- Disturbance
- Underwater noise changes
- Electromagnetic changes

Sites were assessed to determine if there was a potential pressure-receptor pathway between the Proposed Development and the Qualifying Feature(s).

Initial screening concluded, that it is considered possible that there exists a pressure-receptor pathway between the Proposed Development and the Qualifying Features of eleven of the twelve European sites reviewed, and three of the twelve SSSIs assessed (Table 4-6). Further analysis of the LSEs taking into consideration the sites conservation objectives identified four sites, where it cannot be ruled out that the Proposed Development will not have a LSE. Table 4-10 summarises the conclusions of the assessment of LSE.

Twenty-six other projects or plans within 10km of the proposed Development were also assessed to determine it there was a potential for cumulative effects on the European Sites. No PCEs were identified.

Screening has concluded that Appropriate Assessment is required for:

- Pembrokeshire Marine / Sir Benfro Forol SAC (site code: UK0013116)
- West Wales Marine / Gorllwein Cymru Forol SAC (site code: UK0030397)
- Bae Ceredigion / Cardigan Bay SAC (site code: UK0012712)
- Bristol Channel Approaches/ Dynesfeydd Môr Hafren SAC (site code: UK0030396)

Table 4-10 Summary – Potential for likely significant effects

Site Name & Code	Applicable Qualifying Feature	Potential Pressure on Site	Conclusion
Pembrokeshire Marine / Sir Benfro Forol SAC UK0013116	Reef	Penetration and/or disturbance including abrasion Physical change (to another seabed type)	Potential LSE. AA is required
	Sandbanks which are slightly covered by seawater all the time	Penetration and/or disturbance including abrasion	No potential for LSE / AA is not required
	Mudflats and sandflats not covered by seawater at low tide	Hydrological changes	No potential for LSE / AA is not required
	Grey seal	Underwater noise changes - UXO deflagration	Potential for LSE. AA is required
		Disturbance (visual)	No potential for LSE / AA is not required
	Otter	Underwater noise changes Disturbance	No potential for LSE / AA is not required
	Allis shad	Underwater noise changes	No potential for LSE / AA is not required
	Twaite shad	Underwater noise changes	No potential for LSE / AA is not required

Site Name & Code	Applicable Qualifying Feature	Potential Pressure on Site	Conclusion
Skomer, Skokholm and the seas off Pembrokeshire /Sgomer, Sgogwm a moroedd Penfro SPA UK9014051	Breeding birds	Disturbance	No potential for LSE / AA is not required
West Wales Marine / Gorllewin Cymru Forol SAC UK0030397	Harbour porpoise	Underwater noise changes - UXO deflagration	Potential for LSE. AA is required
Castlemartin Coast SPA	Red-billed chough	Disturbance	No potential for LSE / AA is not required
Grassholm SPA UK9014041	Gannet	Disturbance	No potential for LSE / AA is not required
Bristol Channel Approaches/ Dynesfeydd Môr Hafren SAC UK0030396	Harbour porpoise	Underwater noise changes - UXO deflagration	Potential for LSE. AA is required.
North Anglesey Marine / Gogledd Môn Forol SAC UK0030398	Harbour porpoise	Underwater noise changes	No potential for LSE / AA is not required
North Channel SAC UK0030399	Harbour porpoise	Underwater noise changes	No potential for LSE / AA is not required
Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd SAC UK0020020	Allis shad	Underwater noise changes	No potential for LSE / AA is not required
	Twaite shad	Underwater noise changes	No potential for LSE / AA is not required
Bae Ceredigion / Cardigan Bay SAC UK0012712	Bottlenose dolphin	Underwater noise changes	No potential for LSE / AA is not required
	Grey seal	Underwater noise changes - UXO deflagration	Potential for LSE. AA is required
Pen Llyn a'r Sarnau / Lleyn Peninsula and the Sarnau SAC UK0013117	Bottlenose dolphin	Underwater noise changes	No potential for LSE / AA is not required
Broomhill Burrows SSSI 1136	Red-billed chough	Disturbance	Conservation objectives will not be hindered
Arfordir Penrhyn Angle / Angle Peninsula Coast SSSI 0923	Red-billed chough	Disturbance	Conservation objectives will not be hindered
Castlemartin Range SSSI 0140	Breeding seabirds	Disturbance	Conservation objectives will not be hindered

5. Stage 2 – Information to Inform Appropriate Assessment

5.1 Introduction

The Stage 1 Screening documented in Section 4 concluded that there is the potential for likely significant adverse effects on the following four sites and that an AA is required:

- Pembrokeshire Marine / Sir Benfro Forol SAC (site code: UK0013116)
- West Wales Marine / Gorllwein Cymru Forol SAC (site code: UK0030397)
- Bristol Channel Approaches/ Dynesfeydd Môr Hafren SAC (site code: UK0030396)
- Bae Ceredigion / Cardigan Bay SAC (site code: UK0012712)

The AA is a focused and detailed impact assessment of the implications of the plan or project alone and in combination with other plans and projects, on the integrity of a European site in view of its conservation objectives. It is undertaken by the competent authority, which for Marine Licence applications is the Welsh Government, supported by NRW. To inform the AA, the proponent of the plan (i.e. Greenlink Interconnector Limited) must provide 'Information to Inform AA' which provides data and information on the project and an analysis of potential effects on the European site.

Welsh Government (2017) guidance on Stage 2 simply states the developer should *"Provide information to the competent authority as reasonably required for the purposes of assessing the implications for N2K* [European] *sites in light of relevant conservation objectives. Draft a report to inform the competent authority's Appropriate Assessment."*

In the absence of more specific guidance, the Irish National Parks & Wildlife Service (NPWS) 2012 guidance has been followed. This has been used for the Irish Marine component of Greenlink, and therefore provides a common standard across the project.

The NPWS guidance (2012) on the content of the Stage 2 Information to Inform AA (referred to as Natura Impact Assessment in Ireland) states:

"The more detailed ecological assessment of proposed activities requires that two key questions be addressed: 'What are the likely impacts of the proposed activity?' and 'How quickly could the qualifying interest recover from the impact, if at all?'".

The guidance identifies questions which should be considered when providing information to support the AA for habitats and species Qualifying Features.

This Stage 2 - Information to Inform AA draws on information provided in the HRA as outlined in Table 5-1. It considers the four sites for which the potential for a LSE has been identified and provides further assessment of the significant effects on the Primary/Qualifying Feature(s) of these sites. Where appropriate it proposes mitigation measures which could be taken by GIL to reduce the significance of effects.

Table 5-1 Cross-reference to other supporting information

Relevant information	Section
Description of the Project	Section 3
Conservation objectives of the European site	Section 4.3
Assessment of aspects of the Proposed Development which could negatively affect the conservation objectives of the European site	Section 4.3

5.2 *Pembrokeshire Marine / Sir Benfro Forol SAC*

5.2.1 Primary Feature - Reef

5.2.1.1 Screening conclusion

The AA screening identified that there is the potential for a LSE on the Primary Feature Reef from the following pressures:

- penetration and/or disturbance including abrasion; and
- physical change (to another seabed type).

The conservation objectives for the Primary Features are:

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status.

- Range - The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing.
- Structure and function - The physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include; geology; sedimentology; geomorphology; hydrography and meteorology; water and sediment chemistry; and biological interactions.
- Species - The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include: species richness; population structure and dynamics; physiological health; reproductive capacity; recruitment; mobility; and range.

The AA screening concluded that in relation to the conservation objectives the two pressures have the potential to affect the range, structure and function, and have localised effects on species abundance.

5.2.1.2 Assessment of effects

Background Information

A detailed assessment of effects on Reef habitat has been provided in the Greenlink Marine ES – Wales; Chapter 7 Benthic and Intertidal Ecology. The assessment provided here summarises the pertinent information and relates it to the conservation objectives to determine if there will be a significant adverse effect on the SAC. For ease of reference, the Greenlink Marine ES – Wales Chapter 7 has been provided as Appendix C (please note the Chapter was not updated for Revision F2 to reflect the requests for clarification. All necessary changes have been made in the HRA itself).

All three sub-types of Reef habitat were identified by the cable route survey within the Proposed Development; Bedrock Reef, Stony Reef and Biogenic Reef. The location of the habitat in relation to the indicative centreline and Proposed Development boundaries is displayed in Appendix C, Figures 7-10 to 7-13 (Drawings P1975-HAB-005, P1975-HAB-004 Sheet 2, P1975-HAB-006, and P1975HAB- 004 Sheet 5).

Cable installation is a one-off event, but the seabed along the cable centreline could be disturbed on two to three discrete occasions within approximately a three month period. The first occasion will be for any seabed preparation works e.g. boulder clearance; the second occasion will be the pre-lay grapnel run; and the third occasion will be the cable lay and burial and if necessary the deposit of external cable protection. These activities will be within the same zone of influence. When assessing the significance of the effect the assessment has considered the cumulation of these activities.

It is important to note that the preference is to bury the cables in the seabed as this provides the best protection and minimises environmental effects (embedded mitigation EM15). The refinement of the locations and quantities for the deposit of external cable protection will be an iterative process following the below sequence, which will not be concluded until the cables have been installed:

1. Selected Installation Contractor undertakes Burial Assessment Study (BAS) and determines potential external cable protection locations.
2. Installation Contractor undertakes planned trenching.
3. Locations of external cable protection confirmed.

The locations where potentially external cable protection may be required have been defined based on initial interpretation of the Greenlink cable route survey geophysical and geotechnical data. The assessment took into consideration soil conditions, depth of bedrock, the target depth of lowering (TDOL) and the capabilities of burial equipment to identify locations where burial may not be achieved. A precautionary approach was taken to ensure the HRA presented the worst-case. It is feasible that not all locations indicated in the HRA will require external cable protection.

The potential for LSEs on each of the conservation objectives is discussed in turn below.

Range (Distribution and Extent)

The extent of Reef habitat within the SAC is reported as 409.97km^2 (40997.43 hectares) (JNCC 2016). Maps showing the extent of 'Reef' habitat are available from the JNCC, which classifies the area according to confidence in the presence of the habitat. The JNCC maps indicate a slightly higher estimate of Reef in the SAC although confidence in some areas is given as low. The habitat maps indicate Bedrock Reef covers an area of 377km^2, whilst Stony Reef covers 70km^2. In addition, the Reef extends outside of the SAC boundaries. No areas of Biogenic Reef have been indicated as present within the SAC.

Three aspects of the Proposed Development have the potential to have a LSE on the Primary Feature (PF): boulder clearance, cable burial, and if required deposition of external cable protection. Table 5-2 provides a summary of the footprints of these aspects in relation to each Reef sub-type. It has been sub-divided into the preferred solution (burial in seabed); and the alternative contingency whereby select areas of external cable protection is required. It should be noted that other areas of Reef were identified in the Proposed Development but there is sufficient room such that these areas can be micro-routed around without effects; and the intention is to avoid the Reef.

Table 5-2 Footprint of activities within Reef habitat

Reef sub-type	Aspect	Location	Footprint (m^2)	Extent of PF in SAC (km^2)	% of PF affected	EUNIS habitat code
Preferred solution						
Bedrock Reef	Cable burial	KP2.38 - KP2.41	450 (15m x 30m)	377	0.00068%	A4.138
		KP4.86 - KP5.00*	2,100 (15m x 140m)			
Medium Grade Stony Reef	Boulder clearance Cable burial	KP15 - KP23	120,000 (15m x 8000m)	70	0.17%	A5.141 A5.14
Biogenic Reef - Potential	Cable burial	KP43.89 - KP45.23	19,500 (15m x 1330m)	Unknown - not previously recorded in SAC	-	A5.611
		KP45.6 KP46.6	15,000 (15m x 1000m)			A5.611
Low-grade Biogenic Reef		KP40.9 - KP41.7	12,000 (15m x 800m)			A5.611
Alternative contingency solution						
Bedrock Reef	External cable protection	KP2.38 - KP2.41	300 (10m x 30m)	377	0.00045%	A4.138
		KP4.86 - KP5.00	1400 (10m x 140m)			

Reef sub-type	Aspect	Location	Footprint (m^2)	Extent of PF in SAC (km^2)	% of PF affected	EUNIS habitat code
Medium Grade Stony Reef	External cable protection	KP15.00 – KP23.00	80,000 (10m x 8000m)	70	0.11%	A5.141 A5.14
Biogenic Reef	External cable protection	KP43.89 – KP44.00	1100 (10m x 110m)	Unknown – not previously recorded in SAC	-	A5.611
* The indicative Greenlink centreline crosses the Bedrock Reef habitat at approximately KP4.86 for 140m. The cable route survey and video transect T06 identified a narrow (approximately 20m wide) sand channel approximately 1m deeper than the surrounding Bedrock through the Reef. It is believed installation will be feasible within the channel. As of the submission of the Greenlink Marine Environmental Statement (Document reference: P1975_R4484_RevF1), this area is considered to lack the characteristic species typical of the EUNIS habitat A4.138 *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock. Sediments are sandy and similar to those identified on Turbot Bank, directly to the west. However, as a precaution it has been assumed that a Bedrock Reef habitat could become established within the sand channel between the baseline survey and installation and therefore this area has been included in the assessment of Bedrock Reef.						

Table 5-3 Percent of Reef Primary Feature affected

Category	Aspect	Footprint (km^2)	Extent of PF in SAC (km^2)	% of PF affected
Preferred solution - Temporary disturbance	Boulder clearance / cable burial (only)	0.17	409.97	0.04% 0.011%
Alternative contingency – Permanent habitat change	External cable protection	0.083	409.97	0.02%

Table 5-3 presents calculations to show that the maximum extent of Reef affected by the preferred solution - cable burial is equivalent to 0.04% % of the habitat within the SAC.

It is likely that a high proportion of the benthic invertebrates within the width of the installation footprint (<15m), will be susceptible to mortality, injury or displacement as a result of the cable burial activities. The three habitats identified within the Reef habitat sub-types are characterised by fragile sessile or slow-moving species such as *Sabellaria spinulosa*, ascidians (sea squirts), hydroids, bryozoans and barnacles.

To determine the sensitivity of the habitats to cable installation techniques e.g. ploughing or jetting, the Marine Life Information Network (MarLIN) was used to determine the sensitivity of habitats to the pressure penetration and disturbance including abrasion. Appendix C, Table 7-8 and Section 7.6.2.1 presents the assessment which concluded:

- Habitat A4.138 (Bedrock Reef) has low sensitivity to abrasion. The characterising species, *Molgula manhattenis* is a small solitary ascidian (sea squirt) which can form dense aggregations. It is short-lived with a life-span of less than 1 year and reproduces several times during this period. Recruitment is generally from

existing individuals no more than a few kilometres away, but the fast growth rates means recolonization, and a dense cover can be established within about two months of disturbance (Stamp 2016).

- Habitat A5.141 (medium grade Stony Reef) has low sensitivity to the pressures penetration and abrasion. The fauna associated with this habitat are typically fast-growing epifauna, that are opportunistic as the habitat experiences seasonal and sporadic cycles of severe scour. The pebbles and cobbles are likely to be moved by the tidal streams in the region, which will be more severe during winter storms. The habitat covers an extensive area within the Proposed Development, in comparison to the footprint of cable installation and there will be a good larval supply to support colonisation of the disturbed area. Evidence suggests that recolonization of disturbed habitat will occur within one year post-disturbance (Tillin and Tyler-Walters 2016).
- Habitat A5.611 (Biogenic Reef) has medium sensitivity to the pressure. The Biogenic Reef within the direct path of cable installation is low grade or potential reef. Recovery rates are likely to be determined by a range of factors such as degree of effect, the season of effect, larval supply and local environmental factors. However, evidence suggests that recovery could be rapid (within weeks) but is more likely to occur within two years (Tillin et al 2018).

Based on the information above, in areas where burial in seabed is achieved the Reef sub-types are expected to recover in the short-term (within 1-2 years), maintaining the extent of the habitat in the long-term.

As indicated in Table 5-2, external cable protection could be required in all three Reef sub-types; Bedrock Reef, medium grade Stony Reef and Biogenic Reef. It is calculated that 0.083km^2 of habitat could be affected by external cable protection. The external cable protection will change the seabed in this area.

The habitats within the areas affected by external cable protection have been classified by the cable route survey as:

- A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock (Bedrock Reef);
- A5.141 *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (medium grade Stony Reef); and
- A5.611 *Sabellaria spinulosa* on stable circalittoral mixed sediment (Biogenic Reef).

According to MarLIN, Sabellaria reef habitats have no resistance, very low resilience, and high sensitivity to the pressure change in habitat type; however, it should be noted that *S.spinulosa* is considered not sensitive based on studies of habitat preferences. While there will be a permanent change from the existing seabed type to a novel hard substrate, it is noted that *S.spinulosa* can colonise bedrock and artificial structures, therefore an increase in availability of hard substratum may be beneficial providing areas for colonisation (Tillin et al. 2020). Wider evidence

suggests that *S.spinulosa* has been recorded on a variety of substrates including artificial surfaces such as pipelines, wave-breakers, seawalls and artificial reefs (Pohler 2004; Braithwaite *et al*. 2006; Chen and Dai 2009; Ponti *et al*. 2010). While existing *S.spinulosa* reefs would be removed, evidence has shown that cable protection measures can be considered a positive effect, stimulating the development of biological communities and increasing local diversity (Coolen 2017). Furthermore, evidence suggests that *S.spinulosa* reefs can recover quickly from short-term or intermediate levels of disturbance, with recovery accelerating if some of the reef is left intact following disturbance which will promote larval settlement of the species (Tillin et al. 2020).

Where external cable protection is installed, the underlying Reef habitat will be lost. Any loss of the Primary Feature; reef habitat is considered a significant adverse effect.

In conclusion, burial in seabed will not have an adverse effect on the conservation objective. However, following consultation with NRW, it is concluded that it cannot be ruled out that there will not be an adverse effect on the conservation objective if the contingency to deposit external cable protection is required. It is uncertain that the overall distribution and extent of the Primary Feature Reef habitat will not decrease in the long-term.

Structure and Function

Cable jetting and trenching will not alter or contaminate the underlying sediments. There may be a fractional coarsening of sediments, as finer silts are suspended by the burial process. However, this is unlikely to have any significant effect, given the narrow trench size (1m).

If jetting or trenching is feasible in the area of medium grade Stony Reef, the cobbles will be used to cover the cable, returning the seabed to a similar state as pre-installation.

If external cable protection is deposited, the seabed height will become elevated in comparison to the surrounds. Large boulders have been observed in the area up to 2m high and therefore structures of this height are not uncommon in the area. Camera drops on these boulders were undertaken during the cable route survey. Imagery indicates the presence of habitat A4.111 - *Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock. This biotope is characterised by a few species that are capable of maintaining a strong foothold in strong tides, either by forming a flat adherent crust, or by having strong attachment points. Species typically associated with the biotope include hydroids, sponges and anemones, as well as mobile species such as starfish, crab and whelk (Tillin 2016). The species associated with the biotope grow rapidly, are short-lived, and generally thought of as early colonisers of bare surfaces. Tillin (2016) cite evidence of *Balanus crenatus* colonising artificial reef structures and sublittoral rock surfaces within months. For example, the ship, HMS Scylla was colonised by *Balanus crenatus* four weeks after sinking in March; the timing of the sinking would have ensured a good larval supply.

This suggests that the height of the external cable protection (if required) will not detrimentally affect the function of the reef habitat.

The presence of the external cable protection (if required) may cause very localised changes in water flows. This in turn could cause localised scour. Scour will only occur in areas of sediment where bottom currents either already exceed the critical bedload parting velocity, or where external cable protection results in an increase in current velocity to above the critical bedload parting velocity. Given that current speeds within the Proposed Development are relatively low, particularly near the seabed due to frictional effect, high level of scour is unlikely to be a significant issue.

Based on the above, cable burial and external cable protection (if required) will not alter the structure or functions necessary for the long-term maintenance of the habitat and there will be no significant effects on the conservation objective.

Species (Presence, Abundance, Condition and Diversity of Typical Species)

As noted above, the habitats affected by cable burial are characterised by short-lived, fast-growing, opportunistic epifauna which have fast rates of colonisation. The habitats are common within the Proposed Development and the wider area and therefore there will be a good larval supply to support colonisation of disturbed ~~or new~~ substrates. Colonisation of the affected areas is expected within the short-term (within months to two-years).

Cable burial will therefore not adversely affect the achievement of the conservation objective in the long-term.

The deposit of external cable protection (if required) will introduce a new novel substrate into the environment. The external cable protection could be viewed as an artificial reef. The OSPAR Commission (2009) defines an artificial reef, as a 'submerged structure placed on the seabed deliberately, to mimic some characteristics of a natural reef. It could be partly exposed at some stages of the tide'. This places the external cable protection material outside the formal definition on the basis of purpose. However, almost all man-made structures placed on the seabed are rapidly and quickly colonised by marine organisms (Linley et al 2008). The effects of artificial reefs are ambiguous with Linley et al (2008) citing studies such as Ambrose and Anderson (1990) which have shown that some species of infauna were enhanced whilst others were depressed. It is therefore acknowledged that whilst the external cable protection could enhance the productivity and biodiversity of the habitat, it will also represent a variation on the habitat that was previously there.

A literature review was undertaken to investigate the colonisation of external cable protection in the marine environment. Provided as Appendix A of the Greenlink Habitat Compensation Plan (see Appendix D of this HRA) it provides evidence for the following conclusions:

- Where external cable protection (rock revetment) is deposited it is predicted to be colonised by epibenthic species from the surrounding Annex I Reef habitat to a similar extent as the existing habitat;

- The colonisation of the rock revetment would likely be within a relatively short time scale. Evidence, presented in Appendix D of the HRA, indicates a period of 3.5 – 5 years for the novel habitat to fully colonise, likely with some individual characterising species recovering more rapidly; and
- It is reasonable to assume that that artificial reef created over any rock revetment locations may be comparable in terms of ecological functioning to that of the surrounding natural reef; and therefore also any existing natural reef lost as a result of the installation of the Greenlink cable.

The above conclusions are supported by evidence from post-construction monitoring of offshore windfarms. The examples provided below are from the introduction of a hard substrate into a predominantly sandy environment. This however can be used to infer that colonisation of external protection in areas where there is already rock habitat, will likely be quicker than colonisation of external protection on sand habitats. This is dependent on the passive transport of adult organisms or the availability of larvae from the surrounding region.

Case studies on the Offshore Windfarm Egmond aan Zee, Prinses Amalia Wind Farm and Horns Rev Wind Farm found that the density of species on scour protection material were high and the number of species observed increased with time. In addition, in many cases the number of rare species had also increased (Waardenburg et al 2017). Studies (Lindeboom et al 2011) at OWEZ identified 11-17 hard substratum benthos species on the rock material, noting the surrounding habitat was sandy. At the Horns Rev Windfarm the scour protection has been colonised by sea anemones and the soft coral *Alcyonium digitatum* (Langhamer 2012). Monitoring of the Nord Stream pipeline in Swedish waters showed that over a period of four years a general increase in epifauna was seen on the introduced hard substrate (pipeline and rock berms) (Nord Stream 2014).

Further studies (although limited) to the effects of artificial structures on adjacent soft sediments have provided contrasting results. Changes in localised community structure as a result of changes in sediment texture have previously been identified by Ambrose and Anderson (1990). Results showed reduced densities of some taxa near artificial structures which may have either resulted from increased predation as reef-associated fish move over sand to feed or changes in localised sediment composition creating a less suitable habitat for certain species. In contrast to this, Davis et al (1982) identified no measurable decrease in adjacent infauna densities at a distance of 4m from artificial structures over the two-year period since their introduction (cited in Pidduck et al 2017).

As the external cable protection will represent a variation of the habitat that was previously there, it cannot be concluded with certainty that the habitat quality will not degrade in the long-term. Therefore, where external cable protection is used, it has been concluded in consultation with NRW, that it cannot be ruled out that there will not be an adverse effect on the conservation objective.

Cumulative effects

Stage 1 Screening concluded that there will be no PCEs between the Proposed Development and any other known project or plans.

5.2.1.3 What measures can be implemented to mitigate the significance of the likely adverse impact into insignificance?

The most effective mitigation is to avoid the sensitive habitat. Route development has been an iterative process of desk-based assessment, consultation and marine survey. The route selected avoids large areas of Bedrock Reef identified to the south of the Proposed Development and areas of Reef habitat to the north which would have required more extensive external cable protection. A sediment channel has been identified within outcropping bedrock between KP2 and KP5 which is suitable for cable installation, and which allows the cable route to avoid crossing this feature. It will also be possible to micro-route around other areas of Reef habitat further offshore.

The adverse effect identified is associated with the deposit of external cable protection; considered as a contingency solution. The most effective measure will therefore be to make all reasonable endeavours to bury the cables negating the requirement for external cable protection. This requirement has been communicated to the potential Installation Contractors throughout the EPC tender process and will continue to be monitored and challenged as the cable burial study is completed by the selected Installation Contractor. In particular, the extent of the required deposits will be closely examined to ensure the footprint is minimised as far as possible.

The following Project Specific Mitigation is being proposed and will be included in the Greenlink Marine ES – Wales.

1. No intrusive works will be undertaken at Freshwater West between mean high-water springs and mean low water springs.
2. Exclusion zones have been established around the majority of Annex I Bedrock Reef features identified within the Proposed Development; shown on Drawing P1975-INST-009. No intrusive works (e.g. cable installation, deposit of external cable protection material) will be undertaken within these exclusion zones.
3. The preference is to bury the HDD duct exit and all cables in sediment to the required depth of lowering. No external cable protection should be deposited at the HDD exit point.
4. A burial assessment study will be carried out by the Installation Contractor that defines the feasibility of achieving the required depth of burial. When determining the installation technique for the cable route between KP15 and KP23 (medium grade Stony Reef) the preference shall be to bury the cables in the seabed. If ground conditions do not allow this, then cutting should be investigated as the next alternative. External cable protection shall only be considered as the final option, and if necessary, the Installation Contractor shall seek to minimise the

footprint (length and width) of external cable protection required between KP15 and KP23 (Annex I Stony Reef).

5. Where external cable protection is used an environmental monitoring plan will be established to monitor colonisation of the external cable protection to demonstrate that the structure and function of the Reef feature has not been adversely affected in the long-term.
6. A tool box talk will be given ahead of all works. It will provide key identifying features for slipper limpet. Any slipper limpet found during installation will be kept and destroyed.

Without prejudice to NRWs determination of the Greenlink Interconnector Marine Licence Application and decision with respect to adverse effect on site integrity, and in consultation with NRW TE, a Habitat Compensation Plan has been produced to describe the compensatory measures and monitoring plan that could be implemented by GIL to ensure the coherence of the European Site Network and specifically Pembrokeshire Marine / Sir Benfro Forol SAC; provided as Appendix D to this HRA.

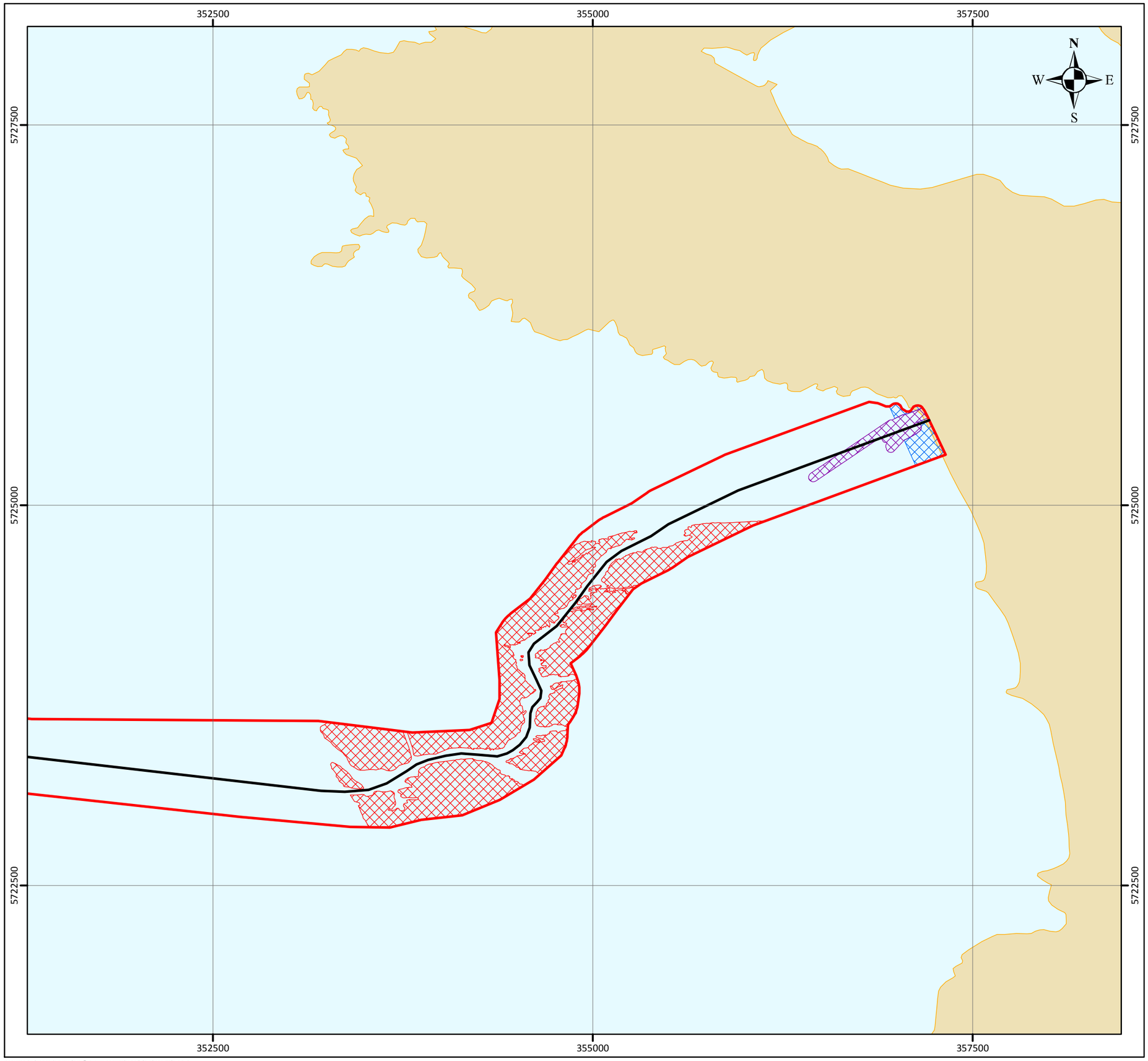
5.2.1.4 Conclusion

Cable burial will cause short-term habitat disturbance. Cable burial in the seabed is the best technical solution and therefore the preferred method of installation for the cables. Evidence has been provided to support the conclusion that in areas of Primary Feature Reef where cable burial is used, disturbance will be temporary with the Reef habitat able to re-colonise the disturbed ground within two years. **Burial in the seabed will not have a significant adverse effect on the Primary Feature Reef.**

If external cable protection is required, due to ground conditions preventing burial in the seabed, mitigation has been proposed to minimise the footprint of the external cable protection. Consultation with NRW (March 2020) has concluded that the presence of the external cable protection cannot be considered as mitigation, as previously concluded by the HRA process. Therefore, as there are no means of mitigating the effect, it is agreed there where external cable protection is used on the Primary Feature Reef there will be a loss of the habitat.

As it is uncertain that the integrity of the European site will not be adversely affected, **Stage 3 Assessment is required**.

Conclusion – Stage 3 Assessment required



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GREENLINK INTERCONNECTOR

INSTALLATION

Annex I Habitat Exclusion Zones - UK Route

Drawing No: P1975-INST-009	A

Legend

- Indicative Greenlink Route Centreline
- Proposed Development
- Annex I Habitat Exclusion Zone
- Decommissioned MOD Cable Avoidance Zone
- Trenching Exclusion Zone



NOTE: Not to be used for Navigation

Date	Monday, April 29, 2019 08:37:30
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OS; MMT; ESRI; Greenlink
File Reference	J:\P1975\Mxd\15_INST\ P1975-INST-009.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

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5.2.2 Primary Feature – Grey seal

5.2.2.1 Screening conclusion

The AA screening identified that there is the potential for a LSE on grey seal from the pressure underwater noise changes; related specifically to the deflagration of UXO (if required).

The conservation objectives for the Qualifying Feature are:

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status.

- Populations - The population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements include: population size; structure, production; condition of the species within the site. Population should not be reduced as a consequence of human activity.
- Range - The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future.
- Supporting habitats and species - The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include; distribution; extent; structure; function and quality of habitat; and prey availability and quality.

The AA screening concluded that in relation to the conservation objectives, the deflagration of UXO would not affect the range of the species population, nor will it affect the supporting habitats and species required to support the species population. However, if a number of adults and juveniles are within the water and the zone of influence at the time of UXO deflagration, without appropriate mitigation, they could potentially be killed or injured which will reduce the population size, and may also affect the structure of the population e.g. alter the ratio of adults and juveniles.

5.2.2.2 Background Information

The risk of encountering UXO has been a concern for GIL throughout the design lifecycle of Greenlink. To manage this risk a UXO desk-based assessment was commissioned in 2019 (reference: 1st Line Defence 2018) and a preliminary UXO survey was conducted in 2018/2019 along the Proposed Development where it crosses the Castlemartin Firing Range. The UXO survey did not identify any large UXO. The Greenlink UXO desk-based assessment identified 3lb shells (1.54kg charges) as the most likely UXO to be encountered within the Castlemartin Firing Range, based on current and historical use of the area.

If any significant UXO are identified GIL will implement the following decision-making process:

1. Avoid by micro-routeing the marine cables within the permitted corridor.
2. If it cannot be avoided, visual inspection confirms a UXO, and it is safe to do so, remove the UXO.
3. If it cannot be moved, detonate on site in accordance with Best Practice.

5.2.2.3 Assessment of effects prior to mitigation

High sound pressures and explosion related shock waves from high order detonation of UXO can lead to severe injury and hearing impairment in marine mammals including grey seal. Physical injury to marine mammals such as crushing, fracturing, hemorrhages and rupture of body tissue, caused either directly or indirectly by the blast wave, resulting in immediate or eventual mortality, is possible from underwater explosions. However, most research including von Benda-Beckmann *et al*. (2015) into effects of underwater explosions, focuses on the sound levels that are high enough to cause hearing loss i.e. a permanent threshold shift (PTS), as it is acknowledged that this is likely to occur at lower sound pressure levels than would cause the physical trauma injuries listed above. The justification is that if mitigation can be proposed to avoid PTS level effects this will also effectively mitigate for blast injuries.

High order detonations can cause disturbance over large ranges, although it is recognised that given the instantaneous nature of the explosion a one-off explosion may only elicit a startle response rather than causing widespread and prolonged displacement.

In order to establish the potential worst-case risk associated with a high order UXO detonation underwater noise modelling for the largest UXO historically used in the area was undertaken; a World War Two (WW2) sea mine with a charge size of 794kg. Detonation at two locations was modelled; Location 1 is representative of the range of environments (i.e. bathymetry and water depth) present along the Proposed Development and is close to both the Pembrokeshire Marine / Sir Benfro Forol SAC and West Wales Marine / Gorllewin Cymru Forol SAC. Location 2 is within the Castlemartin Firing Range.

The modelling results are presented in Appendix A and demonstrate that detonation of a 794kg UXO without any form of mitigation could cause significant noise changes over large ranges. At Location 1 (offshore) the radius for significant injurious auditory effects (PTS) is 7.8km increasing to 10.2km for a temporary auditory effect (TTS). Whilst decreasing the charge size also decreases the range of effect, it is concluded that there is the potential for a significant effect on grey seal unless mitigation is implemented. Therefore the 'do-nothing' scenario i.e. UXO detonation alone, is not a feasible alternative.

It is therefore recognised that UXO detonation cannot take place without mitigation in order to ensure no significant effects on grey seal.

5.2.2.4 Mitigation

GIL have committed to a series of mitigation measures to ensure there are no significant effects to grey seals as outlined below.

1. Avoid the need for detonation

The most effective mitigation is to avoid the need for detonation completely. Mitigation embedded into the design of the project (embedded mitigation EM21) seeks to do this by establishing a decision-making strategy in which UXO detonation is the last option.

This decision-making strategy will be supported by a UXO survey, to be carried out by the Installation Contractor prior to installation. The survey typically covers an area of seabed 50m either side of the proposed centreline, although this may be refined by specific constraints. The survey will identify magnetic anomalies within the corridor which will be categorised depending on their attributes as likely or potential UXO. If anomalies cannot be avoided by routeing, a visual inspection of the anomaly will be made.

Visual inspections (e.g. by diver or ROV) will be made by a suitably qualified survey contractor and Explosives Ordnance Detonation (EOD) expert. For each confirmed UXO a disposal strategy will be agreed. Detonation will only be considered as the last resort.

If UXO detonation is the only feasible option, the target could either be detonated in-situ (typically the preferred option for health and safety reasons); or relocated on the seabed and then detonated. Relocation could occur when detonating in-situ would compromise the safety of Greenlink, third party assets or the public, or where one UXO is relocated close to another to allow a single detonation to take place.

If a UXO detonation is required, the Greenlink Marine Mammal Mitigation Plan (see point 6 below) will be reviewed ahead of any works to ensure it remains current and takes into consideration any new advice published by statutory bodies.

2. Use of deflagration for all UXO charge sizes

GIL will commit to undertaking deflagration (low order detonation) on any UXO charge size that requires disposal. The deflagration process is described in Cheong *et al*. (2020) as *"the UXO casing is penetrated by a shaped charge that generates insufficient shock to detonate. The explosive material inside the UXO reacts with a rapid burning rather than a chain reaction that would lead to a full explosion. Deflagration is a much less energetic process and anecdotal evidence has suggested that it is "quieter" than traditional high-order detonation."*.

Cheong *et al*. (2020) goes on to say that US test studies show that low-order detonation procedures are very effective in reducing blast effects with a yield reduction exceeding 97% in comparison to the equivalent high-order detonation. Cheong *et al*. (2020) reports the results of an experimental trial conducted in Limehillock Quarry, Scotland to study the acoustic characteristics of underwater explosions, including low order detonation by deflagration. The study observed a

more than 20dB reduction in peak sound pressure levels (SPL) and sound exposure levels (SEL) between high-order detonations and low-order detonations of the same charge size. The data clearly showed that low-order detonations *"offer a much lower amplitude of peak sound pressure than high-order detonations (by a factor of approximately 10 [in our trials])"* Cheong *et al.* (2020). The study concluded that low-order deflagration is an effective mitigation measure.

Deflagration involves the selection of an appropriate charge size based on the size of the UXO, however it is understood that the maximum deflagration charge size is equivalent to 1.54kg. This significantly reduces the potential zone of effect for injurious and temporary auditory effects. Appendix A concluded that for grey seal, the zone of influence for a 1.54kg charge ranges from 3.2km to 4.4km for PTS and 4.8km to 6.2km for TTS depending on the location within the Proposed Development. These zones are based on modelling of at a frequency of 10kHz. Modelling was also undertaken as the 40kHz frequency to provide an estimate of the potential impacts of the shockwave, which is more likely to cause damage beyond the auditory system (Keevin and Hempner 1997). This resulted in the thresholds for PTS (assumed to represent the level at which damage to organs outside the auditory system will begin to occur) and TTS decreasing to 0.78km and 1.1km respectively.

3. Use of Acoustic Deterrent Devices (ADD)

The Lofitech AS seal scarer, an acoustic deterrent device (ADD) will be activated 50 minutes prior to UXO deflagration dependant on the UXO charge size. ADDs are used to exclude animals from a mitigation zone and are used in conjunction with visual and / or acoustic monitoring and should normally be used for as short period as necessary to minimise the introduction of additional noise. These devices emit medium to high frequency sounds that deter animals from injury zones. They have been widely used by offshore industries during pile-driving, and at windfarms for UXO clearance activities (McGarry et al. 2017, McGarry et al. 2020). McGarry et al. (2017) observed that fleeing individuals were at least 1,500 m from the sound source when exposed to the ADD for 15 minutes. It is therefore considered that the use of ADDs combined with marine mammal observations for this purpose would be more effective than traditional passive mitigation methods.

4. Use of Passive Acoustic Monitoring to support visual observations

The use of Passive Acoustic Monitoring (PAM) systems has also been identified as a further mitigation measure. PAM is a software system that utilises hydrophones to detect the vocalisations of marine mammals. It is useful during periods of darkness, poor visibility or when the sea state is not conducive to visual mitigation. A PAM system would be used to support the marine mammal visual observations and will be used during periods of darkness and/or poor visibility. It would be operated by a suitably trained and experienced marine mammal observer (MMO). The PAM system typically comprises signal processing equipment located in a control room, an intermediary deck cable, and a cable terminating with a hydrophone array. The PAM system would be optimised for the real-time detection (i.e. live visual display and audible output) of marine mammals know to be present within the Proposed

Development. A PAM system could be used in conjunction with ADDs – this would enable the MMO to monitor the presence or absence of marine mammals within the zone of influence prior to deflagrating any UXO.

5. Soft start

If required, a soft-start procedure will also be used in combination with the ADDs. In this scenario, the MMO's would conduct a pre-start search, the ADDs would be activated and then a sequence of small to large charges would be implemented to allow additional time for marine mammals to leave the area of potential effect. Typically, charges of 50g, 100g, 150g and 200g would be deployed 5 minutes after the deactivation of the ADD and would be sequenced to commence at 5 minute intervals, with the a further 5 minute interval before the deflagration of the UXO. An additional 250g charge may be added to the sequence if the UXO requiring deflagration is greater than 250kg.

6. Use of Big Bubble Curtain (BBC)

Big bubble curtains (BBC) are noise abatement techniques designed to change the physical condition of the water and the outward propagation of the acoustic/shock waves. The aim of using a BBC is to reduce the sound energy emitted into the environment, thereby reducing the distance over which injury/PTS onset may occur.

A bubble curtain consists of walls of bubbles rising from a nozzle or porous pipe that is secured to the seabed and connected to an air compressor. Bubble curtains can consist of one or two hoses lined up parallel to each other.

A review of literature was conducted to determine environmental limitations and efficacy of BBC; with reference made to Verfuss *et al.* (2019).

Cheong *et al.* (2020) states that *"increased water depth militates*[5] *against bubble curtains"*. Verfuss *et al.* (2019) supports this statement reporting that the deployment and efficacy of BBCs is more challenging in water depths deeper than 30m. The challenge is to get sufficient air from surface compressors to the hoses lying on the seabed. The report states *"a larger number of compressors and a higher operating pressure are needed for deeper water to generate a higher air flow to ensure that large enough bubbles are released into the water at depth."* However, it does report the commercial deployment of BBCs on windfarms in water depths up to 45m; and that suppliers report commercial deployment of their systems in water depths >70m (with Nord Stream 2 using BBCs during UXO clearance in water depths up to 90m).

Verfuss *et al.* (2019)[Error! Bookmark not defined.] also reports that for BBC deployment, a s ignificant wave height of 1.5m is the frequent limiting factor for safe deployment. However, information provided by the suppliers to the report authors suggests that deployment and operation is feasible in significant wave heights up to 3m. Other environmental limitations include a water current speed of 1m/s. The report states that "*With a rise velocity of 0.3 m/s, (realistic for a BBC) and a tidal current of 1*

[5] Represents a conclusive factor in preventing

m/s, bubbles would drift off by about 70 m when rising from 20 m depth to the water surface. Thus, the resulting bubble curtain would not build up vertically but obliquely. Therefore, to provide a complete shield, the BBC would need to be deployed in an oval shape, with the point of the oval ring greater than 70 m away from the pile position facing the current." The efficacy of the BBC is therefore impacted by strong currents, especially in deep water.

At water depths of up to 40m Verfuss *et al.* (2019) states that a reduction of 7-11 dB SEL_{ss} can be achieved with respect to piling noise and the use of a BBC. However, the efficacy decreases with increasing deployment depth. Verfuss *et al.* (2019) also reports that studies undertaken by the German Federal Armed Forces Underwater Acoustics and Marine Geophysics Research Institute concluded that attenuation of more than 10 dB and up to 16dB in peak sound pressure levels could be achieved with 1 to 3 BBCs when detonating a 1kg charge at 13m water depth; and although noise measurements of UXO clearance using BBCs for the Nord Stream 2 gas pipeline in water depths of up to 90m showed that peak pressure levels were less than assessed in the permit application, no evaluation of the effectiveness of the bubble curtain was presented.

With respect to environmental conditions within the Proposed Development the key factors are presented below:

- Water depths within the Proposed Development increase relatively rapidly from the coast with the 40m depth contour reached at KP9.4. The seabed then gradually slopes to the 70m depth contour at KP42.9.
- Spring tidal currents reach peak speeds of 1.0m/s to 1.5m/s generally in a northwest-southeast direction past the Pembrokeshire coast. Currents during neap tides peak at around 0.75m/s (Barne *et al.* 2005).
- The average wave height for the Proposed Development ranges from 1.75m to 2m at the UK/Irish median line increasing to between 2.5m to 4m at the Freshwater West landfall (Barne *et al.* 2005). Data for South Wales Wave Resource Area (Fairley 2014) which although not located in the Proposed Development provides a good indication of the likely wave climate and indicates mean significant wave height of 1.63m.

Based on the environmental limitations reported in Verfuss *et al.* (2019) this would suggest that wave height, tidal currents and water depth all could be limiting factors within the Proposed Development; especially as a seasonal restriction limiting UXO detonation to winter months is proposed (see below) which would decrease the chance of achieving optimal weather conditions for deployment. It can therefore not be guaranteed that the deployment of a BBC is technically feasible.

However, taking the above into consideration, Greenlink will commit to:

- A big bubble curtain (BBC) will be used for deflagration in water depths equal to or less than 40m i.e. between KP0 and KP9.4.

- If a UXO is identified in water depths of 40-70m advice would be sought as to practicalities and cost of deploying a BBC in winter at the specific location. A BBC will be used if the contractor concludes it will be effective.

7. Seasonal (winter) Restriction

UXO deflagration will only be carried out during the winter season - between 01 October and 31 March.

8. Implement Greenlink Marine Mammal Mitigation Plan

For UXO deflagration/detonation it is best practice to follow the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010, or as updated) (see embedded mitigation EM23). The procedures outlined in the guidance and the additional site specific measures outlined above have been incorporated into a Greenlink Marine Mammal Mitigation Plan; provided as Appendix E.

The MMMP:

1. Outlines the mitigation measures that will be implemented to avoid or reduce injury and disturbance effects to marine mammals;
2. Provides the procedures to be followed to implement the mitigation measures effectively and in line with current guidelines and best practice;
3. Sets out the roles and responsibilities of key personnel who will implement the MMMP; and
4. Describes the reporting protocol in place to demonstrate that the MMMP has been successfully implemented.

GIL and its contractors are responsible for ensuring the MMMP is implemented.

5.2.2.5 Assessment of effects having implemented mitigation

The assessment below has been undertaken considering the mitigation measures proposed in Section 5.2.2.4 above; specifically that UXO deflagration will take place in winter using ADDs, visual observations and PAM and in certain locations a BBC.

Questions	Response
Will the proposed operation or activity result in death, injury or disturbance of individuals?	If UXO deflagration is required, modelling estimates that for Location 2 within the Castlemartin Firing Range (e.g. coastal shallow waters), the sudden pressure change could cause auditory injury i.e. PTS within 4.4km and temporary auditory damage (TTS) within 6.2km for grey seal. The zone of influence decreases with the depth of water so that at Location 1 the onset of PTS would occur at 3.2km and TTS at 4.8km. The distance for the onset of disturbance was 26.8km at Location 1 and 40km at Location 2 using deflagration. It should be noted that the modelling of the 40kHZ frequency, to represent damage beyond the auditory system indicates effects are limited to 0.78km (PTS) and 1.1km (TTS). There are three categories of noise mitigation that can be applied to UXO detonation, namely noise abatement/reduction, spatial/temporal restrictions and acoustic deterrents. The range of mitigation proposed in Section 5.2.2.4 is a combination of all three categories and represents all currently available noise mitigation techniques. Individually, each of the techniques have been proven to mitigate UXO detonation, for example,

Questions	Response
	deflagration reduces blast effects by 97% in comparison to the equivalent high-order detonation (Cheong *et al*. 2020). The implementation of a BBC will reduce sound levels by approximately 7-11dB (Verfuss *et al*. 2019). Acoustic deterrent devices will deter animals within 2km of the deflagration (McGarry *et al*. 2020). Based on Verfuss *et al*. 2019, the effects of both a 7 and 11dB reduction to a 1.54kg UXO deflagration were modelled for Location 2. As the feasibility of BBC in deeper water is limited, Location 1 was not included in the BBC reduction modelling and zone of influences remain as reported above for Location 1. A 7dB reduction reduces the zone of influence for PTS to 2.8km and TTS to 4.2km. A 11dB reduction means the onset of PTS will occur within 1.9km and TTS within 3.3km. When BBC are combined with ADD which are effective up to 2km, for a 7dB reduction, there remains approximately 12.06km^2 of the zone of influence that would be exposed to PTS level noise changes; and 42.85km^2 of the zone of influence zone exposed to TTS level noise changes. For the 11dB reduction, there will be no PTS effects to grey seal and the zone of influence for TTS will be limited to 21.65km^2 It should be noted that, while the zone of influence for TTS remains in both BBC scenarios, animals can recover from TTS effects. While it cannot be categorically ruled out that injurious effects will not occur, the mitigation proposed represents all reasonable measures to avoid and reduce significant effects to grey seal. The potential remains for animals within 30km of Location 1 and 40km of Location 2 to be disturbed, however effects will not be significant. The UXO deflagration will be a one-off instantaneous event. Although animals may display a startle reaction there will not be widespread or prolonged displacement.
Is it possible to estimate the number of individuals that are likely to be affected	As a mobile species that range over a large area, it is not possible to estimate with certainty how many grey seal could be within the water and zone of influence at the time of a UXO deflagration. The population estimate for south-west Wales is approximately 5000 individuals. It is estimated (based on grey seal at-sea usage maps, Russell et al 2017) that the mean number of individuals in the waters of the Proposed Development will vary from 5 to 10 individuals per 5km^2. Conservatively, this could mean that: • If deflagration was to occur between KP0 and KP9.4 (i.e. where ADD and a BBC can be implemented) between 12 and 24 individuals may experience PTS level noise changes, and between 43 and 86 individuals may experience TTS level noise changes (assuming only a 7dB reduction in SPL due to the BBC). • If deflagration was to occur from KP9.4 onwards it cannot be guaranteed that the BBC will be effective and therefore it is assumed that only ADDs will be used. Between 48 and 97 individuals may experience PTS level noise changes and between 121 and 242 individuals could experience TTS level noise changes. • These figures represent between 0.2% (12 individuals) and 4.8% (242 individuals) of the south-west Wales population. As the zone of influence for disturbance is potentially wider than the SAC boundary it would also mean that the whole population could be subject to brief disturbance, but this is highly unlikely as not all animals will be in the water at the same time. Grey seal will be most vulnerable to UXO deflagration during summer months (May – August) when they are more likely to be in the water. From August through to December animals are likely to be hauled up on beaches for pupping. The seasonal restriction proposed will therefore aid in limiting the number of animals that could be present within the zones of influence.
Will individuals be disturbed at a sensitive	The sensitive time for grey seal at the site will be during breeding (August to December), moulting (December – February) and resting (all year). The thresholds for injury are for pinnipeds in water. Animals engaged in the

Questions	Response
time or location during their life cycle	activities listed above will be hauled-out on beaches out of the water. Therefore, noise generated by UXO deflagration will not affect breeding, moulting and resting. Sound in air will be a brief event. Although the exact location of the UXO deflagration is unknown, the closest haul-out sites to the Proposed Development are Linney Head (4.5km east) and Skokholm Island (4.5km north). It is highly unlikely that this would adversely affect seal that are hauled out, engaged in breeding, resting and moulting behavior.
Are the effects likely to focus on a particular section of the population, e.g., adults vs. juveniles, males vs. females	It is possible that both sexes of juveniles and adults could be within the zone of influence during UXO detonation.
Will the operation/activity cause displacement from key functional areas	Underwater noise activities will not displace seal. The UXO deflagration, if required, will be a brief one-off event and any animals disturbed by the sudden but brief underwater noise change will be able to return to the area rapidly.
Is the habitat of the species likely to deteriorate causing disturbance to individuals or populations	No. The change in underwater noise will be brief and will not affect grey seal habitat.
How quickly is the affected population in the SAC likely to recover once the operation/activity has ceased	The south-west Wales population was estimated at 5000 individuals. Average pup production remained consistent between 1992 and 2008 averaging 208 pups per year. However, pup production has been steadily increasing with 2013-15 recording the highest average productions at 357 pups. If sufficient numbers of animals were injured by the UXO deflagration there could be a long-term effect on the population. However, the range of mitigation proposed in Section 5.2.2.4 represents all currently available noise mitigation techniques. Individually, each of the techniques have been proven to mitigate the effects of high order UXO detonations, and are widely accepted as best practice especially for activities within European sites. Given the seasonal restriction proposed it is not thought likely that high numbers of animals will be present in the water however this cannot be categorically stated. It is not possible to determine how quickly the population will recover, given that exact numbers affected cannot be firmly predicted.
Are the effects of the proposed operation/activity on Annex II species likely to have a significant effect on the favourable conservation condition of the Annex II species at the site	While it cannot be categorically ruled out that injurious and disturbance effects will not occur, the mitigation proposed represents all reasonable currently available measures to avoid and reduce significant effects to grey seal.
Is there the potential for cumulative effects with other plans or projects?	Stage 1 Screening concluded that there will be no PCEs between the Proposed Development and any other known project or plans.

5.2.2.6 Conclusion

As a precaution, because it cannot be confirmed that UXO deflagration will not be required, GIL will apply for an EPS Licence to disturb grey seal.

If grey seal are injured, this could disrupt the population composition of the European site. It is possible that between 0.2% (12 individuals) and 4.8% (242 individuals) of the south-west Wales population could be exposed to either auditory injury or temporary auditory damage if UXO deflagration was required.

To mitigate the potential for significant effects, Greenlink has committed to using deflagration for all UXO charge sizes; proposed a seasonal restriction to ensure deflagration will occur when species densities are likely to be at their lowest; and proposed the use of noise abatement and acoustic deterrents. These mitigation measures have proven successful for similar projects in UK waters e.g. NEMO Link, Moray East Offshore Wind Farm, Rampion Offshore Windfarm, Beatrice Offshore Windfarm, and represents all reasonable currently available measures to avoid and reduce significant effects to grey seal.

Implementation of the mitigation will reduce the significance of the effect to a level whereby the three conservation objectives for the Qualifying Feature (i.e. populations, range, and supporting species and habitats) will not be adversely affected.

In light of this, it is concluded that the Proposed Development will not have an adverse effect on the integrity of the Pembrokeshire Marine / Sir Benfro Forol SAC either alone or in combination with other plans or projects.

Conclusion - No adverse effect on integrity of site, either alone or in combination with other plans or projects.

5.3 West Wales Marine / Gorllewin Cymru Forol SAC

5.3.1 Primary Feature – Harbour porpoise

5.3.1.1 Screening conclusion

The AA screening identified that there was potential for a LSE on harbour porpoise from the pressure underwater noise changes; related specifically to the deflagration of UXO.

The conservation objective for this site is to avoid deterioration of the habitats of harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise. The following attributes are maintained or restored in the long term:

a. The species is a viable component of the site.

b. There is no significant disturbance of the species.

c. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

The AA screening concluded that in relation to the conservation objectives, UXO deflagration will not affect harbour porpoise habitat and following deflagration,

harbour porpoise will still remain a viable component of the site. However, as the UXO deflagration could be within the boundary of the SAC, if animals are within the zone of influence at the time of UXO deflagration ~~n~~, they could be injured or significantly disturbed.

5.3.1.2 Background Information

The risk of encountering UXO has been a concern for GIL throughout the design lifecycle of Greenlink. To manage this risk a UXO desk-based assessment was commissioned in 2019 (reference: 1st Line Defence 2018) and a preliminary UXO survey was conducted in 2018/2019 along the Proposed Development where it crosses the Castlemartin Firing Range. The UXO survey did not identify any large UXO. The Greenlink UXO desk-based assessment identified 3lb shells (1.54kg charges) as the most likely UXO to be encountered within the Castlemartin Firing Range, based on current and historical use of the area.

If any significant UXO are identified GIL will implement the following decision-making process:

1. Avoid by micro-routeing the marine cables within the permitted corridor.
2. If it cannot be avoided, visual inspection confirms a UXO, and it is safe to do so, remove the UXO.
3. If it cannot be moved, detonate on site in accordance with Best Practice.

5.3.1.3 Assessment of effects prior to mitigation

High sound pressures and explosion related shock waves from high order detonation of UXO can lead to severe injury and hearing impairment in marine mammals including harbour porpoise. Physical injury to marine mammals such as crushing, fracturing, hemorrhages and rupture of body tissue, caused either directly or indirectly by the blast wave, resulting in immediate or eventual mortality, is possible from underwater explosions. However, most research including von Benda-Beckmann *et al*. (2015) into effects of underwater explosions, focuses on the sound levels that are high enough to cause hearing loss i.e. a PTS, as it is acknowledged that this is likely to occur at lower sound pressure levels than would cause the physical trauma injuries listed above. The justification is that if mitigation can be proposed to avoid PTS level effects this will also effectively mitigate for blast injuries.

High order detonations can cause disturbance over large ranges, although it is recognised that given the instantaneous nature of the explosion a one-off explosion may only elicit a startle response rather than causing widespread and prolonged displacement.

In order to establish the potential worst-case risk associated with a high order UXO detonation underwater noise modelling for the largest UXO historically used in the area was undertaken; a WW2 sea mine with a charge size of 794kg. Detonation at two locations was modelled; Location 1 is representative of the range of environments (i.e. bathymetry and water depth) present along the Proposed

Development and is close to both the Pembrokeshire Marine / Sir Benfro Forol SAC and West Wales Marine / Gorllewin Cymru Forol SAC. Location 2 is within the Castlemartin Firing Range.

The modelling results are presented in Appendix A and demonstrate that detonation of a 794kg UXO without any form of mitigation could cause significant noise changes over large ranges. At Location 1 (offshore) the radius for significant injurious auditory effects (PTS) in harbour porpoise is 17.5km increasing to 19.6km for a TTS. Whilst decreasing the charge size also decreases the range of effect, it is concluded that there is the potential for a significant effect on harbour porpoise unless mitigation is implemented. Therefore the 'do-nothing' scenario i.e. UXO detonation alone, is not a feasible alternative.

It is therefore recognised that UXO detonation cannot take place without mitigation in order to ensure no significant effects on harbour porpoise.

5.3.1.4 Mitigation

GIL have committed to a series of mitigation measures to ensure there are no significant effects to marine mammals (including specifically harbour porpoise and grey seal, which are Primary Features of European sites which the Proposed Development crosses). These are discussed in detail in Section 5.2.2.4 above and have not been repeated here. However in summary they include:

1. Avoid the need for detonation completely;
2. Use of deflagration for all UXO charge sizes;
3. Use of ADDs;
4. Use of a PAM system to support visual observation;
5. Soft start;
6. Use of BBCs;
7. Seasonal (winter) restriction; and
8. Implement the Greenlink Wales Marine Mammal Mitigation Plan (Appendix E).

5.3.1.5 Assessment of effects having implemented mitigation

The assessment below has been undertaken considering the mitigation measures proposed in Section 5.3.1.4 above and described fully in Section 5.2.2.4.

Questions	Response
Will the proposed operation or activity result in death, injury or disturbance of individuals?	If UXO deflagration is required, modelling estimates for Location 2 within the Castlemartin Firing Range (e.g. coastal shallow waters), the sudden pressure change could cause PTS within 10.6km and TTS within 14km for harbour porpoise. The zone of influence decreases with the depth of water so that at Location 1 the onset of PTS would occur at 8.6km and TTS at 11.2km. The distance for the onset of disturbance was 26.8km at Location 1 and 40km at Location 2. It should be noted that the modelling of the 40kHZ frequency, to represent damage beyond the auditory system indicates effects are limited to 1.6km (PTS) and 1.9km (TTS)

Questions	Response
	There are three categories of noise mitigation that can be applied to UXO detonation, namely noise abatement/reduction, spatial/temporal restrictions and acoustic deterrents. The range of mitigation proposed in Section 5.2.2.4 is a combination of all three categories and represents all currently available noise mitigation techniques. Individually, each of the techniques have been proven to mitigate UXO detonation, for example, deflagration reduces blast effects by 97% in comparison to the equivalent high-order detonation (Cheong *et al*. 2020). The implementation of a BBC will reduce sound levels by approximately 7-11dB (Verfuss *et al*. 2019). Acoustic deterrent devices will deter animals within 6km of the deflagration (McGarry *et al*. 2020). Based on Verfuss *et al*. 2019, the effects of both a 7 and 11dB reduction to a 1.54kg UXO deflagration were modelled for Location 2. As the feasibility of BBC in deeper water is limited, Location 1 was not included in the BBC reduction modelling and zones of influence remain as reported above for Location 1. A 7dB reduction reduces the zone of influence for PTS to 7.3km and TTS to 10.0km. A 11dB reduction means the onset of PTS will occur within 5.8km and TTS within 8.3km. When BBC are combined with ADD which are effective up to 6km, for a 7dB reduction, there remains approximately 54.32km^2 of the zone of influence that would be exposed to PTS level noise changes; and 201km^2 of the zone of influence zone exposed to TTS level noise changes. For the 11dB reduction, there will be no PTS effects to harbour porpoise and the zone of influence for TTS will be limited to 103.3km^2 It should be noted that, while the zone of influence for TTS remains in both BBC scenarios, animals can recover from TTS effects. While it cannot be categorically ruled out that injurious effects will not occur, the mitigation proposed represents all reasonable measures to avoid and reduce significant effects to harbour porpoise. Where only ADDs are used the ranges for physical auditory injury and temporary auditory damage are larger; approximately 119km^2 for PTS and 394km^2 for TTS. The potential remains for animals within 30km of Location 1 and 40km of Location 2 to be disturbed, however effects will not be significant. The UXO deflagration will be a one-off instantaneous event. Although animals may display a startle reaction there will not be widespread or prolonged displacement. Noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoises from more than: 1. 20% of the relevant area of the site in any given day, and 2. an average of 10% of the relevant area of the site over a season. The largest zone of influence estimated by the underwater modelling is 40km with respect to disturbance. A GIS was used to establish the maximum percentage of the European site that a 40km zone of influence would affect. Depending on the location of the deflagration the percentage of the European site affected increased or decreased depending on how close the boundary of the site or the coastline were. However, the maximum percentage that could be affected is 22.5% of the summer area. As the proposed deflagration will take place during winter, and the zones of influence will not overlap with the winter grounds it will not cause significant disturbance.
Is it possible to estimate the number of individuals that are likely to be affected	As a mobile species that range over a large area, it is not possible to estimate with certainty how many harbour porpoise could be within the zone of influence at the time of a UXO deflagration. Baines and Evans (2012) suggests densities could exceed 10 animals per 10km^2. Hammond et al (2017) suggests densities are lower, in the range of 0.118 – 0.239 animals per km^2. It is estimated that the SAC supports approximately 2506 individuals (95% Confidence Interval: 1410 - 4455) for at least part of the year, as seasonal differences are likely to occur. The European site has been designated for both summer and winter harbour

Questions	Response
	porpoise grounds. The Proposed Development crosses the summer grounds and therefore densities will be lower during winter months (i.e. when deflagration is proposed). The estimated zones of influence for PTS, TTS and disturbance do not overlap with the winter grounds. Conservatively, (based on summer densities) this could mean that: • If deflagration was to occur between KP0 and KP9.4 (i.e. where ADD and a BBC can be implemented) between 6 and 54 animals could be exposed to PTS level noise changes, and between 23 and 200 animals could be exposed to TTS level noise changes. These ranges have been calculated assuming that all the zone of influence is within the European site. However, given the proximity of the coastline, a significant proportion of the zone of influence will intersect with the coastline, and therefore these ranges are overestimates and may be reduce by as much as 50% when the exact location of the UXO deflagration is known. • If deflagration was to occur from KP9.4 onwards it cannot be guaranteed that the BBC will be effective and therefore it is assumed that only ADDs will be used. Between 14 and 119 individuals may experience PTS level noise changes and between 46 and 394 individuals could experience TTS level noise changes. • These figures represent between 0.23% and 15.7% of the European site population.
Will individuals be disturbed at a sensitive time or location during their life cycle	The European site has specific winter and summer grounds defined within it. The Proposed Development crosses the summer grounds. The estimated zones of influence for UXO deflagration do not intersect the winter grounds. By proposing to undertake the deflagration during winter months the highest densities of harbour porpoise will be avoided.
Are the effects likely to focus on a particular section of the population, e.g., adults vs. juveniles, males vs. females	It is possible that both sexes of juveniles and adults could be within the zone of influence during UXO deflagration.
Will the operation/activity cause displacement from key functional areas	The UXO deflagration, if required, will be a brief one-off event and any animals disturbed by the sudden but brief underwater noise change will be able to return to the area rapidly.
Is the habitat of the species likely to deteriorate causing disturbance to individuals or populations	The change in underwater noise will be brief and will not affect supporting habitat or species.
How quickly is the affected population in the SAC likely to recover once the operation/activity has ceased	The European site population is estimated at 5000 individuals but the population forms part of the large MU where numbers are estimated to be around 47,229 (DECC 2006). If sufficient numbers of animals were injured by the UXO deflagration there could be a long-term effect on the population. However, the range of mitigation proposed in Section 5.2.2.4 represents all currently available noise mitigation techniques. Individually, each of the techniques have been proven to mitigate the effects of high order UXO detonations, and are widely accepted as best practice especially for activities within European sites. Given the seasonal restriction proposed it is not thought likely that high numbers of animals will be present in the water however this cannot be categorically stated. It is not possible to determine how quickly the population will recover, given that exact numbers affected cannot be firmly predicted.

Questions	Response
Are the effects of the proposed operation/activity on Annex II species likely to have a significant effect on the favourable conservation condition of the Annex II species at the site	While it cannot be categorically ruled out that injurious and disturbance effects will not occur, the mitigation proposed represents all reasonable currently available measures to avoid and reduce significant effects to harbour porpoise.
Is there the potential for cumulative effects with other plans or projects?	Stage 1 Screening concluded that there will be no PCEs between the Proposed Development and any other known project or plans.

5.3.1.6 Conclusion

As a precaution and as it cannot be confirmed that UXO deflagration will not be required, GIL will apply for an EPS Licence to disturb harbour porpoise.

If harbour porpoise are injured, this could disrupt the population composition of the European site. It is possible that between 0.12% and 7.88% of the European site population could be exposed to either auditory injury or temporary auditory damage if UXO deflagration was required.

To mitigate the potential for significant effects, Greenlink has committed to using deflagration for all UXO charge sizes; proposed a seasonal restriction to ensure deflagration will occur when species densities are likely to be at their lowest; and proposed the use of noise abatement and acoustic deterrents. These mitigation measures have proven successful for similar projects in UK waters e.g. NEMO Link, Moray East Offshore Wind Farm, Rampion Offshore Windfarm, Beatrice Offshore Windfarm, and represents all reasonable currently available measures to avoid and reduce significant effects to harbour porpoise.

Implementation of the mitigation will reduce the significance of the effect to a level whereby the three conservation objectives for the Primary Feature (i.e. populations, range, and supporting species and habitats) will not be adversely affected.

In light of this, it is concluded that the Proposed Development will not have an adverse effect on the integrity of the West Wales Marine / Gorllewin Cymru Forol SAC either alone or in combination with other plans or projects.

Conclusion – No adverse effect on integrity of site, either alone or in combination with other plans or projects.

5.4 Bristol Channel Approaches/ Dynesfeydd Môr Hafren SAC

5.4.1 Primary Feature – Harbour porpoise

5.4.1.1 Screening conclusion

The AA screening identified that there was potential for an LSE on harbour porpoise from the pressure underwater noise changes; related specifically to the deflagration of UXO.

The conservation objective for this site is to avoid deterioration of the habitat of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise.

To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:

1. The species is a viable component of the site.
2. There is no significant disturbance of the species.
3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

If any significant UXO are identified GIL will implement the following decision-making process:

1. Avoid by micro-routeing the marine cables within the permitted corridor.
2. If it cannot be avoided, visual inspection confirms a UXO, and it is safe to do so, remove the UXO.
3. If it cannot be moved, detonate on site in accordance with Best Practice.

5.4.1.2 Background Information

The risk of encountering UXO has been a concern for GIL throughout the design lifecycle of Greenlink. To manage this risk a UXO desk-based assessment was commissioned in 2019 (reference: 1st Line Defence 2018) and a preliminary UXO survey was conducted in 2018/2019 along the Proposed Development where it crosses the Castlemartin Firing Range. The UXO survey did not identify any large UXO. The Greenlink UXO desk-based assessment identified 3lb shells (1.54kg charges) as the most likely UXO to be encountered within the Castlemartin Firing Range, based on current and historical use of the area.

GIL's primary objective is to avoid encountered potential UXO by micro-routeing within the Application Area. If re-routeing around a particular potential UXO appears not to be possible, and visual inspection confirms a UXO, then if it is safe to do so the UXO will be removed. As a last resort deflagration measures will be undertaken in accordance with Best Practice.

5.4.1.3 Assessment of effects prior to mitigation

High sound pressures and explosion related shock waves from high order detonation of UXO can lead to severe injury and hearing impairment in marine mammals including harbour porpoise. High order detonations can also cause disturbance over large ranges, although it is recognised that given the instantaneous nature of the explosion a one-off explosion may only elicit a startle response rather than causing widespread and prolonged displacement.

In order to establish the potential worst-case risk associated with a high order UXO detonation underwater noise modelling for the largest UXO historically used in the area was undertaken; a WW2 sea mine with a charge size of 794kg. Detonation at two locations was modelled; Location 1 is representative of the range of environments (i.e. bathymetry and water depth) present along the Proposed Development and is close to both the Pembrokeshire Marine / Sir Benfro Forol SAC and West Wales Marine / Gorllewin Cymru Forol SAC. Location 2 is within the Castlemartin Firing Range.

The modelling results are presented in Appendix A and demonstrate that detonation of a 794kg UXO without any form of mitigation could cause significant noise changes over large ranges. At Location 1 (offshore) the radius for significant injurious auditory effects (PTS) in harbour porpoise is 17.5km increasing to 19.6km for a TTS. As the European site is further than 20km from the Proposed Development there will be no noise levels sufficient to cause injurious or temporary auditory effects within the site boundary. However, the threshold for the onset of disturbance has been calculated as greater than 40km from the deflagration location. It is therefore possible that deflagration may disturb harbour porpoise within the European site.

5.4.1.4 Mitigation

GIL have committed to a series of mitigation measures to ensure there are no significant effects to marine mammals (including specifically harbour porpoise and grey seal, which are Primary Features of European sites which the Proposed Development crosses). These are discussed in detail in Section 5.2.2.4 above and have not been repeated here. However, in summary they include:

1. Avoid the need for detonation completely;
2. Use of deflagration for all UXO charge sizes;
3. Use of ADDs;
4. Use of a PAM system to support visual observation;
5. Soft start;
6. Use of BBCs;
7. Seasonal (winter) restriction; and
8. Implement the Greenlink Wales Marine Mammal Mitigation Plan (Appendix E).

5.4.1.5 Assessment of effects having implemented mitigation

The assessment below has been undertaken considering the mitigation measures proposed in Section 5.4.1.4 above.

Questions	Response
Will the proposed operation or activity result in death, injury or disturbance of individuals?	Modelling indicates that the zone of influence for auditory injury (PTS) and temporary auditory damage (TTS) from UXO deflagration will not overlap with the European site. There will be no injury of individuals. Noise levels sufficient to cause disturbance may be experienced up to 40km from the deflagration. However, it is recognised that given the instantaneous nature of the explosion a one-off explosion may only elicit a startle response rather than causing widespread and prolonged displacement. The European site is designated as a winter ground for harbour porpoise. Noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoises from more than: 1. 20% of the relevant area of the site in any given day, and 2. an average of 10% of the relevant area of the site over a season. A GIS was used to establish the maximum percentage of the European site that a 40km zone of influence would affect. Depending on the location of the deflagration the percentage of the European site affected increased or decreased depending on how close the boundary of the site or the coastline were. However, the maximum percentage that could be affected is 17.36% during the relevant season (winter). Therefore, noise disturbance will not be considered significant. It should be noted that this percentage will decrease if a BBC is used.
Is it possible to estimate the number of individuals that are likely to be affected	As a mobile species that range over a large area, it is not possible to estimate with certainty how many harbour porpoise could be within the zone of influence at the time of a UXO deflagration. It is estimated that the site supports 2147 individuals (95% Confidence Interval: 810 – 5,693) for at least part of the year. Although it is recognised that there is uncertainty in this number as it is based on estimates derived from the July 2005 SCANS-11 survey and is unlikely to be reflective of abundances in other months. Assuming an equal distribution across the site, approximately 373 animals could be disturbed if 17.36% of the site experiences underwater noise changes.
Will individuals be disturbed at a sensitive time or location during their life cycle	The Bristol Channel Approaches SAC has been identified as important during the winter season (containing persistent high densities). Deflagration is proposed during the winter season as mitigation to avoid sensitivities within other European sites the Proposed Development crosses.
Are the effects likely to focus on a particular section of the population, e.g., adults vs. juveniles, males vs. females	It is possible that both sexes of juveniles and adults could be within the zone of influence for disturbance during UXO deflagration.
Will the operation/activity cause displacement from key functional areas	No. The UXO detonation, if required, will be a brief one-off event and any animals disturbed by the sudden but brief underwater noise change will be able to return to the area rapidly.
Is the habitat of the species likely to deteriorate causing disturbance to	No. The change in underwater noise will be brief and will not affect supporting habitat or species.

Questions	Response
individuals or populations	
How quickly is the affected population in the SAC likely to recover once the operation/activity has ceased	If required UXO deflagration will be a brief one-off event (less than one day). The SAC is within the zone of influence for disturbance only. Given the instantaneous nature of the explosion a one-off explosion may only elicit a startle response rather than causing widespread and prolonged displacement. Animals will resume normal activity quickly with no long term effects predicted.
Are the effects of the proposed operation/activity on Annex II species likely to have a significant effect on the favourable conservation condition of the Annex II species at the site	No, based on calculations presented above including mitigation there will be no TTS and PTS effects to harbour porpoise. Animals may still experience disturbance effects, however this will not have a significant effect on the favorable conservation condition of harbour porpoise at the site.
Is there the potential for cumulative effects with other plans or projects?	Stage 1 Screening concluded that there will be no PCEs between the Proposed Development and any other known project or plans.

5.4.1.6 Conclusion

As a precaution and as it cannot be confirmed that UXO deflagration will not be required, GIL will apply for an EPS Licence to disturb harbour porpoise.

It is possible that a maximum of 17.36% of the European site could be exposed to noise levels sufficient to cause disturbance if UXO deflagration is required. This would not constitute significant disturbance as it is less than 20% of the relevant area of the site in any given day. The disturbance effect will be instantaneous and will not lead to any long-term displacement.

It is concluded that the Proposed Development will not have an adverse effect on the integrity of the Bristol Channel Approaches SAC either alone or in combination with other plans or projects.

Conclusion - No adverse effect on integrity of site, either alone or in combination with other plans or projects.

5.5 Cardigan Bay / Bae Ceredigion SAC

5.5.1 Qualifying Feature – Grey seal

5.5.1.1 Screening conclusion

The AA screening identified that there is the potential for an LSE on grey seal from the pressure underwater noise changes; related specifically to the deflagration of UXO (if required).

The conservation objectives for the Qualifying Feature are:

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status.

The conservation objectives for the sites are to achieve and maintain in the long-term favourable conservation status for the species features. With respect to Grey seal this means:

- The population is maintaining itself on a long-term basis as a viable component of its natural habitat;
- Grey seal populations should not be reduced as a consequence of human activity;
- The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future; and
- The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing.

The AA screening concluded that in relation to the conservation objectives, the deflagration of UXO would not affect the range of the species population, nor will it affect the supporting habitats and species required to support the species population. However, as there is a large interchange of animals throughout the management unit; there is interconnection between Pembrokeshire Marine SAC and Cardigan Bay SAC; and animals foraging outside of the SAC could swim into the zone of influence, there is the potential for a LSE on the population structure as a consequence of injurious effects or disturbance.

5.5.1.2 Background Information

The risk of encountering UXO has been a concern for GIL throughout the design lifecycle of Greenlink. To manage this risk a UXO desk-based assessment was commissioned in 2019 (reference: 1st Line Defence 2018) and a preliminary UXO survey was conducted in 2018/2019 along the Proposed Development where it crosses the Castlemartin Firing Range. The UXO survey did not identify any large UXO. The Greenlink UXO desk-based assessment identified 3lb shells (1.54kg charges) as the most likely UXO to be encountered within the Castlemartin Firing Range, based on current and historical use of the area.

If any significant UXO are identified GIL will implement the following decision-making process:

1. Avoid by micro-routeing the marine cables within the permitted corridor.
2. If it cannot be avoided, visual inspection confirms a UXO, and it is safe to do so, remove the UXO.

3. If it cannot be moved, detonate on site in accordance with Best Practice.

5.5.1.3 Assessment of effects prior to mitigation

High sound pressures and explosion related shock waves from high order detonation of UXO can lead to severe injury and hearing impairment in marine mammals including grey seal. Physical injury to marine mammals such as crushing, fracturing, hemorrhages and rupture of body tissue, caused either directly or indirectly by the blast wave, resulting in immediate or eventual mortality, is possible from underwater explosions. However, most research including von Benda-Beckmann *et al.* (2015) into effects of underwater explosions, focuses on the sound levels that are high enough to cause hearing loss i.e. a PTS, as it is acknowledged that this is likely to occur at lower sound pressure levels than would cause the physical trauma injuries listed above. The justification is that if mitigation can be proposed to avoid PTS level effects this will also effectively mitigate for blast injuries.

High order detonations can cause disturbance over large ranges, although it is recognised that given the instantaneous nature of the explosion a one-off explosion may only elicit a startle response rather than causing widespread and prolonged displacement.

In order to establish the potential worst-case risk associated with a high order UXO detonation underwater noise modelling for the largest UXO historically used in the area was undertaken; a WW2 sea mine with a charge size of 794kg. Detonation at two locations was modelled; Location 1 is representative of the range of environments (i.e. bathymetry and water depth) present along the Proposed Development and is close to both the Pembrokeshire Marine / Sir Benfro Forol SAC and West Wales Marine / Gorllewin Cymru Forol SAC. Location 2 is within the Castlemartin Firing Range.

The modelling results are presented in Appendix A and demonstrate that detonation of a 794kg UXO without any form of mitigation could cause significant noise changes over large ranges. At Location 1 (offshore) the radius for significant injurious auditory effects (PTS) is 7.8km increasing to 10.2km for a TTS. Whilst decreasing the charge size also decreases the range of effect, it is concluded that there is the potential for a significant effect on grey seal unless mitigation is implemented. Therefore the 'do-nothing' scenario i.e. UXO detonation alone, is not a feasible alternative.

It is therefore recognised that UXO deflagration cannot take place without mitigation in order to ensure no significant effects on grey seal.

5.5.1.4 Mitigation

GIL have committed to a series of mitigation measures to ensure there are no significant effects to marine mammals (including specifically harbour porpoise and grey seal, which are Primary Features of European sites which the Proposed Development crosses). These are discussed in detail in Section 5.2.2.4 above and have not been repeated here. However, in summary they include:

1. Avoid the need for detonation completely.
2. Use of deflagration for all UXO charge sizes.
3. Use of ADDs.
4. Use of a PAM system to support visual observation.
5. Soft start.
6. Use of BBCs.
7. Seasonal (winter) restriction; and
8. Implement the Greenlink Wales Marine Mammal Mitigation Plan (Appendix E).

5.5.1.5 Assessment of effects following the implementation of mitigation

The assessment below has been undertaken considering the mitigation measures proposed in Section 5.5.1.4 above.

Questions	Response
Will the proposed operation or activity result in death, injury or disturbance of individuals?	Whilst the zones of influence estimated for auditory injury, temporary auditory damage and disturbance do not overlap with the European site, it is recognised that the population of grey seal present within the site are not a discrete population and form part of the south-west Wales population. The population is not isolated and interchange of animals between Pembrokeshire Marine SAC and Cardigan Bay SAC is highly likely. Therefore, it is possible that animals within the Pembrokeshire Marine SAC at the time of UXO deflagration (if required) could be exposed to the sudden noise and pressure changes associated with the deflagration event and may experience PTS, TTS or disturbance. If UXO deflagration is required, modelling estimates that for Location 2 within the Castlemartin Firing Range (e.g. coastal shallow waters), the sudden pressure change could cause auditory injury i.e. PTS within 4.4km and temporary auditory damage (TTS) within 6.2km for grey seal. The zone of influence decreases with the depth of water so that at Location 1 the onset of PTS would occur at 3.2km and TTS at 4.8km. The distance for the onset of significant disturbance was 26.8km at Location 1 and 40km at Location 2. It should be noted that the modelling of the 40kHZ frequency, to represent damage beyond the auditory system indicates effects are limited to 0.78km (PTS) and 1.1km (TTS). There are three categories of noise mitigation that can be applied to UXO detonation, namely noise abatement/reduction, spatial/temporal restrictions and acoustic deterrents. The range of mitigation proposed in Section 5.2.2.4 is a combination of all three categories and represents all currently available noise mitigation techniques. Individually, each of the techniques have been proven to mitigate UXO detonation, for example, deflagration reduces blast effects by 97% in comparison to the equivalent high-order detonation (Cheong *et al*. 2020). The implementation of a BBC will reduce sound levels by approximately 7-11dB (Verfuss *et al*. 2019). Acoustic deterrent devices will deter animals within 2km of the deflagration (McGarry *et al*. 2020). Based on Verfuss *et al*. 2019, the effects of both a 7 and 11dB reduction to a 1.54kg UXO deflagration were modelled for Location 2. As the feasibility of BBC in deeper water is limited, Location 1 was not included in the BBC reduction modelling and zone of influences remain as reported above for Location 1. A 7dB reduction reduces the zone of influence for PTS to 2.8km and TTS to 4.2km. A 11dB reduction means the onset of PTS will occur within 1.9km and TTS within 3.3km.

Questions	Response
	When BBC are combined with ADD which are effective up to 2km, for a 7dB reduction, there remains approximately 12.06km^2 of the zone of influence that would be exposed to PTS level noise changes; and 42.85km^2 of the zone of influence zone exposed to TTS level noise changes. For the 11dB reduction, there will be no PTS effects to grey seal and the zone of influence for TTS will be limited to 21.65km^2 It should be noted that, while the zone of influence for TTS remains in both BBC scenarios, animals can recover from TTS effects. While it cannot be categorically ruled out that injurious effects will not occur, the mitigation proposed represents all reasonable measures to avoid and reduce significant effects to grey seal. The potential remains for animals within 30km of Location 1 and 40km of Location 2 to be disturbed, however effects will not be significant. The UXO deflagration will be a one-off instantaneous event. Although animals may display a startle reaction there will not be widespread or prolonged displacement.
Is it possible to estimate the number of individuals that are likely to be affected	As a mobile species that range over a large area, it is not possible to estimate with certainty how many grey seal could be within the water and zone of influence at the time of a UXO deflagration. The population estimate for south-west Wales is approximately 5000 individuals. It is estimated (based on grey seal at-sea usage maps, Russell *et al.* 2017) that the mean number of individuals in the waters of the Proposed Development will vary from 5 to 10 individuals per 5km^2. Conservatively, this could mean that: • If deflagration was to occur between KP0 and KP9.4 (i.e. where ADD and a BBC can be implemented) between 12 and 24 individuals may experience PTS level noise changes, and between 43 and 86 individuals may experience TTS level noise changes (assuming only a 7dB reduction in SPL due to the BBC). • If deflagration was to occur from KP9.4 onwards it cannot be guaranteed that the BBC will be effective and therefore it is assumed that only ADDs will be used. Between 48 and 97 individuals may experience PTS level noise changes and between 121 and 242 individuals could experience TTS level noise changes. • These figures represent between 0.2% (12 individuals) and 4.8% (242 individuals) of the south-west Wales population. This numbers should be treated with caution. The UXO deflagration will not affect animals within the European site boundary; only animals that are within the Pembrokeshire Marine SAC (as the European sites are functionally linked). The number of animals affected is a percentage of the south-west Wales population rather than the SAC population. It should therefore be recognised that these numbers should not be added cumulatively to estimates of animals affected within the Pembrokeshire Marine SAC. Grey seal will be most vulnerable to UXO deflagration during summer months (May – August) when they are more likely to be in the water. From August through to December animals are likely to be hauled up on beaches for pupping. The seasonal restriction proposed will therefore aid in limiting the number of animals that could be present within the zones of influence.
Will individuals be disturbed at a sensitive time or location during their life cycle	The sensitive time for grey seal at the site will be during breeding (August to December), moulting (December – February) and resting (all year). The thresholds for injury are for pinnipeds in water. Animals engaged in the activities listed above will be hauled-out on beaches out of the water. Therefore, noise generated by UXO deflagration will not affect breeding, moulting and resting. As stated previously the zones of influence for UXO deflagration do not overlap with boundaries of the European site and therefore animals within the site will not be affected. Effects on animals that have moved to the Pembrokeshire Marine SAC for breeding or haul-out are assessed in Section 5.2.2.5 above.

Questions	Response
Are the effects likely to focus on a particular section of the population, e.g., adults vs. juveniles, males vs. females	It is possible that both sexes of juveniles and adults from the south-west Wales population could be within the zone of influence during UXO deflagration.
Will the operation/activity cause displacement from key functional areas	Underwater noise activities will not displace seal. The UXO deflagration, if required, will be a brief one-off event and any animals disturbed by the sudden but brief underwater noise change will be able to return to the area rapidly.
Is the habitat of the species likely to deteriorate causing disturbance to individuals or populations	No. The change in underwater noise will be brief and will not affect grey seal habitat.
How quickly is the affected population in the SAC likely to recover once the operation/activity has ceased	The south-west Wales population was estimated at 5000 individuals. Average pup production remained consistent between 1992 and 2008 averaging 208 pups per year. However, pup production has been steadily increasing with 2013-15 recording the highest average productions at 357 pups. If sufficient numbers of animals were injured by the UXO deflagration there could be a long-term effect on the population. However, the range of mitigation proposed in Section 5.2.2.4 represents all currently available noise mitigation techniques. Individually, each of the techniques have been proven to mitigate the effects of high order UXO detonations, and are widely accepted as best practice especially for activities within European sites. Given the seasonal restriction proposed it is not thought likely that high numbers of animals will be present in the water however this cannot be categorically stated. It is not possible to determine how quickly the population will recover, given that exact numbers affected cannot be firmly predicted.
Are the effects of the proposed operation/activity on Annex II species likely to have a significant effect on the favourable conservation condition of the Annex II species at the site	While it cannot be categorically ruled out that injurious and disturbance effects will not occur, the mitigation proposed represents all reasonable currently available measures to avoid and reduce significant effects to grey seal.
Is there the potential for cumulative effects with other plans or projects?	Stage 1 Screening concluded that there will be no PCEs between the Proposed Development and any other known project or plans.

5.5.1.6 Conclusion

As a precaution, because it cannot be confirmed that UXO detonation will not be required, GIL will apply for an EPS Licence for UXO detonation to disturb grey seal.

Whilst the zones of influence estimated for auditory injury, temporary auditory damage and disturbance do not overlap with the European site, it is recognised that the population of grey seal present within the site are not a discrete population; instead forming part of the south-west Wales population. The population is not isolated and interchange of animals between Pembrokeshire Marine SAC and Cardigan Bay SAC is highly likely. It is possible that animals within the Pembrokeshire Marine

SAC at the time of UXO deflagration (if required) could be exposed to the sudden noise and pressure changes associated with the deflagration event and could experience auditory injury, temporary auditory damage or disturbance. Between 0.2% (12 individuals) and 4.8% (242 individuals) of the south-west Wales population could be affected. These numbers should not be added cumulatively to estimates of animals affected within the Pembrokeshire Marine SAC; as they would be the same animals.

To mitigate the potential for significant effects, Greenlink has committed to using deflagration for all UXO charge sizes; proposed a seasonal restriction to ensure deflagration will occur when species densities are likely to be at their lowest; and proposed the use of noise abatement and acoustic deterrents. These mitigation measures have proven successful for similar projects in UK waters e.g. NEMO Link, Moray East Offshore Wind Farm, Rampion Offshore Windfarm, Beatrice Offshore Windfarm, and represents all reasonable currently available measures to avoid and reduce significant effects to grey seal.

Implementation of mitigation will reduce the significance of the effect to a level whereby the three conservation objectives for the Qualifying Feature (i.e. populations, range, and supporting species and habitats) will not be adversely affected.

In light of this, it is concluded that the Proposed Development will not have an adverse effect on the integrity of the Bae Ceredigion / Cardigan Bay SAC either alone or in combination with other plans or projects.

Conclusion – No adverse effect on integrity of site, either alone or in combination with other plans or projects.

6. Stage 3 – Test 1 Alternative Solutions

6.1 Introduction and Scope

This section of the HRA provides evidence and information which demonstrates that NRW can be satisfied that there are no feasible alternative solutions to the Greenlink Interconnector and the application to use external cable protection (as a contingency) within Pembrokeshire Marine / Sir Benfro Forol SAC.

The HRA process has identified that the use of external cable protection, specifically rock revetment will result in a loss of the Primary Feature 'Reef' habitat within the European Site. NRW consider that if the external cable protection is used, the resultant loss in extent of Annex I Reef habitat would constitute a significant loss. It is therefore uncertain that the integrity of the European site will not be adversely affected. The total area of Reef habitat that could be affected is up to 82,800m^2 0.083km^2)[6].

The primary objective of the project is to develop an interconnector linking the electricity transmission networks in Republic of Ireland and GB. This can only be delivered by the development of an onshore and subsea interconnector between the two countries.

6.2 Approach

The Habitats Regulations do not define the phrase 'no alternative solutions', and there is no legislative framework for the approach to alternative solutions.

The European Commission's interpretation document "Managing Natura 2000 Sites: The provisions of Article 6 of the 'Habitats Directive'" (referred to as MN2000) (EC 2000) identifies two stages: the first is to identify feasible alternative solutions, and the second is to assess those feasible alternative solutions.

Defra (2012) states:

"Alternatives must be considered objectively and broadly. This could include options that would be delivered by someone other than the applicant, or for example at a different location, using different routes, scale, size, methods or timing".

"Alternative solutions are limited to those which would deliver the same overall objective as the original proposal. For example, in considering alternative solutions to an offshore wind renewable energy development the competent authority need only consider alternative offshore wind renewable energy developments. Alternative forms of energy generation are not alternative solutions to this project as they are beyond the scope of its objective."

Therefore, when considering the feasibility of alternative solutions GILs approach has been to identify the need, public benefits and objectives which the project is

[6] 1700m^2 in Bedrock Reef, 80,000m^2 in Stony Reef and 1,100m^2 in Biogenic Reef

designed to address (e.g. as described in European, UK and Welsh policy) first. This has enabled GIL to identify alternative means of meeting those objectives.

This is consistent with the recent Court of Appeal decision in Heathrow[7] which states, in relation to the Habitats Directive, that the decision maker: "*was clearly entitled to reject the Gatwick second runway scheme as an "alternative solution" under the Habitats Directive for its failure to meet an essential objective of his policy*". (paragraph 119).

The objectives of Greenlink are genuine and critical objectives; and reflect the central project aim of delivering an interconnector between Ireland and Wales. This is the approach to objectives endorsed by the Court of Appeal in (paragraphs 92 and 93) where the Court of Appeal endorsed the Divisional Court's statement that "*a proposed option is not an alternative solution unless it meets the core…objective*" and stated that an alternative that did not meet the objectives would be "*no solution at all*".

Following this guidance and the Court authority, Section 6 presents information on the alternative solutions that have been investigated by GIL throughout the development of the project. Alternatives to a range of decisions have been investigated and assessed at different development stages. GIL has worked with NRW and key stakeholders e.g. Castlemartin Firing Range, Milford Haven Port Authority, throughout this iterative process to ensure all potential alternative solutions have been identified and considered and as necessary the design of Greenlink has been reassessed to account for newly identified environmental and technical constraints, alternatives and solutions.

The detailed consideration of alternative solutions has included identifying feasible alternatives which are those alternatives which are deliverable (having regard to the options and their financial, legal and technical deliverability). Cost is a relevant factor in assessing whether alternative solutions are feasible solutions. One of the principles applied in the assessment is that additional costs associated with an alternative solution should not be such that the alternative becomes undeliverable or unviable. In addition, every theoretically imaginable alternative does not need to be considered. Alternatives which are improbable or impracticable can be discounted without assessment.

Where feasible solutions have been identified, their effects on the integrity of European sites has been considered. An alternative which would lead to damage or deterioration to a European site is not considered to be an alternative solution to Greenlink.

The 'do nothing' option has also been considered but is not an alternative solution (unless the need and project objectives can be delivered by doing nothing).

The structure of this section, as outlined in Table 6-1, follows sequentially the decision-making process that has led to the conclusion that there are no viable

[7] Plan B Earth and others) v Secretary of State for Transport and others [2020] EWCA Civ 214

alternatives to the Proposed Development that will be less damaging to the integrity of the European Site Network.

Table 6-1 Structure of Section 6

Section	Title	Description
Section 6.3	Need for the Project	This sub-section outlines the need and public benefits the development of an interconnector addresses.
Section 6.4	Objectives of the Project	This sub-section defines the objectives any feasible solution must fulfil.
Section 6.5	Alternative Solutions that can be Discounted Immediately	This sub-section identifies all alternative solutions that have been discounted immediately as they do not meet the Project Need or Project Objectives. It has been split into the following sub-sections: 6.5.1 - Do Nothing 6.5.2 - Alternative Generation Options 6.5.3 - Reduce Generation Demand
Section 6.6	Alternative Solutions that are Feasible Alternatives	This sub-section identifies all feasible alternative solutions, examines their effects on the integrity of European sites and justifies why the selected solution is the only feasible solution. It has been split into the following sub-sections: 6.6.1 – Alternative Technology 6.6.2 – Alternative National Connection Points 6.6.3 - Alternative GB Connection Points 6.6.4 – Alternative Landfall Sites 6.6.5 – Alternative Offshore Cable Routes 6.6.6 – Alternative Installation Techniques
Section 6.7	Conclusion	Summary table showing all alternatives investigated and options selected.

6.3 Need for the Project

Action against climate change is high on the global agenda. It is recognised at International, European, National and Regional levels that ambitious packages of measures are required to reduce greenhouse gas emissions to preserve the environment.

The Committee on Climate Change (CCC) state "*the bulk of emissions derive from our demand for energy*" (CCC undated). The energy sector is undergoing a transformation as it moves away from fossil fuels towards renewable energy generation e.g. solar, wind, biomass, tidal, and low-carbon energy. However, renewable sources are difficult to forecast and control – leading to issues with integration, capacity and security of supply.

Interconnectors are an important tool in tackling the challenges of integrating renewable energy and facilitating the decarbonisation of the energy sector. This view is reflected in European, National and Regional Policy as outlined below - which clearly sets out the need for interconnectors to address security of supply, promote

sustainability through the connection of renewables, and increase competition reducing the cost to the consumer.

The UK's Draft Integrated National Energy and Climate Plan (NECP) (BEIS 2019a) recognises that interconnectors provide a range of benefits and "strongly supports greater electricity trading with our European partners".

Great Britain is currently connected to north-west Europe by 3GW of interconnector capacity; and to the island of Ireland via 1GW of capacity. The 1GW of capacity to the island of Ireland derives from two operational interconnectors; the East West Interconnector (EWIC) between Rush North Beach, Co. Dublin, Ireland and Barkby Beach, Prestatyn, Wales; and the Moyle Interconnector between Ballycronan More, County Antrim, Northern Ireland and Auchencrosh, South Ayrshire, Scotland. Although there are a further two proposed interconnectors in Ireland, neither of them would connect to mainland UK.

The NECP states that *"further interconnection projects are currently under construction (4.4GW) or seeking regulatory approval (4GW) and, as set out in our Clean Growth Strategy (CGS), project assessments indicate the potential for a further 9.5GW interconnection beyond this in the early to mid-2020s."* Greenlink is included within the 9.5GW for delivery in the early to mid-2020s; and is therefore a recognised component of the UK Governments Clean Growth Strategy.

6.3.1 European Policy

The 'Energy Union' launched by the European Commission in February 2015, and endorsed by Member States in October 2015, is driving a fundamental transition towards more innovative ways to produce, transport and consume energy, and to address different approaches to design, implement and, where needed, enforce energy policy. A range of actions will be required to make this happen, including improvements to the physical interconnectedness of energy grids to meet a 10% interconnection target by 2020 and to possibly reach 15% by 2030. As of November 2017, 17 EU Member States have reached the 10% target, with a further 7 on the path to reach the target by 2020. The UK's expected level of interconnection in 2020 is 8% (European Commission 2017).

An interconnected European energy grid is vital for Europe's energy security, for more competition in the internal market resulting in more competitive prices, and for better achieving the decarbonisation and climate policy targets, to which the EU has committed. An interconnected grid will help to deliver the ultimate goal of the Energy Union, i.e. to ensure affordable, secure and sustainable energy, as well as growth and jobs across the EU.

In 2013, the EU adopted Regulation (EU) No 347/2013 on Guidelines for Trans-European Networks for Energy (TEN-E Regulation). The TEN-E Regulation sets out guidelines for streamlining the permitting processes for major energy infrastructure projects that contribute to European energy networks. These are referred to as Projects of Common Interest (PCIs).

Greenlink achieved PCI status under the TEN-E Regulation in November 2017, making it one of Europe's most important energy infrastructure projects and granting it the "highest national significance" possible.

6.3.2 Irish Policy

On 6 July 2018 the Irish Department of Communications, Climate Action and Environment (DCCAE) published its National Policy on Electricity Interconnection in Ireland which sets out the strategic importance of interconnection to Ireland and the three pillars of its energy policy – sustainability, security of supply and competitiveness and recognises the benefits to the consumer 'including lower long-term costs of electricity' (DCCAE 2018).

Following public consultation in relation to the initial project assessment of Greenlink, the Irish utilities regulator, the Commission for Regulation of Utilities (CRU), determined that Greenlink passes the public interest test in Ireland (CRU 2018).

6.3.3 UK Policy

In the UK, there is clear support for further interconnection. The Secretary of State for Energy and Climate Change explained that the UK "must step up the integration of European Energy markets so that countries can buy clean competitive low carbon electricity from where-ever it is cheapest". In 2013 the Department of Energy & Climate Change (DECC) commissioned a study which concluded that "our least regret interconnection analysis (on the basis of net welfare) has shown that incremental increases in interconnection with GB's closest neighbours including France, Ireland and Belgium, with a total new additional GB interconnection reaching 5.0GW by 2040, are likely to be beneficial to GB net welfare under a broad range of future states of the world."

In May 2014, Ofgem decided to roll out a cap and floor regulatory regime to new near-term electricity interconnectors. Ofgem recognised that "Before the cap and floor regime was introduced, only a limited number of electricity interconnectors had been built or proposed. Ofgem therefore created the cap and floor regime to unlock beneficial investment by reducing risks". Following the success of the cap and floor window, Ofgem opened a second cap and floor window on 31 March 2016. In November 2016, the Secretary of State for Energy and Climate Change confirmed that "We remain strongly supportive of new interconnectors".

Against this background, Greenlink has received strong support from the UK regulatory authorities, including receipt of a GB Interconnector Licence on 10 February 2015, award of a cap and floor regime in principle following a successful Initial Project Assessment on 30 September 2015 and is now proceeding to Final Project Assessment.

6.3.4 Welsh Policy

Planning Policy Wales (PPW Edition 10) sets out the land use planning policies of the Welsh Government, supporting the UK's commitment to the EU Renewable Energy Directive and the UK target of 15% of energy from renewables by 2020 (Welsh Government 2018).

PPW Edition 10 states that the new PPW embeds the spirit of the Wellbeing of Future Generations Act, through moving us towards a low carbon, resilient society, of providing secure and well-paid jobs, and of building well-connected environments for everyone in Wales that improves our lives and health and enhances our wellbeing.

It seeks to promote adequate and efficient infrastructure, highlighting services such as electricity and telecommunications, as crucial for the economic, social and environmental sustainability of all parts of Wales.

Greenlink aligns with the strategies and objectives described in PPW Edition 10 in developing Wales' access to a more diverse energy mix including energy from renewable and low carbon energy sources, promoting energy efficiency and enhancing security of supply.

6.4 Objectives of the Project

The Project Objectives that any viable solution needs to fulfil are outlined in Table 6-2 below.

Table 6-2 Project objectives

Category	Objective ID	Description	Basis of objective
Core Objectives	1	Develop an interconnector linking the Republic of Ireland and the GB.	To enable the trading of electricity between Ireland and GB and promote the delivery of: low carbon energy; energy security; and increase system flexibility and efficiency to reduce costs to Irish and GB consumers.
	2	Deliver energy market integration allowing transportation of renewable energy throughout Europe.	Promote progress towards a more secure and low carbon energy network across Europe.
	3	Deliver security of supply to the Republic of Ireland and the UK by allowing sharing of electricity reserves, generation capacity and ancillary services.	Enable the Irish and GB transmission networks to benefit from the flexibility and security created by enabling access to a pathway to additional sources of generation.
	4	Deliver competition in electricity and capacity markets, lowering the cost of energy to the consumer in Republic of Ireland and the UK.	Enable the Irish and GB consumers to access low carbon and lower cost generation in each jurisdiction and reduce reliance on higher cost domestic generation.
	5	Shortest combined onshore and offshore cable route.	Develop the shortest and least constrained route; balancing length, environmental, technical and economic constraints. Avoid constraints that cannot be physically moved in order to install the cables or will have severe/major financial and legal implications e.g. wrecks, offshore oil and

Category	Objective ID	Description	Basis of objective
			gas platforms, or physical implications on the route e.g. large expanses of rock or areas of sandwaves. Avoid areas of seabed used by others e.g. marine aggregate sites, disposal sites, renewable energy sites, ports and anchorage areas. Avoid or minimise the number of third-party asset crossings.
	6	Project delivery (commissioning) in the early 2020s.	Enable the GB and Irish transmission networks and consumers to access the benefits from Greenlink in the early 2020s and facilitate the timely delivery of low carbon targets.
	7	Project infrastructure should be permittable and deliverable.	Proposals will consider all environmental and technical constraints to ensure that Greenlink can be delivered both economically (to maximise benefits to consumers) and with a minimal environmental impact to ensure that it can be permitted responsibly in line with key guidance and policy.
	8	The installation, operation and eventual decommissioning of Greenlink can be undertaken in a safe and efficient manner.	The project will ensure that the safety and amenity of neighbours and workers is central to the design and delivery of Greenlink.
Secondary Objectives	9	To avoid where possible, or otherwise minimise the distance through which the route crosses Reef habitat within the Pembrokeshire Marine / Sir Benfro Forol SAC.	Avoid areas where seabed conditions may not be conducive to burial in seabed. Reef habitat is the Primary Feature of the European site, therefore the objective is to avoid or otherwise minimise the potential for a LSE.
	10	To avoid where possible, or otherwise minimise the distance through which the route crosses the Castlemartin Firing Range.	Ensure disruption to Ministry of Defence operations is kept to a minimum. Minimise the risk of encountering UXO during installation. Safeguard the integrity of the Greenlink cables by ensuring the length of cable at risk from future UXO is minimised.
	11	To avoid where possible impact on leisure users.	Design and management of the project does not give rise to unsatisfactory risk or disruption to the public and local businesses.
	12	To minimise disruption to shipping associated with Milford Haven, Port of Waterford and offshore traffic separation schemes.	Design and management of the project does not give rise to unsatisfactory risk to other sea users, particularly in areas of higher use.

6.5 *Alternative Solutions that can be Discounted Immediately*

This sub-section identifies all alternative solutions that were discounted immediately because either they are not supported by European or UK policy; or they will not achieve any of the Core Project Objectives.

6.5.1 Do Nothing

The 'do nothing' option dictates the generation of electricity need to be based in the country where it is used and constrains export of electricity when generation exceeds demand.

One of the key actions identified in the European Commission Priority Interconnection Plan and the TEN-E regulations (part of the Energy Union, described in Section 6.3.1) is to increase the transmission capacity between countries and improve security of supply through projects of community interest.

Greenlink has been awarded Project of Common Interest (PCI) status by the European Commission, making it one of Europe's most important energy infrastructure projects and granting it the "highest national significance" possible.

There is broad consensus that, in a post-Brexit world, the efficient cross-border trade in electricity between the UK and the EU should continue. The UK government has stated its commitment to mechanisms to achieve this (BEIS 2019b).

The requirement and need for Greenlink has been reinforced by Ofgem (GB) and CRU (Ireland) via the completion of a Cost Benefit Analysis which demonstrates that Greenlink offers economic benefit to consumers in both jurisdictions.

The 'do nothing' option would therefore not be supported by the UK government and EU policy.

In addition, but fundamentally, the 'do nothing' option would not achieve any of the Core Project Objectives and therefore this is not a feasible alternative solution.

6.5.2 Alternative Generation Options

Whilst other forms of electricity generation may be capable of meeting decarbonisation objectives, no other form of generation would be capable of meeting the interconnection objectives.

GIL consider that interconnectors are substantially the same as offshore wind farms for the purposes of identifying alternative solutions, in that the consideration of alternatives should be limited to alternative interconnector solutions in the manner envisaged by Defra (2012).

Therefore, alternative forms of electricity generation projects have been discounted based on their inability to meet Greenlink's Core Project Objectives. In any event, alternative forms of renewable electricity generation would not be alternatives to the objectives for Greenlink but would be complementary to those objectives.

It is lawful for the consideration of alternatives to an interconnector project to limit the consideration of alternatives to interconnectors, including alternative installation methods.

There are no feasible alternative solutions comprising alternative generation options.

6.5.3 Reduce Generation Demand

This solution would not meet any of the Core Project Objectives and is complementary (not an alternative to) the Project Need served by Greenlink.

The NECP states that *"to meet the UK's 2050 climate change target, emissions from buildings will need to be near zero, coupled with action on industrial processes."* As this drive for decarbonisation across the economy sees sectors e.g. industry, heating and transport, change to electricity, the demand for electricity is likely to increase. Whilst it is recognised that energy demand management will play an important role in the future energy balance it cannot on its own deliver the decarbonised energy system. Different pathways will need to be delivered concurrently. For example, reduction in use of fossil fuels, increasing energy efficiency, reducing electricity demand, investment in large-scale generation capacity (e.g. renewables, new nuclear and new combined cycle power gas turbine plants), more decentralised energy, limited expansion of electrification of heat and transport and a great level of interconnection (Energy UK 2016).

In summary, this solution is akin to 'do nothing'. It will not meet the European, UK or Welsh Policy objectives for decarbonisation on its own, does not meet the Project Need and does not deliver any of the Core Project Objectives. It is therefore not a feasible alternative solution.

6.5.4 Summary

Table 6-3 summarises the assessment for alternative solutions that can be discounted against Project Objectives.

Table 6-3 Comparison of alternative solutions that can be discounted

Category	Do Nothing	Alternative Generation Options	Reduce Generation Demand
Project Need	X	X	X
Core Project Objective 1	X	X	X
Core Project Objective 2	X	X	X
Core Project Objective 3	X	X	X
Core Project Objective 4	X	X	X
Core Project Objective 5	X	X	X
Core Project Objective 6	X	X	X
Core Project Objective 7	X	X	X
Core Project Objective 8	X	X	X
Justification	Does not meet Project Need and does not deliver any	Does not meet Project Need and does not	Does not meet Project Need and does not

Category	Do Nothing	Alternative Generation Options	Reduce Generation Demand
	of the Project Objectives	deliver any of the Project Objectives	deliver any of the Project Objectives
Decision	Discounted	Discounted	Discounted

6.6 *Alternative Solutions that are Feasible Alternatives*

This sub-section identifies all alternative solutions considered, assesses how they meet the Project Objectives (Core & Secondary), examines their effects on the integrity of European sites and justifies why the selected solution is the only feasible solution.

6.6.1 Alternative Technology

There are two viable technical solutions to transport electricity; high voltage alternating current (HVAC) technology and high voltage direct current (HVDC) technology. GB and Irish electricity transportation grids operate as HVAC systems, in which the direction of the current changes (and then changes back) on average fifty times a second.

The British and Irish Grids are not "synchronized", i.e. the current reversals are not happening at the same times – without this synchronization, power cannot be successfully transmitted between the grids with an HVAC interconnector. An HVAC interconnector cannot meet Core Project Objective 1 and therefore Core Project Objectives 2 – 4.

The capacity of HVAC underground or subsea cables to transmit power reduces significantly with distance travelled. Long lengths of HVAC cable transmission require electrical compensation (using large shunt reactors) installed, typically every 50km along the cable route. If HVAC technology was used for Greenlink compensation would be required at four locations (two offshore and one each at of the respective converter stations). Offshore shunt reactors would require a small fixed platform, like those used in the oil and gas industry to house the equipment.

HVDC does not require electrical compensation and operates over long distances more efficiently than HVAC with lower transmission losses; thereby maintaining greater capacity.

In addition, HVDC uses two cables to transmit power, whereas for Greenlink HVAC would require three separate cables – increasing the environmental footprint of installation e.g. increased trench widths, additional HDD bores etc.

In summary, a HVAC solution would in comparison to HVDC:

- Increase project costs and installation footprint due to the requirement for a third cable and two offshore fixed platforms. This would reduce the chance Core

Project Objective 4 (competition) can be met; and the solution compares less favourably than HVDC in considering the effects on Project Objectives 9-12.

- Would require programme extensions to deliver fixed offshore platforms reducing the likelihood that Core Project Objective 6 (project delivery in early 2020s) can be met.
- Would not be as efficient as HVDC and therefore compares less favourably in meeting Core Project Objective 8 (safe & efficient).

In conclusion, as illustrated in Table 6-4, HVAC cannot meet all the Core Project Objectives and in comparison, to HVDC will perform less well against Secondary Project Objectives due to the larger installation footprint. HVAC is therefore is not a suitable alternative. HVDC was selected as it offers the best technical solution, can deliver all Core Project Objectives and will perform better in meeting the Secondary Project Objectives.

Table 6-4 Comparison of alternative technological solutions against Project Objectives

Category	HVDC	HVAC
Project Need	✓	✓
Core Project Objective 1	✓	X
Core Project Objective 2	✓	X
Core Project Objective 3	✓	X
Core Project Objective 4	✓	X
Core Project Objective 5	✓	✓
Core Project Objective 6	✓	✓ (comparatively less favourable)
Core Project Objective 7	✓	✓ (comparatively less favourable)
Core Project Objective 8	✓	✓ (comparatively less favourable)
Secondary Project Objective 9	✓	✓ (comparatively less favourable)
Secondary Project Objective 10	✓	✓ (comparatively less favourable)
Secondary Project Objective 11	✓	✓ (comparatively less favourable)
Secondary Project Objective 12	✓	✓ (comparatively less favourable)
Justification	Meets all Project Objectives	Does not meet Project Objective 1 and compares unfavourably to HVDC on Project Objectives 6-12.
Decision	Selected	Discounted

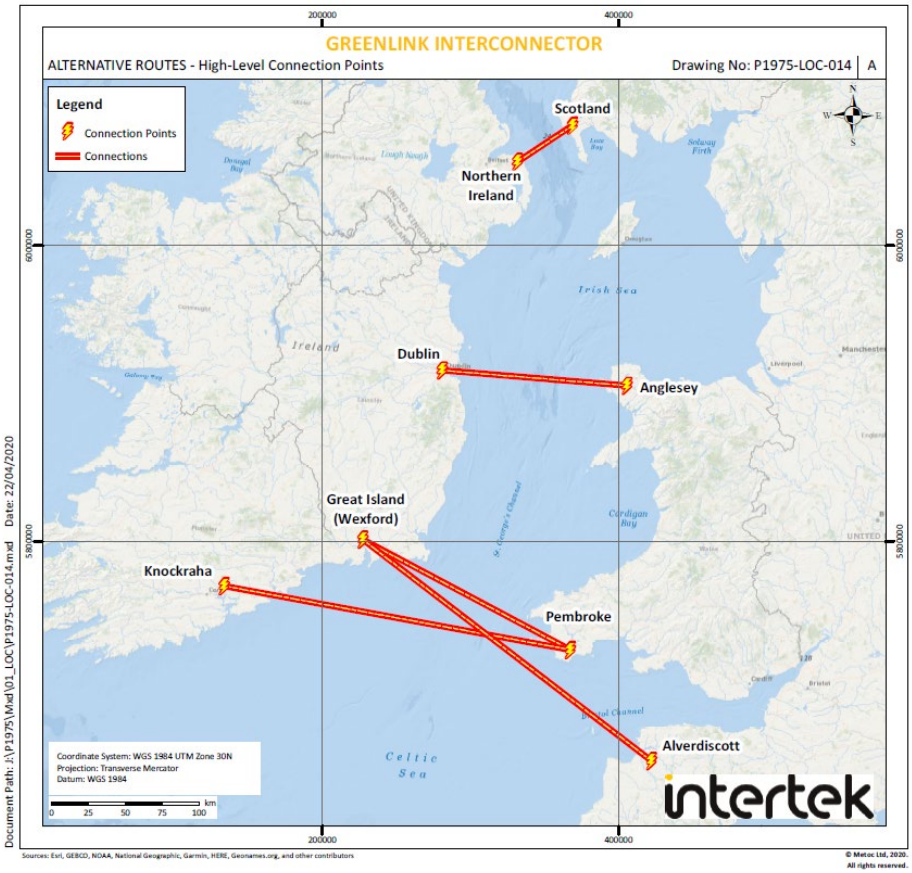
6.6.2 Alternative National Connection Points

In the project definition phase, the definition of Core Project Objective 1 – to deliver an interconnector between Ireland and Great Britain led to the consideration of the location of the link.

Since both the Irish and UK electricity markets have a uniform non-locational price, there was no market reason to choose one location over another for the link; once the power flows the benefits are accrued. The primary factor driving the choice of location of Greenlink was distance between the markets. A location which results in the shortest cable distance i.e. meets Core Project Objective 5, between the two markets will have the lowest losses and thus generate the most effective trades (delivering Core Project Objectives 4 and 8). A cable which is twice as long has twice the losses. Trades are only economic if the difference in prices between the markets exceeds the losses. The relevant distance is not between coastlines, but rather between feasible grid connection points. Practically this means existing 220kV or 400kV substations with more than 2 circuits connecting them. GIL ruled out 110kV substations in Ireland and 132kV substations in the United Kingdom on the basis that such substations cannot support 500MW of demand or generation.

There were three broad choices for the interconnector location: Northern Ireland - Scotland, Dublin - Liverpool (including Anglesey North Wales) and Wexford - Wales.

Figure 6-1 Alternative National Connection Points



6.6.2.2 Scotland

Scotland currently has 500MW of interconnector capacity delivered through the Moyle interconnector with a further 2.4GW proposed through interconnector projects such as NorthConnect (link to Norway) and Icelink (link to Iceland).

A connection from Northern Ireland to Scotland would be the shortest distance (meeting Project Objective 5); and is the reason the Moyle interconnector is located here. GIL considered building Greenlink parallel to the Moyle interconnector, but this was discounted, because at the time there was not sufficient grid capacity in Scotland even to accept Moyle's flow in both directions[8]. Locating Greenlink at Moyle would result in power flowing in only one direction - halving the effectiveness of the project and reducing the benefit of the Moyle interconnector. In the intervening period (since the decision was made), Scotland has been building wind power generation and large sub-sea reinforcements to its grid, such as Western Link, but this capacity is going to be utilised by the increased wind generation. As Greenlink would effectively duplicate the Moyle Interconnector at this location, this connection point would not be economically viable, and the location was discounted as not a feasible alternative solution.

6.6.2.3 North Wales

Moving southwards down the respective Ireland and Great Britain coastlines, the next location was Dublin to Anglesey in North Wales. There is strong grid capacity onshore in both locations. However, an interconnector must operate as both generation and demand. Dublin has been experiencing a surge in demand through data centre growth. Seeking a grid connection at Poolbeg, for example, for the generator mode of operation would be feasible and very welcome, but the demand mode of operation would be very problematic inside the Dublin region. Trades on the interconnector are driven by market forces, and so on occasion Great Britain prices would drive the interconnector to export 500MW at a time when Dublin was experiencing supply shortage. This in turn would drive EirGrid to limit trades at these sensitive times, thus limiting the public benefit and economic viability of Greenlink. As this would compromise the delivery of Project Objectives 3 and 4 and economic viability of the project the location was discounted as a feasible alternative solution.

6.6.2.4 Mid Wales

Mid Wales is geographically close to the coastline running from Carrickmines to Rosslare. However, there is only a single 220kV circuit (Carrickmines to Great Island) in Ireland near that coastline. A single circuit is less likely to be able to provide for the full trading, for example if one part is offline for maintenance or fault. The 220kV circuit moves inland south of Arklow. In Wales there is no 400kV circuit near the west coast of Wales, other than at Anglesey and Pembroke. These factors ruled out a mid-Wales to Irish east coast connection and this is not a feasible alternative solution.

[8] Refer to All-Ireland Generation Capacity Statement 2019-2028 EirGrid / SONI (2019)

6.6.2.5 South Wales & South West England

England currently has 3.5GW of interconnection capacity delivered by IFA, BritNed and East-West interconnector. In addition, a further six interconnectors have been accepted into the Ofgem Cap and Floor regime proposing to deliver 7.2GW of capacity by 2022 (Ofgem 2020), with a further three interconnectors having passed the initial project assessment (IPA) phase with Ofgem granting a cap and floor regime in principle. These operational and planned interconnectors connect England to the Republic of Ireland, Norway, Denmark, Germany, Belgium, The Netherlands and France. No connection point between Ireland and South Wales or South West England currently exists.

The configuration of any interconnector project is influenced by the location of the existing network infrastructure, its ability to accommodate the required connection capacity, any requirement for network reinforcements, and other factors such as environmental constraints. A review of potential grid connection locations, assessing these factors, was undertaken for the GB Transmission Network by National Grid Electricity System Operator. This was a collaborative process, referred to as the 'Connections and Infrastructure Options Note' (CION) process, involving both National Grid and GIL to identify the most suitable grid connection point for Greenlink.

The CION process identified eight substations in South West England and South Wales as feasible solutions, with Pembroke, South Wales selected as the feasible solution. All other alternatives, including locations in South West England were discounted as they did not meet Project Objectives, or comparatively did not offer a suitable alternative to Pembroke.

In conclusion, the selection of the GB connection point as Pembroke confirmed the final selection of South Wales as the National Connection Point. South West England was discounted as it does not meet all Project Objectives and therefore as an alternative solution for a National Connection Point is less suitable.

6.6.2.6 Summary

Table 6-5 summarises the assessment of alternative national connection points against Project Objectives.

Table 6-5 Comparison of alternative national connection points against Project Objectives

Alternative	Project Need	Core Project Objectives								Justification	Decision
		1	2	3	4	5	6	7	8		
Scotland	✓	✓	✓	✓	X	✓	✓	✓	✓	Not economically viable	Discounted
North Wales	✓	✓	✓	X	X	✓	✓	✓	✓	Does not meet Project Objectives 3 and 4 and economically less favourable	Discounted
Mid Wales	✓	X	X	X	X	X	X	X	X	Not technically feasible	Discounted

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Alternative	Project Need	Core Project Objectives								Justification	Decision
		1	2	3	4	5	6	7	8		
South Wales	✓	✓	✓	✓	✓	✓	✓	✓	✓	Meets all Project Objectives.	Selected
South England	✓	✓	✓	✓	✓	X	✓	✓	✓	Does not meet Project Objective 5 and would have same environmental effects as Wales due to location of potential connection point.	Discounted

6.6.3 Alternative GB Connection Points

The CION process completed by National Grid in collaboration with GIL identified eight substations that could offer connection locations to the west of the GB Transmission Network and access to the Irish Coast, thereby meeting Project Objective 1. The joint process considered the technical, commercial, regulatory, environmental and socio-economic aspects of Greenlink and potential grid connection points.

One substation in South West England (Alverdiscott) and seven in Wales were initially considered as connection points. These sites were:

- Alverdiscott 400kV;
- Swansea North 400kV;
- Pembroke 400kV;
- Pentir 400kV;
- Wylfa 400kV;
- Dinorwig 400kV;
- Indian Queens 400kV; and
- Taunton 400kV.

Following the initial assessment the following four sites were removed from consideration on the basis that they were not technically feasible. These were:

- Wylfa 400kV substation – discounted due to the extent of required enabling works and no real benefit in comparison to a connection at the nearby Pentir 400kV substation.
- Dinorwig 400kV substation – discounted due to the level of required civil works and the potential environmental impact arising from the proximity of the Snowdonia National Park.
- Indian Queens 400kV substation – discounted due to current substation configuration and no significant benefit over Alverdiscott, which is a closer connection point.
- Taunton 400kV substation – discounted due to current substation configuration and no significant benefit over Alverdiscott, which is a closer connection point.

National Grid Electricity System Operator then completed a Cost Benefit Analysis for the four remaining feasible alternatives (Alverdiscott 400kV, Swansea North 400kV,

Pembroke 400kV and Pentir 400kV). Figure 6-2 and Table 6-6 presents a figure and table included in the CION that summarises route distances between Ireland and the four options. Pembroke is the shortest route by a considerable distance and therefore comparatively fulfils Core Objective 5 better than the alternatives.

Table 6-6 Summary of project distances

Site	Distance (km)			European Marine Sites crossed
	Onshore	Offshore	Total Distance	
Alverdiscott 400kV	38	222 (direct) 244.2 (10% added) 266.4 (20% added)	260 (direct offshore) 282.2 (10% offshore added) 304.4 (20% offshore added)	Bristol Channel Approaches SAC Skomer, Skokholm and the Seas off Pembrokeshire SPA Pembrokeshire Marine SAC West Wales Marine SAC
Pembroke 400kV	36	136 (direct) 149.6 (10% added) 163.2 (20% added) 159 (known constraints included)	172 (direct) 185.6 (10% offshore added) 199.2 (20% offshore added) 195 (known offshore constraints included)	Skomer, Skokholm and the Seas off Pembrokeshire SPA West Wales Marine SAC Pembrokeshire Marine SAC Limestone Coast of South West Wales SAC Castlemartin Coast SPA
Swansea North 400kV	59	207 (direct) 227.7 (10% added) 248.4 (20% added)	266 (direct offshore) 286.7 (10% offshore added) 307.4 (20% offshore added)	Bristol Channel Approaches SAC Skomer, Skokholm and the Seas off Pembrokeshire SPA Pembrokeshire Marine SAC West Wales Marine SAC Carmarthen Bay SPA
Pentir 400kV	49	220 (direct) 244 (10% added) 264 (20% added)	269 (direct offshore) 293 (10% offshore added) 313 (20% offshore added)	Aberdaron Coast and Bardsey Island SPA Lleyn Peninsula and the Sarnau SAC West Wales Marine SAC

Note: It was acknowledged that length of direct offshore routes is likely to increase by 10 to 20% as constraints become known and therefore costs would increase accordingly.

With respect to the effects on the European Site Network, three of the four alternative connection points would require crossing of a Marine European Site. Information on the European Marine Sites has been included in Table 6-6 above. Routes to Alverdiscott, Pembroke and Swansea North would cross the same European Sites; with slight difference attributed to the landfall sites. However, as all routes would require a crossing of the Pembrokeshire Marine SAC effects on the European Site Network would be comparable for each alternative.

There is the potential that an offshore route to Pentir could be engineered that avoided the three offshore sites crossed by a direct route. However, this would

increase the cable length, reducing the economic viability of the option and benefit to the consumers in both Ireland and GB.

An indication of the impact of the additional route length on delivery cost is shown in Table 6-7.

Table 6-7 Summary of potential additional costs based on connecting to Pentir instead of Pembroke

Connection	Offshore Length (km)	Offshore Cost (€)	Onshore Length (km)	Onshore Cost (€)	Combined Cost (€)
Pembroke (known marine constraints)	159	111.3 million	36	43.2 million	154.5 million
Pentir direct	220	154 million	49	58.8 million	212.8 million
Pentir plus 10% marine	244	170.8 million	49	58.8 million	229.6 million
Pentir plus 20% marine	264	184.8 million	49	58.8 million	243.6 million

Note: Costs calculated presented in the table above are based on the following prices to deliver 1km of an hvdc cable route. 1km of offshore cable route circa. €700,000 and the cost to deliver 1km of onshore cable route circa. €1,200,000.

Pentir was discounted on the grounds that it does not meet Project Objective 5 (shortest route). There were also significant concerns regarding meeting Core Project Objective 7 (Permittable) due to the number of projects looking to connect to Pentir at that time and the impact an additional project connecting would have on the delivery of the projects already contracted for connection. The additional cost of more than €75 million would have made Pentir economically unviable and therefore result in the failure to deliver Project Objectives.

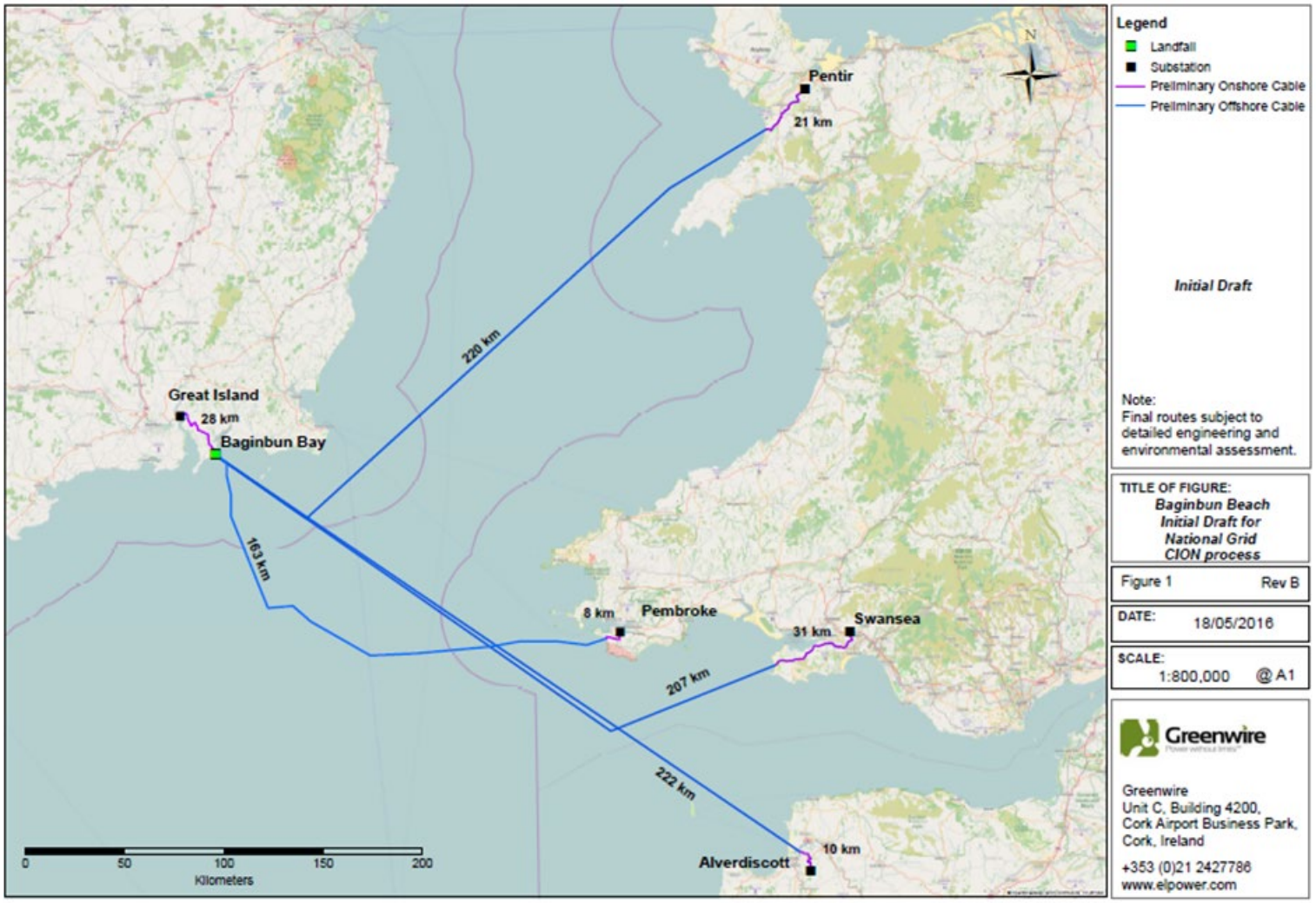
After completing the CION and Cost Benefit Analysis, National Grid Electricity System Operator determined the most economical connection point to be Pembroke 400kV substation, requiring only a busbar extension to provide a connection point for Greenlink. National Grid Electricity System Operator also concluded that the site facilitates the connection from other points of view (environmental, consenting etc). As a connection point Pembroke can meet all Core Project Objectives; and comparatively is the most suitable connection point for Greenlink.

Table 6-8 presents the comparison of alternative connection points with Core Project Objectives.

Table 6-8 Comparison of alternative connection points against Project Objectives

Alternative	Core Project Objectives								Justification	Decision
	1	2	3	4	5	6	7	8		
Alverdiscott	✓	✓	✓	✓	X	✓	✓	✓	Does not meet Project Objective 5 and would have same environmental effects as Pembroke.	Discounted
Swansea North	✓	✓	✓	✓	X	✓	✓	✓	Does not meet Project Objective 5 and would have same environmental effects as Pembroke.	Discounted
Pembroke	✓	✓	✓	✓	✓	✓	✓	✓	Meets all Core Project Objectives.	Selected
Pentir	✓	✓	✓	✓	X	✓	X	✓	Does not meet Project Objectives 5 or 7.	Discounted
Wylfa	X	X	X	X	X	X	X	X	Not technically feasible.	Discounted
Dinorwig	X	X	X	X	X	X	X	X	Not technically feasible.	Discounted
Indian Queens	X	X	X	X	X	X	X	X	Not technically feasible.	Discounted
Taunton	X	X	X	X	X	X	X	X	Not technically feasible.	Discounted

Figure 6-2 Summary of project distances



6.6.4 Alternative Landfall Sites

6.6.4.1 Assessment

Following identification of Pembroke substation as the connection point for Greenlink, an options appraisal study of the Pembrokeshire coastline was undertaken using a search area from Strumble Head in the north to Tenby in the south.

The options appraisal (desk-top study), undertaken by JP Kenny (2012), considered a range of environmental, technical and economic constraints to identify suitable landfall locations within the search area. It was undertaken in parallel with consideration of onshore locations for converter stations and underground and marine cable routes.

Criteria assessed included vessel access, beach composition, amenity impact, environmental constraints (e.g. presence of protected sites), exposure, coastal erosion, access to beach, cable engineering and protection requirements, obstructions and existing infrastructure.

Eleven potentially suitable landfall locations in Pembrokeshire were identified. Shown on Figure 6-3 (Drawing P1975-LOC-002), these were Broad Haven; Broad Haven South; Freshwater West; Freshwater East; Tenby South Beach; Dale; Whitesands; Abereiddy LF; Aber Mawr 1 & 2; and Strumble Head.

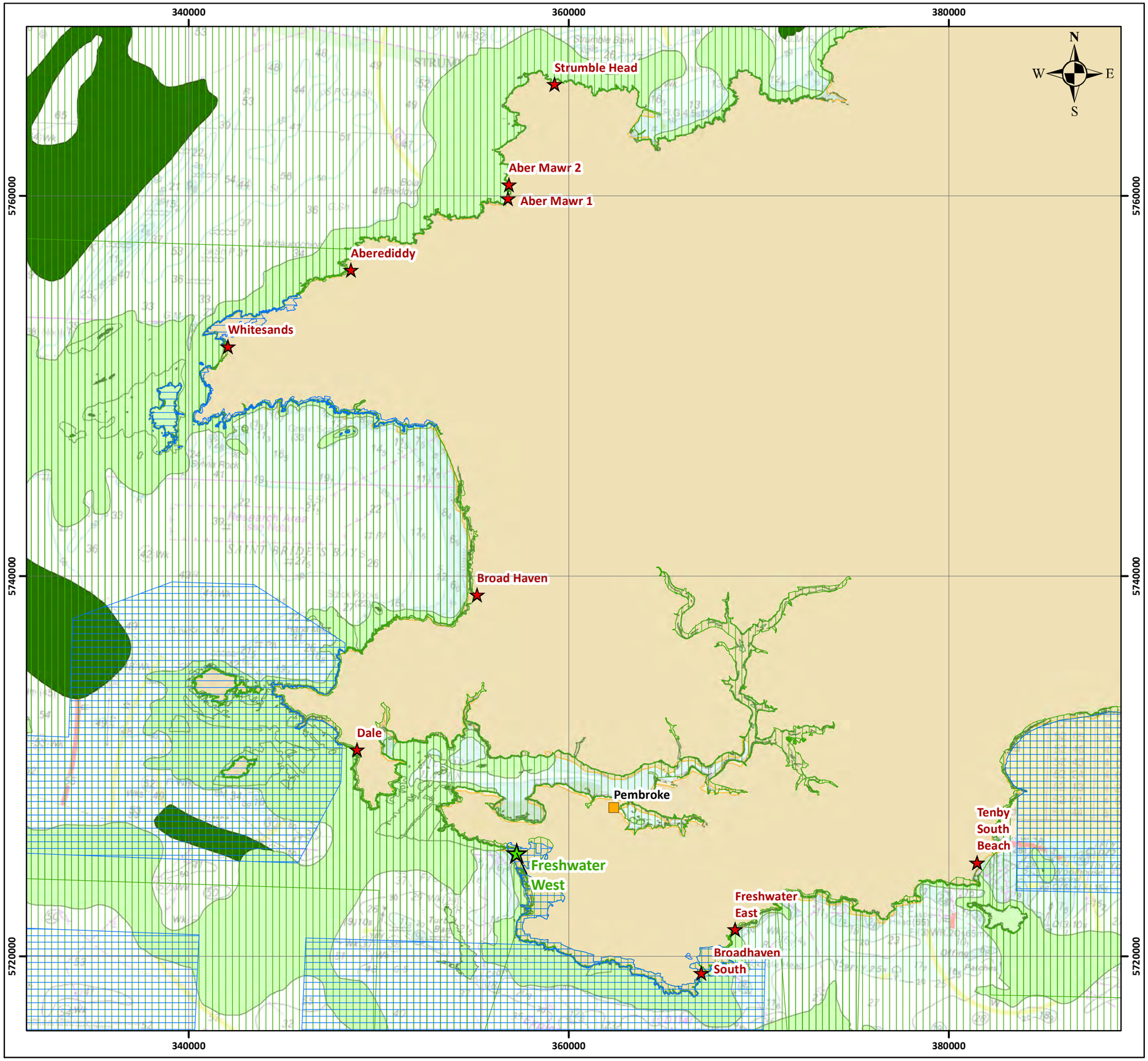
Of the eleven potential sites, nine were discounted as less suitable on environmental and technical grounds meaning they could not meet all Core Project Objectives; and two (Broad Haven and freshwater West) were recommended for further investigations. Justification for this decision is provided in Table 6-9. Table 6-10 summarises the assessment for all landfall alternatives against Project Objectives.

Consultation and preliminary engineering assessment in late 2013 and early 2014 focused on two questions:

1. Would routeing across Castlemartin Firing Range be permitted by the Ministry of Defence?
2. How would a crossing of Milford Haven be undertaken e.g. HDD, tunnel, using existing bridges?

Routeing within the vicinity of the range was thought to be not feasible or at the very least problematic. However, consultation with the Ministry of Defence (MoD) in late 2013 and early 2014 with respect to Freshwater West being a suitable landfall, indicated that routeing within the Castlemartin Firing Range would be permitted. Further discussions with the MoD throughout 2016 and 2017 determined that the co-location of a submarine cable and the military firing range was possible, from the MoD perspective.

Concurrently, consideration of the engineering requirements for a Milford Haven crossing confirmed that although feasible it would be extremely challenging technically. Milford Haven port Authority confirmed that they would not grant permission to trench the cables across the Haven and therefore significant construction work would be required adjacent to and under the Pembrokeshire Marine SAC to make the crossing. Combined with the long onshore route and the comparatively more economically, technically and environmentally straightforward solution offered by Freshwater West Broadhaven was discounted as a solution.



GREENLINK INTERCONNECTOR

ROUTE OVERVIEW
UK Landfall Options

Drawing No: P1975-LOC-002	A

Legend

- Landfall Selected
- Landfall Considered
- Power Station

Protected Sites

- SAC
- SPA

Potential Reef

- Bedrock
- Stony



NOTE: Not to be used for Navigation

Date	Monday, April 8, 2019 08:48:09
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	CDA; GEBCO; UKHO; JNCC; MarineFind
File Reference	J:\P1975\Mxd\01_LOC\ P1975-LOC-002.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

Co-financed by the European Union Connecting Europe Facility

intertek

0 2 4 6 8 km

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Table 6-9 Summary of landfall selection

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Freshwater West	Advantages: It has the shortest onshore route of all options under consideration; • Technically straightforward; • The nearshore route avoids the firing range; • Sandy foreshore with favourable nearshore beach profile; • Reasonable onshore access. Disadvantages: Proximity to firing range; • Proximity to Milford Haven harbour entrance; • High value recreational amenity; used by surfers. • Shore crossing and working area likely to be through dunes to public carpark and subsequently be likely be subject to environmental restrictions. • Evidence of land movement in the slope behind dunes leading up to the public access road; • Potential for rock to be encountered in the nearshore (slate and conglomerate exposed on the beach at low tide at far Northern end of beach), areas of rock identified on admiralty chart.	Intertek agrees that this is a good choice for the Greenlink Interconnector to landfall. The greatest advantage of using this location as the preferred landfall option is that it is the shortest route to the connection point with no technical challenges. It is also south of the haven and therefore avoids a harbour crossing. The offshore route does not avoid the firing range but consultation with the MoD has resulted in permission to route within the Castlemartin military area thus eliminating this as a routeing constraint and potential disadvantage. Using HDD will also eliminate the disadvantages posed by the environmental restrictions behind the beach and the high amenity value of the intertidal area. The major disadvantage of using this landfall is the potential risk the firing range will have in the operation and maintenance phase of the cables life; however, this isn't thought to be significant as the cable lies on the northern edge of Castlemartin firing range.	Landfall is within the following European sites: Castlemartin Coast SPA • Pembrokeshire Marine SAC • Limestone Coast of South West Wales SAC An offshore route to this landfall would additionally need to cross: West Wales Marine SAC • Skomer, Skokholm and Seas off Pembrokeshire SPA. JNCC mapping of potential reef habitat indicates a route can be engineered that avoids reef habitat with Pembrokeshire marine SAC or crosses at shortest distance. Grey seal from Pembrokeshire Marine SAC likely to be present offshore but disturbance from cable installation will be limited and if necessary managed through appropriate mitigation. HDD under intertidal area will avoid negative adverse effects on Limestone Coast of South West Wales SAC. Potential disturbance effects to Qualifying bird Species of SPA will be short-term (<1-year) due to nature of installation and could be managed by appropriate mitigation if necessary e.g. seasonal restrictions. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation.

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Broad Haven	Advantages: The nearshore route can avoid the Castlemartin firing range; • Sandy foreshore (with some exposed rocks at northern end); • Nearshore geology on the admiralty chart is mostly sand, muds and gravels; • Favourable beach profile; • Onshore routing is constructible. Disadvantages: Consultation with Milford Haven Port Authority concluded that trenching within Milford Haven would not be permitted (due to existing infrastructure & dredging requirements). • It necessitates a technically challenging but feasible crossing of Milford Haven (~3km) e.g. either restricted to existing bridges or directional drill / tunnel under Milford Haven; • Long onshore route. • Broad Haven is a high value recreational amenity area and it is probable that the permit construction window will exclude the summer months; • Desire to avoid laying the cable along the seafront and through the town where possible; • Admiralty chart indicates some areas of rock in the nearshore; • Crossing under seawall is required if routing at the northern end of Broad Haven (not a major concern); • Storm water culvert at the northern end of the beach may impact on northern shore crossing route options.	Intertek also agrees that Broad Haven is a good choice for the Greenlink Interconnector to landfall. The beach profile is very favourable from a construction perspective. At the time of the desktop study, the major attraction of this landfall selection was that it avoids the Castlemartin firing range entirely. Subsequent discussions with the MoD has meant that the firing range is no longer a constraint, and therefore avoidance of the area no longer outweighs the disadvantage that the technically challenging crossing of Milford Haven poses to reach the connection point from this landfall.	Landfall is within following European sites: • West Wales Marine SAC • Pembrokeshire Marine SAC A direct offshore route to this landfall could also cross: Skomer, Skokholm and Seas off Pembrokeshire SPA. There is scope to route around the SPA but this would then require crossing potential Reef habitat as identified in JNCC mapping. JNCC mapping of potential reef habitat indicates a route can be engineered that avoids reef habitat or crosses at shortest distance. Offshore route will be approximately same length as to Freshwater West. Grey seal from Pembrokeshire Marine SAC likely to be present offshore but disturbance from cable installation will be limited and if necessary managed through appropriate mitigation. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation. Onshore route would require crossing of Pembrokeshire Marine SAC within Milford Haven.

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Broad Haven South	Broad Haven South is within the Castlemartin Firing range and as such should not be considered further unless other more favourable options are excluded. Points of note for Broad Haven South: Steep walking path access to down to the beach from the carpark (stairs, ~100m, up to 30deg slope); • Landfall construction will likely require an HDD into carpark to avoid open cut on the steep slope; • Tourist information boards identify several bird species local to the area including guillemot, razorbill and the area is also a nesting zone for Chough (Britain's rarest crow); • Rocks offshore (visible, castle rock), and also small breaking waves to the west of castle rock; • Sandy beach; • High tourist amenity and visual landscape value; • Significantly longer offshore route than Freshwater West.	Although Castlemartin firing range is no longer considered a constraint, an offshore route to this landfall would require traversing more of the active area. In addition, the offshore route would be approximately 10 km longer than one routing to Freshwater West; and mapping suggests Reef habitat, a Primary Feature of the Pembrokeshire Marine SAC is likely to be present on the landfall approach which could not be avoided. Only HDD would be feasible at this location.	Landfall is within the following European sites: Castlemartin Coast SPA • Pembrokeshire Marine SAC • Limestone Coast of South West Wales SAC • Skomer, Skokholm and Seas off Pembrokeshire SPA An offshore route to this landfall would additionally need to cross: West Wales Marine SAC. JNCC mapping of potential reef habitat indicates Reef habitat within Pembrokeshire Marine SAC on approach to landfall that could not be avoided. Grey seal from Pembrokeshire Marine SAC likely to be present offshore but disturbance from cable installation will be limited and if necessary managed through appropriate mitigation. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation. HDD under intertidal area will avoid negative adverse effects on Limestone Coast of South West Wales SAC. Castle Rock is significant breeding area for Qualifying Feature seabirds and it is likely that cable installation activities would cause significant disturbance. This would be difficult to mitigate given cable installation timings (likely to be summer) would overlap with breeding season.

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Freshwater East	Freshwater East is within the Castlemartin Firing range and as such should not be considered further unless other more favourable options are excluded. Points of consideration for Freshwater East: Gently sloping beach with gravel/pebbles/cobbles overlying sand; • Admiralty chart indicates gravels and sands in the nearshore; • The main access to the beach is from a car-park located approximately 20m to 50m from the beach at close to it's southern extent: • One walking path passes through small dunes (1-3m high) onto beach; • Another concreted footpath provides access alongside a small stream to the beach; • Difficult onshore route to the southwest: • Tight narrow roads, small stream with one-way narrow bridge (4 to 5m long bridge at the beach access location); • A two-lane road runs from the public access, at the southern end of the beach, towards the north. As soon as it exits the beach the road rises steeply and then run along the top of the slope approximately 300m behind the beach and estimated at over 30m high. Residential properties are located at the top of this steep bank along the length of the beach. There are also some walking access tracks down the slope to the beach and farm access which may be able to be improved for onshore cable construction up the slope; • There are mooring buoys for small watercraft at the southern extent of the beach and buoys marking the boat speed zones; • Significantly longer offshore route than Freshwater West.	Castlemartin Firing Range is no longer considered a constraint. However, the main factor to discount this landfall location is that the offshore route length would be approximately 15 to 20 km further than Freshwater West, and whereas the route to Freshwater West traverses the edge of the Firing Range a more direct path through the active area would be required to reach this landfall. In addition, Reef habitat, a Primary Feature of the Pembrokeshire Marine SAC is likely to be present on the landfall approach which could not be avoided.	Landfall is within the following European sites: Pembrokeshire Marine SAC • Bristol Channel Approaches SAC An offshore route to this landfall would additionally need to cross: West Wales Marine SAC • Skomer, Skokholm and Seas off Pembrokeshire SPA. JNCC mapping of potential reef habitat indicates Reef habitat within Pembrokeshire Marine SAC on approach to landfall that could not be avoided. Grey seal from Pembrokeshire Marine SAC likely to be present offshore but disturbance from cable installation will be limited and if necessary managed through appropriate mitigation. Effects on harbour porpoise from Bristol Channel Approaches SAC and West Wales Marine SAC could be managed through appropriate mitigation

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Tenby South Beach	A landfall at Tenby South Beach can be routed to narrowly avoid the Castlemartin Firing range. However, it is the longest offshore route, is a popular tourist area and has a long onshore route. Points of consideration: Sandy beach, admiralty chart indicates sand and shells in the nearshore area; • Golf course runs behind most of the beach except at the southeastern end; • Any landfall would likely be located at the SE end of beach, near new apartment blocks to avoid the golf course; • There are other cables making landfall at the SE end of beach for which proximity agreements would need to be negotiated; • Offshore, the cable would be routed between Caldey Island and Woolhouse rocks.	Castlemartin firing range is no longer considered a constraint but the added offshore cable route length (50km) necessary to avoid the Range and the potential reef habitat offshore and the additional asset proximity agreements has discounted this landfall location. The offshore cable route would also have to be engineered between Caldey island and Wales mainland which would represent a permanent risk to the cable during installation and the operation and maintenance phase with regards to anchor strike. An additional navigational risk assessment, specific to this location may be necessary.	Landfall is within the following European sites: • Bristol Channel Approaches SAC • Limestone Coast of South West Wales SAC • Carmarthen Bay and Estuaries SAC An offshore route to this landfall would additionally need to cross: • Carmarthen Bay and Estuaries SPA, West Wales Marine SAC, • Skomer, Skokholm and Seas off Pembrokeshire SPA • Pembrokeshire Marine SAC. JNCC mapping of potential reef habitat indicates Reef habitat within Pembrokeshire Marine SAC that could be avoided by adding additional cable length to route. Effects on harbour porpoise from West Wales Marine SAC and Bristol Channel SAC could be managed through appropriate mitigation.
Dale	The option to the west of Dale town is a difficult landfall, due to geology, topography and access issues, and therefore is not suitable.	Intertek agrees with the assessment.	Landfall is within the following European sites: Pembrokeshire Marine SAC An offshore route to this landfall would additionally need to cross: Skomer, Skokholm and Seas off Pembrokeshire SPA • West Wales Marine SAC. JNCC mapping of potential reef habitat indicates significant Reef habitat within Pembrokeshire Marine SAC on approach to landfall that could not be avoided.

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Whitesands	Whitesands appears technically feasible from a landfall construction viewpoint. Observations regarding the Whitesands landfall are noted below: Sandy beach with rock outcrops at northern extent, although rock noted in the nearshore on the admiralty chart; • Exit from a beach landfall could be through to the public car-park (approximately 40m x 120m); • From the car-park a narrow single lane road climbs up in a moderately steeply manner (no parking available on the road); • Adjacent to the access road at the top of the slope leading down to the beach is the St David's City Golf Course (entrance approximately 700m from the beach). The golf course extends to within 100m of the beach, on the southern side of the access road and south of the public car-park; • The beach has a high recreational amenity value and is a prominent surfing location; • The onshore route ~25km longer than that to Broad Haven but correspondingly the offshore route is shorter; • Most of the onshore main access road is suitable except for narrow congested sections through St David's and Solva town. It may be possible for alternative onshore routes to be proposed. However, the feasibility of the onshore route and the potential for public opposition due to the high recreational amenity value would need to be further investigated if this option is to be considered further.	Due to the length & challenges of the onshore route and the potential for public opposition Intertek did not consider this landfall further.	Landfall is within the following European sites: Pembrokeshire Marine SAC • West Wales Marine SAC. • Ramsey and St David's Peninsula Coast SAC JNCC mapping of potential reef habitat indicates Reef habitat within Pembrokeshire Marine SAC on approach to landfall that could not be avoided. Grey seal from Pembrokeshire Marine SAC likely to be present offshore but disturbance from cable installation will be limited and if necessary managed through appropriate mitigation. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation.

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Abereiddy LF	Abereiddy is a small beach located to the northeast of Whitesands and the town of St David's. The landfall comprises the following features: Exposed bedrock to the west of the beach; • To the east the foreshore comprises pebbles overlying sand; • A small (<2m) high concrete seawall is the sea defence for the public carpark which runs along the beachfront (~30m x 120m long); • Admiralty chart indicates shells and pebbles are present in the nearshore. The water depth increases quickly to ~25m at the end of the inlet approximately 400m offshore; • Beach is used for access to the nearby "blue lagoon", a disused slate quarry which has been infilled with seawater through a breach in the outer wall. This lagoon is a popular location for tourism activities that include coasteering; • Road access is generally suitable except for the final access to the beach which is approximately 4 to 5m wide. Much longer onshore route than Broad Haven.	The landfall study carried out by JP Kenny is inconclusive as to why this landfall was not selected. From an offshore perspective this landfall is a similar length to Freshwater West and poses minimal routing restrictions offshore. However, the approach to the beach consists of 2km of rock and potential reef (within the Pembrokeshire Marine Special Area of Conservation) and installation would be technically challenging e.g. extended HDD, rock cutting through potentially protected feature. In addition, as this area is a popular location for tourism, this option was discounted.	Landfall is within the following European sites: Pembrokeshire Marine SAC • West Wales Marine SAC. JNCC mapping of potential reef habitat indicates Reef habitat within Pembrokeshire Marine SAC on approach to landfall that could not be avoided. Grey seal from Pembrokeshire Marine SAC likely to be present offshore but disturbance from cable installation will be limited and if necessary managed through appropriate mitigation. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation.

Landfall	JP Kenny conclusions	Intertek comment	Environmental and European Site Impact
Aber Mawr 1 & 2	Aber Mawr 1 and 2 are gravel/pebble beaches located north of Abereiddy. Both beaches are similar in terms of geology. Access is difficult with no public road to the beaches. The Pembrokeshire coastal path network passes right across both beaches. The admiralty chart identifies the nearshore geology as gravels and pebbles. Access to both beaches is difficult: The public road is only one lane wide for the last 500-800m; • For Aber Mawr 1, construction access would be very challenging as behind the beach is a wetland/marsh area extending for approximately 500m; • For Aber Mawr 2, construction access could be built alongside the coastal walking path which leads at a moderate slope down the cliff, southwest towards the beach. This may require some adjacent landowner permissions.	Access to both beaches would be extremely difficult, therefore these landfalls were not selected.	Landfall is within the following European sites: West Wales Marine SAC. JNCC mapping of potential reef habitat indicates Reef habitat on approach to landfall that could not be avoided. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation. Direct route across to Ireland would avoid additional European sites but is not suitable due to a significant area of sandwaves. It is therefore likely an offshore route would have to cross to the south of the constraint necessitating the crossing of the Pembrokeshire Marine SAC and possibly the Skomer, Skokholm and Seas off Pembrokeshire SPA. Disturbance to grey seal from Pembrokeshire Marine SAC will be limited and if necessary could be managed through appropriate mitigation.
Strumble Head	Strumblehead was not accessed during the site visit as there was no public access available to the beach. It is the most northerly landfall that was identified as part of the desk top review. The location identified is a small inlet at the end of small valley to beach. The aerial view indicates a sandy foreshore but with rocks offshore. The beach is located approximately 500m from the public road and therefore landowner agreement would be required for construction and cable routing.	The lack of access at the landfall site excluded it from further consideration as a landfall option.	Landfall is within the following European sites: West Wales Marine SAC. JNCC mapping of potential reef habitat indicates Reef habitat on approach to landfall that could not be avoided. Effects on harbour porpoise from West Wales Marine SAC could be managed through appropriate mitigation. Direct route across to Ireland would avoid additional European sites but is not suitable due to a significant area of sandwaves. It is therefore likely an offshore route would have to cross to the south of the constraint necessitating the crossing of the Pembrokeshire Marine SAC and possibly the Skomer, Skokholm and Seas off Pembrokeshire SPA. Disturbance to grey seal from Pembrokeshire Marine SAC will be limited and if necessary could be managed through appropriate mitigation.

*Reference: JP Kenny (2012) Greenwire Part 2a: South Wales Landfall Options Report

Table 6-10 Comparison of Landfall Sites against Project Objectives

Alternative Landfall Sites	Core Project Objectives								Secondary Project Objectives				Justification	Decision
	1	2	3	4	5	6	7	8	9	10	11	12		
Freshwater West	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	All Core Project Objectives & Secondary Project Objectives can be met.	Selected
Broad Haven	✓	✓	✓	✓	X	✓	X	X	✓	✓	X	✓	All Core Project Objectives cannot be met. Long onshore route. Permitting & technical risks associated with technically challenging crossing of Milford Haven.	Discounted
Broad Haven South	✓	✓	✓	✓	X	✓	X	X	X	X	X	✓	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.	Discounted
Freshwater East	✓	✓	✓	✓	X	✓	X	X	X	X	✓	✓	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided. Permitting risk associated with location within Firing Range.	Discounted
Tenby South Beach	✓	✓	✓	✓	X	✓	✓	X	✓	✓	X	✓	All Core Project Objectives cannot be met. Long offshore and onshore routes.	Discounted
Dale	✓	✓	✓	✓	X	✓	X	X	X	✓	✓	X	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.	Discounted
Whitesands	✓	✓	✓	✓	X	✓	X	X	X	✓	X	✓	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.	Discounted
Abereiddy LF	✓	✓	✓	✓	X	✓	✓	X	X	✓	✓	✓	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.	Discounted
Aber Mawr 1 & 2	✓	✓	✓	✓	X	✓	✓	X	X	✓	✓	✓	All Core Project Objectives cannot be met.	Discounted
Strumble Head	✓	✓	✓	✓	X	✓	✓	X	X	✓	✓	✓	All Core Project Objectives cannot be met.	Discounted

6.6.4.2 Conclusion

Freshwater West fulfils all the Core and Secondary Project Objectives. There are no feasible suitable alternative landfall sites that can offer the same or better combination of environmental, technical and economic benefits. There is no feasible alternative solution that will have less of an effect on the Pembrokeshire Marine SAC or the European Site Network. Therefore, the selection of Freshwater West as the landfall site represents the most suitable option for the European Site Network and Pembrokeshire Marine SAC.

6.6.5 Alternative Offshore Cable Routes

6.6.5.1 Introduction

The development of the submarine cable route balances the need for a technically feasible and economically viable route corridor whilst limiting disturbance to people and the environment, and minimising cable length. In identifying preferred options, and determining if a route is feasible, the physical, environmental and human aspects were considered.

Route development has been an iterative process that started in 2015, involving cycles of consultation, refinement and survey. The submarine cable route has been designed to avoid or reduce environmental effects to ALARP levels (i.e. As Low As Reasonably Practicable) while also accommodating other factors.

The Greenlink Marine ES provides full details of all the route development work undertaken on Greenlink between Wales and Ireland. This consideration of alternatives focuses specifically on the alternatives considered in Wales that sought to minimise the effects on the European Site Network.

The following Project Objectives have driven route development in Wales:

#5. Shortest combined onshore and offshore cable route.

#9. To avoid where possible, or otherwise minimise the distance through which the route crosses reef habitat within the Pembrokeshire Marine Special Area of Conservation (SAC);

#10. To avoid where possible, or otherwise minimise the distance through which the route crosses the Castlemartin Firing Range; and

#11. To minimise disruption to shipping associated with Milford Haven and offshore traffic separation schemes.

In addition, Core Project Objectives 7 (permittable) and 8 (safe & efficient) have been key in the consideration of alternatives.

Given the position of Freshwater West within the Pembrokeshire Marine SAC a cable route that does not cross any European Sites is not a feasible alternative. In addition, none of the alternative connection points considered in Section 6.6.4 could deliver this alternative.

6.6.5.2 Identification of alternative route options

In 2015, GIL commissioned Intertek EWCS to undertake a desk-top study (Intertek EWCS 2015) to identify feasible submarine cable corridors from Freshwater West to short-listed landfalls in Ireland.

Constraints within the study area were identified and categorised as major, moderate, minor or no constraint, according to the likely impact on cable installation. The constraint categories were mapped and routes were designed to take cognisance of the constraints and their categorisation.

All routes developed in 2015 shared a common 'trunk' route from Freshwater West to approximately 45km from the coastline (as the crow flies). This was due to the mapped constraints such as the presence of the Castlemartin Firing Range, Milford Haven Port and disposal grounds.

Between February and August 2018, the route was re-examined ahead of the planned cable route survey. Consultation with NRW and new high-resolution bathymetric data received from SEACAMS led to refinements and the development of alternative options that sought to reduce the distance the route crossed a European Marine Site or reduced the distance the route crossed the Primary Feature Reef within the Pembrokeshire Marine SAC. Three alternative options were developed in Welsh waters; Route A, Route B and Route E[9] as shown on Figure 6-4 (Drawing P1975-LOC-004).

Route A

- Route A started with the common 'trunk' developed in 2015 but minor amendments were made to move the route further south, reducing the distance the route crossed the Skomer, Skokholm and the Seas off Pembrokeshire SPA. Routeing is constrained by the location of a disused explosive dumping ground in this area.
- Where appropriate, alterations were made to minimise the length of the route across potential reef features (identified using JNCC GIS maps), a Primary feature of the Pembrokeshire Marine SAC.
- The route was optimised to consider new information obtained on wrecks and obstructions.
- Nearshore route adjustments were made using SEACAMS bathymetric data provided by Bangor University. A channel infilled with sediment was identified within the outcropping rock (which was assumed to be Bedrock Reef). The routes were revised to follow this channel.
- The amendment resulted in the route going further into the Castlemartin Firing Range. Consultation with the MoD confirmed that this was feasible.

[9] Routes C and D were options developed in Ireland.

Route B

- An alternative to Route A, this route sought to reduce the distance within the Pembrokeshire Marine SAC and crossing of potential areas of bedrock reef habitat.
- This option encroaches further into the Castlemartin Firing Range; although this was confirmed as acceptable through consultation with the MoD. However, it was agreed that any further south into the active part of the Firing range would not be ideal.
- Route B was later discounted from further investigation, as although it reduced the distance through the Pembrokeshire Marine SAC it did not minimise the length of potential reef habitat crossed. Consultation with NRW confirmed that reef habitat outside the SAC should be regarded in the same manner as reef habitat within the SAC.

Route E

- Following consultation with NRW, it was concluded that further efforts should be made to avoid the potential areas of reef; a Primary feature of the Pembrokeshire Marine SAC.
- Route E sought to avoid potential areas of reef by routeing around it to the north.
- Routeing closer to the Milford Haven harbour entrance was confirmed as possible through consultation with Milford Haven Port Authority.

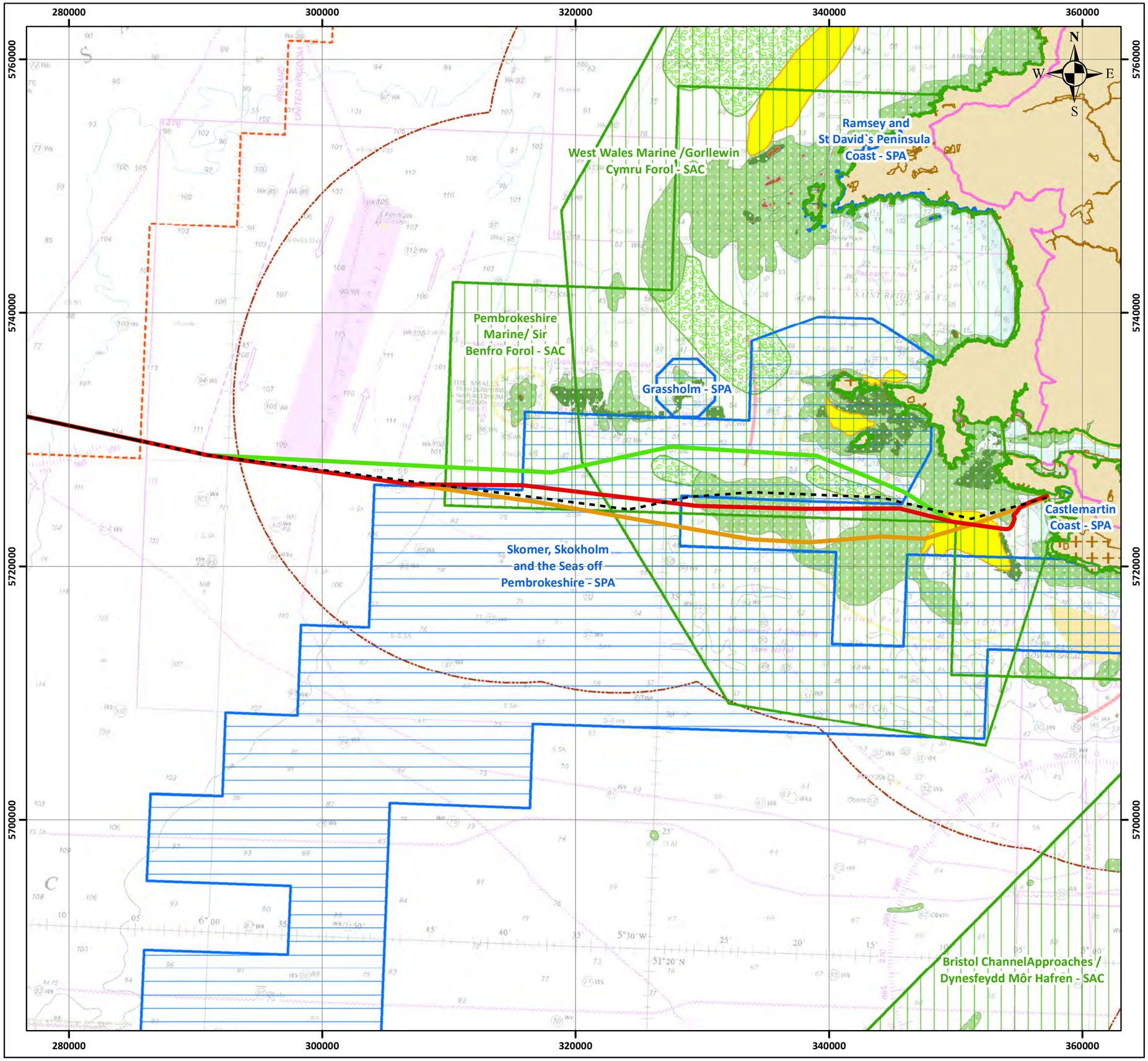
Intertek EWCS (2018) concluded the preferred option for survey was Route A, due to it being the shortest route. However, it was recommended that an initial reconnaissance survey was undertaken to assess the presence and quality of reef and / or sensitive habitats along Route A within the Pembrokeshire Marine SAC. If reef habitat was identified, then investigation of Route E should be undertaken to allow comparison and selection of a route that minimised the effects on the habitat.

A strategy was developed and agreed with NRW, that provided a decision-making process to be followed during the survey. The objective of the strategy was to provide a framework for comparing the environmental results from Route A and Route E leading to a decision on the final route for survey. The area defined as the 'reconnaissance survey' is shown on Figure 6-5(Drawing P1975-SURV-011).

GREENLINK INTERCONNECTOR

ROUTE OVERVIEW
UK Route Development

Drawing No: P1975-LOC-004 | **A**



Legend

- Original Proposed Route
- Route A Rev1
- Route B Rev0
- Route E Rev1

Environmental Designations

- SAC
- SPA
- SSSI
- National Park

Protected Sandbank Slightly Covered by Seawater

- Sandbank Area (High Confidence)
- Potential Sandbank

Potential Reef

- Bedrock (High Confidence)
- Bedrock (Potential)
- Stony (Potential)



NOTE: Not to be used for Navigation

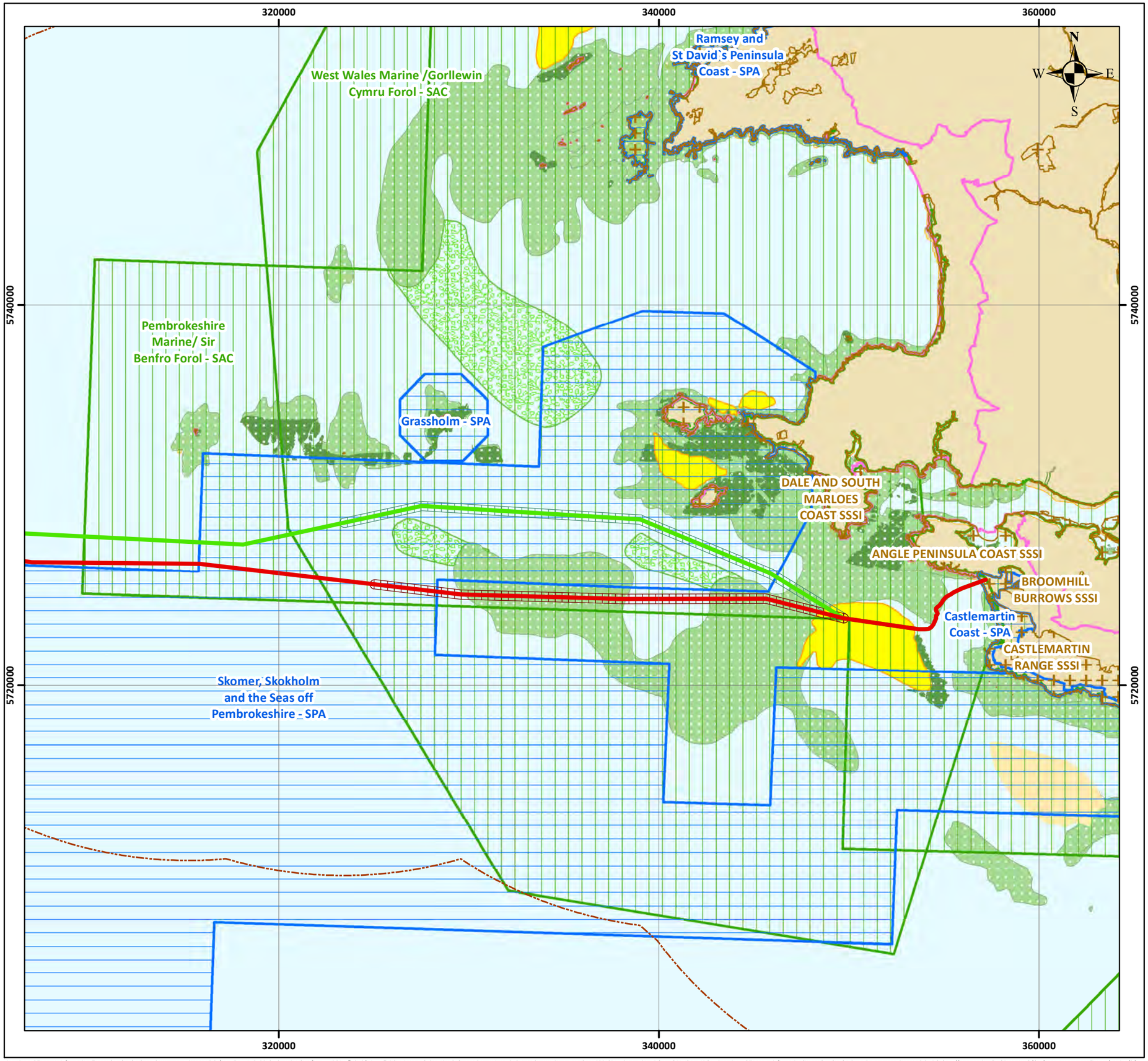
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Data Source	JNCC; NRW; GEBCO; UKHO; CDA; MarineFind; Greenlink
File Reference	J:\P1975\Mxd\01_LOC\ P1975-LOC-004.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

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GREENLINK INTERCONNECTOR

ROUTE OVERVIEW
UK Route Development

Drawing No: P1975-SURV-011	A

Legend

- UK 12nm Territorial Sea Limit

Greenlink Interconnector Proposed Routes

- Route A Rev1
- Route E Rev1

Reconnaisance Section

- Route A (24.84km)
- Route E (27.62km)

Environmental Designations

- SAC
- SPA
- SSSI
- National Park

Protected Sandbank Slightly Covered by Seawater

- Sandbank Area (High Confidence)
- Potential Sandbank

Potential Reef

- Bedrock (High Confidence)
- Bedrock (Potential)
- Stony (Potential)



NOTE: Not to be used for Navigation

Date	Friday, April 12, 2019 15:47:21
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	UKHO; CDA; NRW; JNCC; GEBCO; Greenlink
File Reference	J:\P1975\Mxd\02_SURV\ P1975-SURV-011.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

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0 2 4 6 8 km

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The cable route survey was carried out between September and December 2018 and involved extensive 'live' minor and major route development, in consultation with NRW, to react to the seabed conditions.

Minor route development during survey

Pre-survey analysis of available SEACAMS bathymetric data provided by Bangor University identified a possible sandy channel system through the extensive rock outcrop (potential Annex I Reef habitat) in nearshore Wales. The survey was engineered to acquire data over a 500m corridor with the intent to highlight more of the channel system within the bedrock.

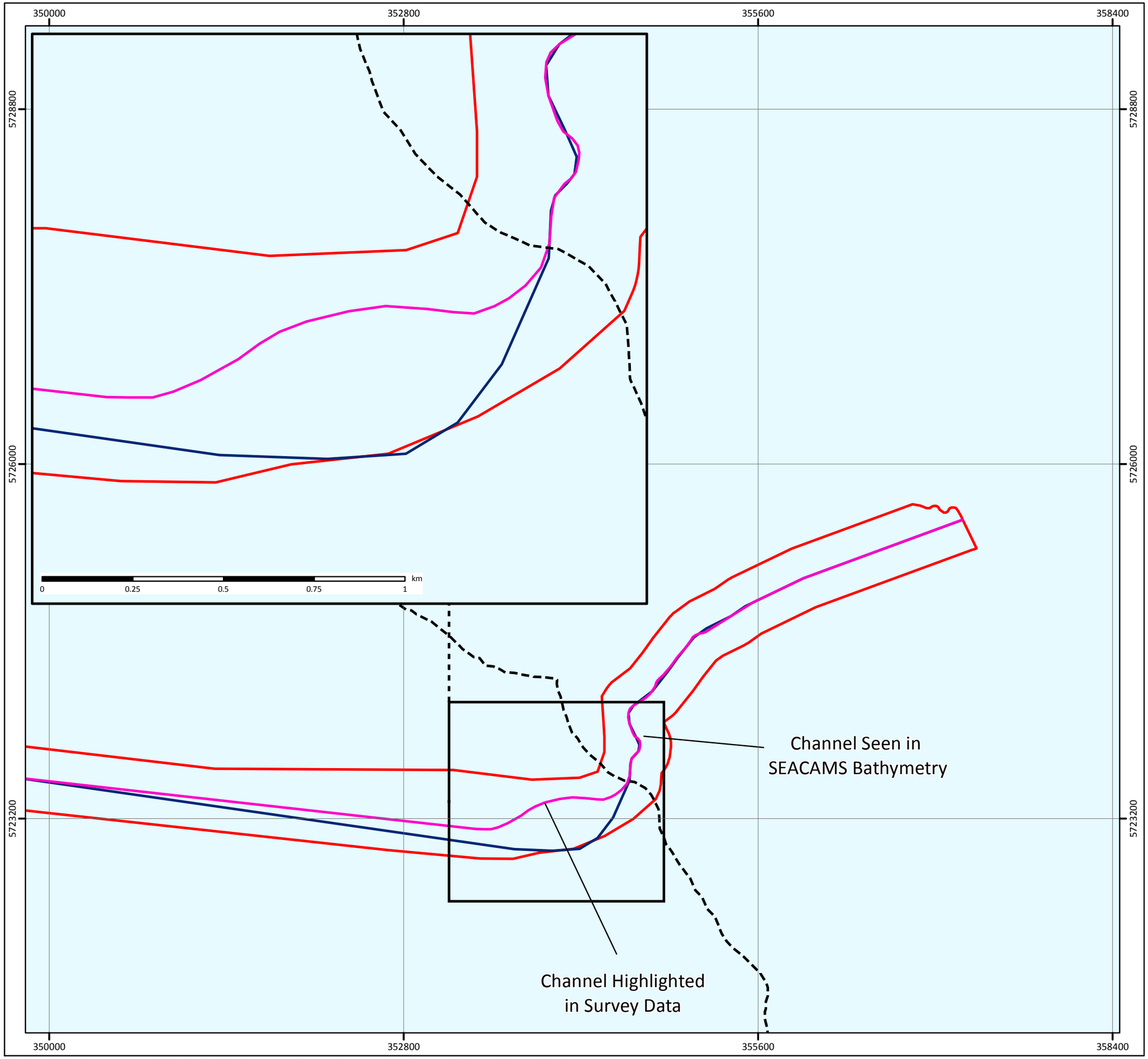
Once the survey was outside the area covered by the SEACAMS data it was identified that the channel system deviated outside the initial survey corridor. Therefore, additional geophysical survey data was acquired showing that it was possible to follow the channel system northwest of the original route. A route was then developed to follow the channel avoiding the outcropping rock where possible, and survey data collected along this alignment; shown in Drawing P1975-SURV-001. Survey data confirmed that there is likely to be sufficient sediment depth within the channel to achieve the likely required burial depths and protection for the cables.

GREENLINK INTERCONNECTOR

SURVEY DATA

Bathymetry Nearshore Freshwater West

Drawing No: P1975-SURV-001 | **A**



Legend

- Post Survey Centreline
- Pre-Survey Centreline
- Proposed Development
- Desktop Bathymetry Extent

Survey Bathymetry Below LAT (m)

High : 80

Low : -80

N
W
E
S



NOTE: Not to be used for Navigation

Date	Monday, April 8, 2019 12:52:17
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	ESRI; OSOD; Bangor University; MMT; Greenlink
File Reference	J:\P1975\Mxd\02_SURV\ P1975-SURV-001.mxd
Created By	Chris Carroll
Reviewed By	Chris Goode
Approved By	Anna Farley

0 0.25 0.5 0.75 1 km

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Major route development

On completion of the reconnaissance survey of Route A and Route E, biotope maps, seabed photographs and an interpretive report were submitted to NRW for review. These identified extensive areas of Annex I Reef habitat on both routes. The Conservation Objectives for the Pembrokeshire Marine SAC for Annex I Reef habitat is that *"The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing"*.

Having reviewed the extent of the Annex I Reef biotopes described for the eastern arm of Route A, NRW concluded:

"due to the extent of the reef and the type of reef habitats contained within, the presence of a cable and associated construction work and protective covering would compromise the conservation objectives of the feature, should this section of Route A be used. (NRW 2018a)"

The same rationale applied for the eastern sections of Route E where Annex I reef feature has been identified throughout the width of the corridor, the loss of reef in that area would also be too great to be considered insignificant.

NRW (2018a) recommended that additional geophysical survey be completed to the eastern end of the reconnaissance survey area between Route A and Route E.

Two north-south geophysical survey lines were run between Route E and Route A (Drawing P1975-SURV-012) to identify if possible, the northern extent of the bedrock outcrop which formed the reef feature on Route A. The additional geophysical lines showed the top of the bedrock slightly north of the extent of the Route A survey corridor. This led to a route being designed between Route E and Route A that avoided the sensitive reef habitat on both routes (Drawing P1975-SURV-012).

Seabed photographs, a biotope map and interpretative report were subsequently submitted to NRW for the new route section for review. NRW (2018b) considered the biotope to be present should be classified as A5.141 or SS.SCS.CCS.SpiB "*Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles". NRW considers this biotope forms part of the Annex I Reef (stony reef) habitat. However, NRW (2018b) advice concluded:

"NRW considers that this alternative route is likely to be preferable to routes A and E because:

- *The cobble/sediment biotope identified, potentially A5.141, will have a low sensitivity to the cable lay. If the cable is buried within this biotope, and covered with the existing sediments, recovery will occur as the sediments are routinely scoured and moved by wave and tidal action. As stated in the JNCC biotope description for A5.141 "This biotope is characterized by a few ubiquitous robust and/or fast growing ephemeral species which are able to colonise pebbles and unstable cobbles and slates which are regularly moved by*

wave and tidal action" and long-lived or delicate species are not regularly present.

- *There are boulders and other potential Annex I habitats including Sabellaria reef present. The side scan and drop-down video however appear to indicate that these habitats can be avoiding through micro-siting of the cable.*

At this stage, and without prejudice to later comments made during the application phase, NRW would not consider that there would be significant issues with laying a cable within A5.141, should burial of the cable be possible within this habitat with covering of local sediments from A5.141 biotope. (NRW 2018b)"

The final Greenlink route being taken forward for consent in Wales, the 'Proposed Development', is shown in Figure 1-2 (Drawing P1975-CORR-001). The advantages of the Proposed Development, in comparison to alternative routes considered are:

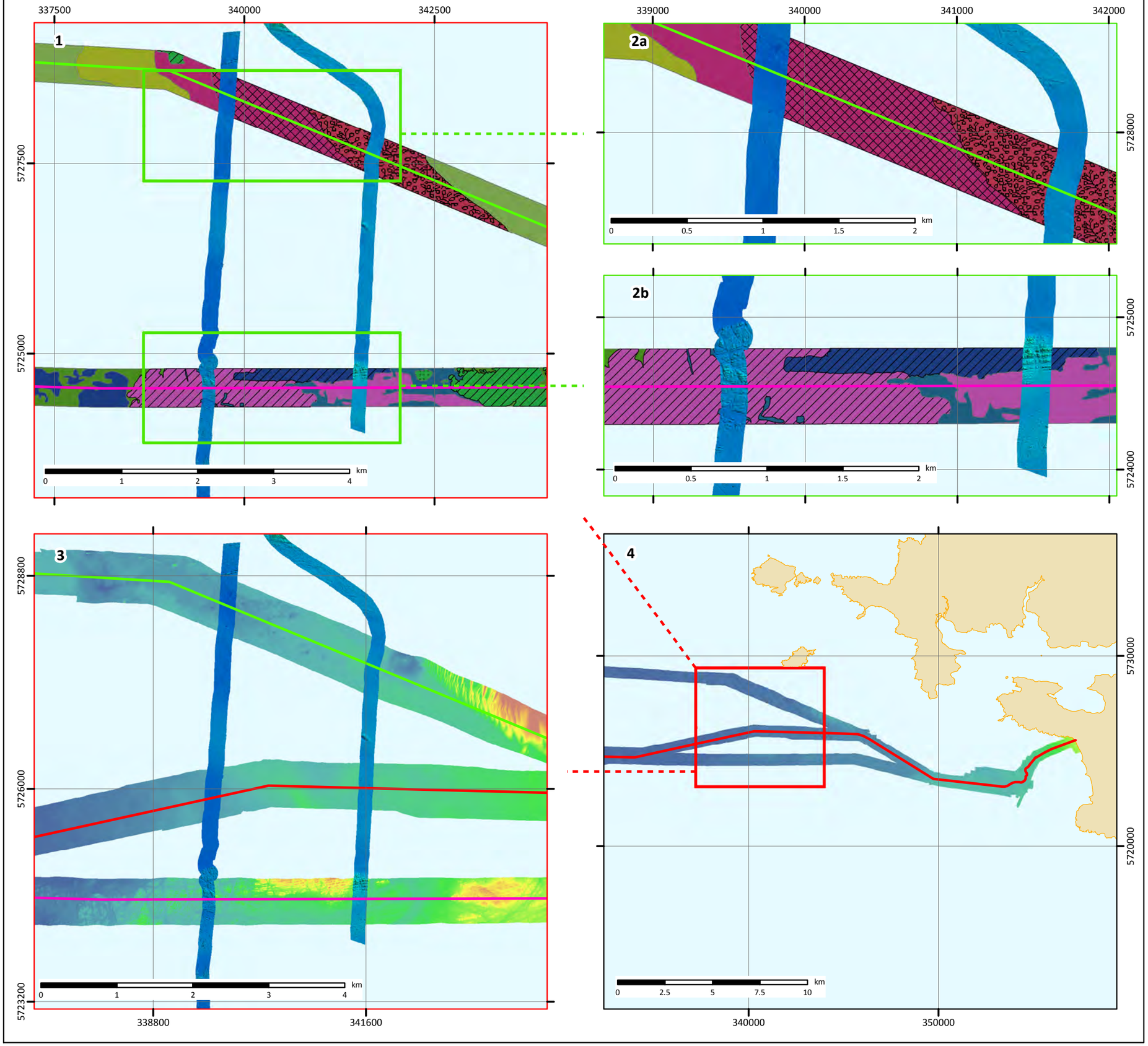
- The route minimises the area of Annex I reef habitat crossed and avoids the most sensitive habitats identified on Route A and Route E.
    - Route A would have required extensive external cable protection due to the presence of Bedrock Reef habitat across the width of the survey corridor.
    - Route E would have required external cable protection in areas of Bedrock Reef and potentially in medium grade Stony Reef and Biogenic Reef.
    - The Proposed Development avoids the sensitive Bedrock reef habitat found on the other routes offshore. The habitat crosses cobble-sediment biotopes which will have a lower sensitivity to cable lay in comparison to habitats found on Routes A and E.
- The route is the minimal length within the Castlemartin Firing Range necessary to avoid other constraints such as presence of Annex I Reef and historical dumping sites.
- The installation solution at the landfall has been selected as horizontal directional drilling, which will ensure that disruption to the recreational use of the beach is minimised and onshore environmental sensitivities are avoided.

GREENLINK INTERCONNECTOR

SURVEY DATA

Survey Routeing to Avoid Sensitive Habitat Post NRW Consultation

Drawing No: P1975-SURV-012 | **A**



Legend

- Greenlink Route Centreline (Indicative)
- Route A Rev 1
- Route E Rev 1

N W E S

BIOTOPE CLASSIFICATION

- A5.44 - Circalittoral mixed sediments
- A4.13 - Mixed faunal turf communities on circalittoral rock
- A4.131 - Bryozoan turf and erect sponges on tide-swept circalittoral rock
- A4.22 - Sabellaria reefs on circalittoral rock
- A4.24 - Mussel beds on circalittoral rock
- A5.14 - Circalittoral coarse sediment
- A5.25 - Circalittoral fine sand
- A5.45 - Deep circalittoral mixed sediments
- A5.611 - Sabellaria spinulosa on stable circalittoral mixed sediment
- Potential AnnexI (1170) - Bedrock Reefs
- Potential Annex I (1170) - Biogenic Reef
- Potential Annex I (1170) - Low Graded Biogenic Reef
- Potential Annex I (1170) - Stony Reefs

Survey Bathymetry
Depth Below LAT (m)

High : 60.55

Low : 32.97



NOTE: Not to be used for Navigation

Date	Wednesday, April 10, 2019 09:44:20
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OSOD; MMT; Greenlink
File Reference	J:\P1975\Mxd\02_SURV\ P1975-SURV-012.mxd
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intertek

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6.6.5.3 Conclusion

As outlined in Table 6-11, the Proposed Development fulfils all the Core and Secondary Project Objectives. There are no suitable alternative offshore routes within the Pembrokeshire Marine SAC that can offer the same or better combination of environmental, technical and economic benefits. Therefore, the selection of the Proposed Development represents the most suitable option for the European Site Network and Pembrokeshire Marine SAC.

Table 6-11 Comparison of Alternative Offshore Cable Route Options against Project Objectives

Alternative Offshore Cable Routes	Core Project Objectives								Secondary Project Objectives				Justification	Decision
	1	2	3	4	5	6	7	8	9	10	11	12		
Route A	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	✓	Extensive outcropping bedrock Reef identified which comparatively would be harder to install than other options and would have a greater effect on the Pembrokeshire Marine SAC; extensive external cable protection would be required as a primary option.	Discounted
Route B	✓	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	Comparatively the option encroached the furthest into the Castlemartin Firing Range and did not reduce the area of potential Reef habitat crossed.	Discounted
Route E	✓	✓	✓	✓	X	✓	X	✓	X	✓	✓	X	Comparatively, the longest option, with the greatest effect on Milford Haven. Would require external cable protection as a primary option.	Discounted
Proposed Development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	All Core Project Objectives & Secondary Project Objectives can be met. Reef cannot be avoided but effects have been minimised. Consideration of external cable protection as a contingency option.	Selected

6.6.6 Alternative Installation Techniques

6.6.6.1 Overview

The options for power cable installation are:

1. Surface lay – no protection
2. Burial in seabed
   a. Cutting / trenching

b. Jetting

3. External cable protection
   a. Rock revetment
   b. Concrete mattressing
   c. Cast iron shells

To determine which option is technically feasible a detailed Cable Burial Risk Assessment (CBRA) (Intertek 2019) has been undertaken for Greenlink to determine a recommended minimum depth of lowering (RMDOL) and a target depth of lowering (TDOL). These are defined as follows:

- RMDOL - This is the minimum depth of lowering recommended for protection from the external threats. It is the direct output of a fishing risk assessment and a probabilistic anchor risk assessment and includes a factor of safety (FoS).
- TDOL - This is the depth that will be specified as the target depth to the cable installation contractor. TDOL is a depth which makes best use of what is achievable by industry standard burial tools to gain additional depth beyond RMDOL without incurring a step change in costs. Target DOL is also a practical application of depth which considers the effect burial depth has on tool stability.

The CBRA split the Proposed Development into zones based on the ground conditions and then determined the RMDOL and TDOL for each zone considering seabed composition and dynamics, fishing risk and anchoring risk within the specific zone.

The CBRA has determined a RMDOL of at least 0.6m, increasing to 0.75m for certain sections for the entire Greenlink route. However, TDOL has been set as between 1.0m and 1.5m.

6.6.6.2 Surface lay – no protection

The RMDOL indicates that Option 1 – surface lay with no protection, is not a viable option as it would expose the cables to the risk of damage from external interaction.

A primary risk to installed interconnectors is the threat of snagging or damage from external threats e.g. anchors or fishing. The risk is heightened where the cable is surface laid without protection. iNLIP (2018) comment that *"The costs of fabricating a new section of cable, mobilisation, exposing and jointing, re-trenching and demobilisation can run to greater than EUR20m (£17.7 million) depending on the extent of the damage, the location, and the ease with which a repair campaign can be completed"*. The Guardian reported in March 2017 that repairs to the Interconnexion France Angleterre (IFA) interconnector following an anchor strike were in the region of £30 to £40 million (Vaughan 2017). GIL therefore need to ensure that this risk is appropriately managed; the best way to do this is to ensure the cables are buried or protected.

In addition, a surface laid cable could represent a navigation hazard to other sea users. In the late 1980s and 1990s a succession of fishing vessels were lost when their gear became fouled on exposed subsea cables (Kazaz 2019). It is therefore

recognised by Regulators, stakeholders and the cable industry that the preference is to bury or protect cables to ensure safety at sea. This is supported by the Welsh National Marine Plan which recognises the potential for conflict and notes that the cable industry can "*increase co-location and coexistence opportunities, by undertaking burial of the cable…Preference should be given to this method of cable installation where there is possibility of significant impact by other activities and where seabed conditions are suitable. Where burial is not achievable or desirable, alternative protection measures may be appropriate (in line with regulatory requirements and industry good practice) (Welsh Government 2019).*" Surface lay is therefore not in line with Welsh Government Policy or Industry Best Practice.

6.6.6.3 Burial in seabed versus external cable protection

The choice of burial technique or protection method depends on location specific seabed conditions. The preference is always to bury the cable in sediment as this offers the best protection, is typically the most economical option and is recognised by the industry and Regulators as the best environmental practice.

The benefit of burial in seabed is that habitats are only temporarily disturbed and are able to recover in the short- to medium-term. The footprint of disturbance is also narrower than would be experienced with deposit of external cable protection. The trench created is generally less than 1m wide (~70cm). Although the installation tools can be up to 15m wide they typically move across the seabed on tracks or skids which may only leave temporary compression depressions of 1m width either side of the trench.

The choice of burial equipment is largely dependent on the shear strength of the soil present.

Cutting is used for hard seabed materials and produces slot or v-type trench types. Mechanical trenchers can work in all sediments including those with high shear strength and even weak bedrock. These machines are usually mounted on tracked vehicles and use chain saws or wheels armed with tungsten carbon steel teeth to cut a defined trench. Most spoil is ejected from the trench by the cutting action and the cable is guided into the trench base by a depressor.

The mechanical action may be augmented in some cases by eductors that suck disrupted material out of the trench and deposit it to the side. The open trench can be back-filled or left to refill naturally. A typical mechanical trencher can make a trench of 0.3-0.7m in width and the overall footprint of the mechanical trencher is approximately 5-15m.

Jetting is used in non-cohesive soils. High powered pumps inject sea-water into the seabed either side of the cables through jetting 'swords'. This fluidises the seabed beneath the cables allowing them to naturally sink to the required burial depth. The seabed sediments naturally re-form and 'back-fill' the trench covering the cables, only creating localised and temporary (less than one tidal cycle) turbidity plumes. If the required burial depth is not achieved, several passes can be made.

However, soil conditions may not be suitable for burial in all locations. Where underlying bedrock in close to the surface, or sediments have a very high shear strength (e.g. stiff clays), it is possible that cutting/trenching or a jetting system would not be capable of achieving cable burial. In these instances, external cable protection is considered.

The indicative locations of external cable protection were defined based on initial interpretation of the Greenlink cable route survey geophysical and geotechnical data. The assessment took into consideration soil conditions, depth of bedrock, the TDOL and the capabilities of burial equipment, to identify locations where burial may not be achieved. A precautionary approach was taken to ensure the HRA presented the worst-case.

It is possible that burial in seabed can be achieved and Project Specific Mitigation (included in the Greenlink Marine ES) will be implemented to ensure that the Installation Contractor considers burial first and justifies if and where external cable protection is used.

Table 6-12 presents the indicative locations where external cable protection may be required on Primary Reef habitat[10] and the installation technique that will be considered first.

Table 6-12 Areas of potential external cable protection within Primary Reef habitat – TDOL and installation technique

KP start	KP end	Primary Feature	Dominant sediment type (within anchor penetration depth)	TDOL	Burial in seabed installation method	Potential area of external cable protection
KP 2.38	KP 2.41	Bedrock Reef	Medium dense sand with loose sand veneer (0.5m)	1.5m	Jetting	10m x 30m
KP 4.86	*KP 5*	*Bedrock Reef**	*Medium dense sand with loose sand veneer (0.5m)*	*1.5m*	*Trencher not expected to be capable of cutting through bedrock. Jet if sand present and use rock revetment for external cable protection.*	*10m x 140m*
KP 15	KP 23	Medium Grade Stony reef	Medium Dense Sand with Very Loose Sand Veneer (0.15m)	1.5m	Cutting followed by remedial jetting; or jetting with remedial pass.	10m x 8000m

[10] Assessment identified other areas within Pembrokeshire Marine SAC where ground conditions may not be conducive to burial in seabed (outlined in Table 3-5. However, as these locations do not overlap areas of sensitive habitat they have not been included in the table.

KP start	KP end	Primary Feature	Dominant sediment type (within anchor penetration depth)	TDOL	Burial in seabed installation method	Potential area of external cable protection
KP 42	KP 44	Potential Biogenic Reef	Medium Dense Sand with Loose Sand Veneer (0.2m)	1.0m	Cutting followed by remedial jetting; or jetting with remedial pass.	10m x ~140m**

*Greenlink cable route survey (MMT 2018) confirmed that Bedrock Reef is not present along the cable centreline at KP5, as there is a narrow sand channel which can be followed between the Reef. However, using a precautionary approach it has been included in the assessment of significance as it is recognised that seabed conditions may change prior to installation.

** Potential biogenic reef is not present for the entire distance between KP42 and KP44. Most patches of Reef can be routed around. However, at approximately KP43.86 Biogenic Reef appears to cover the width of the Proposed Development. It is therefore assumed that approximately 140m of the external cable protection, if required at this location, will be on the Primary Reef Feature.

A request for further information was sent by NRW via email on the 03 July 2020. This request specifically asks for more information for why cable protection on biogenic reef (Annex I Reef – 1170) at KP42-KP44 cannot be ruled out.

For the section of cable between KP43 and KP44 where potential biogenic reef has been identified by survey, the preference will be to bury the cables in sediment as this offers the best protection, is typically the most economical option and is recognised by the industry and Regulators as the best environmental practice. The benefits of burial in seabed versus the use of external cable protection is discussed in detail above. Greenlink are committed to pursuing burial in sediment as the primary option for all sections of the cable where this is feasible. This is outlined in Table 6-12 where it states the primary installation technique to be considered will be cutting followed by remedial jetting, or jetting with a remedial pass.

However, as outlined previously, soil conditions may not be suitable for burial in all locations. A precautionary approach was taken to ensure the HRA presented the worst-case, which identified that external cable protection may be necessary between KP42 and KP44. Table 6-13 provides additional information as to why burial may not be achieved at the location between KP43 and KP44. As can be seen from this table the geotechnical testing (cone penetrometer test, CPT) reached a maximum depth of 0.52m. When a CPT does not penetrate the underlying strata, it is an indication that soil conditions may be too stiff for cable trenching. As a TDOL at the location is 1m (to protect against external aggressors), the current data suggests that the necessary burial depth to achieve cable protection may not be achieved and some level of external cable protection may be required.

Table 6-13 Additional information on burial feasibility on biogenic reef.

KP start	KP end	Primary Feature	Maximum CPT depth	TDOL	Depth and description of top layer	Depth and description of 2nd layer	Depth and description of 3rd layer
KP 42	KP 44	Potential Biogenic Reef	0.52m	1.0m	0.18m - gravelly sand	0.3m - silty sand	0.04m silty sand

Preliminary burial assessment studies have also been completed by the Installation Contractors as part of the Engineering, Procurement and Construction (EPC) Tender Process. This is commercially sensitive information and cannot currently be released with the Marine Licence Application. The Preferred Tenderer has indicated that there is 'moderate confidence' that burial will be achieved between KP43 and KP44 with the caveat that additional cable protection may be required. This suggests that if full burial in sediment is not achieved then at least a certain degree of burial in sediment will be attained. In this scenario, and on review of the cable burial risk assessment (CBRA), agreement would be reached between the Installation Contractor and GIL as to whether the burial depth achieved is enough to forgo any additional cable protection. For example, and as an indication only, possible alternatives would be a) agree that 0.5m burial depth is sufficient to protect the cable from external aggressors and that external cable protection is not required; b) agree that 0.5m burial depth does not offer sufficient protection and that an additional depth (e.g. 0.5m) of cable protection is required to achieve the target burial of 1.0m.

To present a worst-case precautionary assessment the HRA assumed that no level of burial in sediment is achieved and that the full 1.0m protection is required through external cable protection. As outlined above, between KP43 and KP44 this is unlikely to be the case, but based on available data, it cannot be categorically ruled out at this stage.

6.6.6.4 External cable protection options

Three external cable protection options have been considered; rock revetment, concrete mattresses and cast iron shells. Rock revetment has been chosen as the preferred alternative should burial in seabed not be feasible for the following reasons:

- Rock offers the necessary degree of protection from anchor strikes and fishing interaction, ensuring Project Objective 8 can be met.
- Rock can be positioned accurately using fall pipe methods allowing the footprint of the external cable protection to be minimised in line with Project Objective

9; although comparatively the other external cable protection techniques will have smaller seabed footprints.

- Rock is quicker to deposit than the other techniques which comparatively means it will perform better against Project Objectives 11 and 12 in minimising disruption to other marine users.
- Potentially it will be harder to remove rock at decommissioning than cast-iron shells or concrete mattresses. It is feasible, although technically challenging with the use of suction dredgers or excavators. However, there will also be environmental benefits to leaving the rock revetment in place as they will have created artificial reef habitats.
- Deposit of rock protection over large areas is more economic than placement of multiple concrete mattresses.

Cast iron shells were discounted for all locations for the following technical reasons:

- Technique cannot be used on bundled cables and therefore cables would need to be unbundled, separated and then re-bundled for sections where shells were used.
- The indirect effects of using the technique (e.g. associated with separation) would be increases in electromagnetic fields and increased potential for compass deviation (in shallow water). Significant compass deviations would present a risk to navigation and would affect delivery of Project Objectives 7, 8, 11 and 12.
- Shells do not provide sufficient protection from anchor strikes and fishing threats and would still present a navigation risk to the industry e.g. the cables could be snagged by towed gear or anchors and would affect delivery of Project Objective 8, 11 and 12.
- The shells are difficult to install (relative to other external cable protection) and would lengthen the time installation vessels are on site, affecting delivery of Project Objective 11.

Concrete mattresses were discounted for the following technical reasons:

- A single layer of mattresses can't offer the necessary protection from anchor strikes. To obtain the desired protection levels concrete mattresses would have to be stacked (increasing the height and potentially the width of the berm), thickened by using denser concrete, or a combination of the two. There however, still remains concerns that concrete mattresses would be moved by an anchor strike damaging the cable rather than absorbing the force as a rock revetment would.
- Concrete mattresses are uneconomical over long distances, due to the number required and the fact that they must be individually placed with divers in support.

- The installation process is lengthy for longer sections. This increases the level of disruption to leisure users, the fishing industry and navigation; and heightens the risk to the cable as unburied sections remained exposed for longer.

6.6.6.5 Conclusion

Table 6-13 presents the assessment of each technique against the Project Objectives and summarises why burial in seabed is the preferred solution with rock revetment the preferred alternative should burial in seabed not prove feasible.

Table 6-14 Comparison of installation techniques

Alternative Installation Techniques	Core Project Objectives								Secondary Project Objectives				Justification	Decision
	1	2	3	4	5	6	7	8	9	10	11	12		
Surface lay – no protection	✓	✓	✓	✓	✓	✓	X	X	✓	-	X	X	Risk to other seabed users. Risk to asset from damage; significant repair costs if damaged. Not in line with Welsh Government Policy or Industry Best Practice	Discounted
Burial in seabed	✓	✓	✓	✓	✓	✓	✓	✓ X	✓	-	✓	✓	Delivers all Core and Secondary Project Objectives but may not be feasible in all locations.	Selected
External cable protection – rock revetment	✓	✓	✓	✓	✓	✓	✓	✓ X	X	-	✓	✓	May be difficult to remove during decommissioning; but is best alternative technical solution in terms of cable protection and minimising disruption.	Selected as alternative
External cable protection – concrete mattresses	✓	✓	✓	✓	✓	✓	✓	✓ X	X	-	X	X	Easier to remove during decommissioning than rock revetment but doesn't offer same level of cable protection. Performance against Project Objectives 11 and 12 not as favourable as rock revetment.	Discounted
External cable protection – cast iron shells	✓	✓	✓	✓	✓	✓	X	X	✓	-	X	X	Unable to deliver all Core and Secondary Project Objectives.	Discounted

6.7 Conclusion

The development of Greenlink has been an iterative process, with alternative options assessed at different development stages. Alternatives have been assessed against the Project Need, Core Project Objectives and Secondary Project Objectives to ensure that there is no feasible alternative to the option selected that would perform better on technical or environmental grounds. Cost is also a relevant factor in assessing whether alternative solutions are feasible solutions. However, one of the principles applied in the assessment is that additional costs associated with an alternative solution should not be such that the alternative becomes undeliverable or unviable.

Table 6-14 presents all the alternative options considered, as discussed in Sections 6.5 and 6.6 and the justification for why an option has been selected as the least damaging option, as opposed to feasible alternatives. It references the assessment against the Project Need and Project Objectives which decides if a solution is a feasible, deliverable alternative.

The key decisions made in selecting Pembroke as the connection point, and therefore Wales as the national connection point; Freshwater West as the landfall; and the Proposed Development as the offshore route, has led to the requirement to cross the Pembrokeshire Marine / Sir Benfro Forol SAC. Although the preferred installation technique is to bury the cables in sediment it is recognised that this may not be technically feasible for the entire cable route and the option to deposit rock revetment at specific locations within the European Site has been selected as the preferred technical contingency.

GIL is satisfied that the justifications provided in Chapter 6, demonstrate that there are no feasible alternative solutions to the Greenlink Interconnector and the application to use, as a contingency, rock revetment as external cable protection within the Pembrokeshire Marine / Sir Benfro Forol SAC.

Table 6-15 Summary of all alternatives considered

Category	Alternative Option Considered		Decision	Justification for Decision
Do Nothing	Not progressing Greenlink		Discounted	Does not meet Project Need and does not deliver any of the Project Objectives
Alternative Generation Options	Renewables etc		Discounted	Does not meet Project Need and does not deliver any of the Project Objectives
Reduce Generation Demand	Energy efficiency measures etc		Discounted	Does not meet Project Need and does not deliver any of the Project Objectives
Alternative Technology	HVAC		Discounted	Does not meet Project Objective 1 and compares unfavourably to HVDC on Project Objectives 6-12.
	HVDC		Selected	Meets all Project Objectives
Alternative National Connection Points	Scotland		Discounted	Not economically viable.
	Wales	North Wales	Discounted	Does not meet Project Objectives 3 and 4 and economically less favourable
		Mid Wales	Discounted	Not technically feasible
		South Wales	Selected	Meets all Project Objectives.
	England		Discounted	Does not meet Project Objective 5 and would have same environmental effects as Wales due to location of potential connection point.
Alternative GB Connection Points	Alverdiscott 400kV		Discounted	Does not meet Project Objective 5 and would have same environmental effects as Pembroke.
	Swansea North 400kV		Discounted	Does not meet Project Objective 5 and would have same environmental effects as Pembroke.
	Pembroke 400kV		Selected	Meets all Core Project Objectives.
	Pentir 400kV		Discounted	Does not meet Project Objectives 5 or 7.
	Wylfa 400kV		Discounted	Not technically feasible.
	Dinorwig 400kV		Discounted	Not technically feasible.
	Indian Queens 400kV		Discounted	Not technically feasible.
	Taunton 400kV		Discounted	Not technically feasible.
Alternative Landfall Sites	Broad Haven		Discounted	All Core Project Objectives cannot be met. Long onshore route. Permitting & technical risks associated with technically challenging crossing of Milford Haven.

Category	Alternative Option Considered	Decision	Justification for Decision
	Broad Haven South	Discounted	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.
	Freshwater West	Selected	All Core Project Objectives & Secondary Project Objectives can be met.
	Freshwater East	Discounted	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided. Permitting risk associated with location within Firing Range.
	Tenby South Beach	Discounted	All Core Project Objectives cannot be met.
	Dale	Discounted	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.
	Whitesands	Discounted	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.
	Abereiddy LF	Discounted	All Core Project Objectives cannot be met. SAC Primary Reef habitat cannot be avoided.
	Aber Mawr 1	Discounted	All Core Project Objectives cannot be met.
	Aber Mawr 2	Discounted	All Core Project Objectives cannot be met.
	Strumble Head	Discounted	All Core Project Objectives cannot be met.
Alternative Offshore Cable Routes	Cable route avoiding all European Sites	Discounted	Not possible.
	Route A	Discounted	Does not meet Project Objectives 7, 8 and 9.
	Route B	Discounted	Does not meet Project Objectives 8, 9 and 10.
	Route E	Discounted	Does not meet Project Objectives 5, 7, 9 and 12.
	Proposed Development	Selected	Meets all Project Objectives
Alternative Installation Techniques	Surface lay – no protection	Discounted	Does not meet Project Objectives 7, 8, 11 and 12 and is not feasible on technical grounds
	Burial in seabed	Selected	Delivers all Core and Secondary Project Objectives but may not be feasible in all locations.
	External cable protection - Rock revetment	Contingency	Is best alternative technical solution in terms of cable protection and minimising disruption.
	External cable protection - Concrete mattresses	Discounted	Doesn't offer same level of cable protection as rock revetment. Performance against Project Objectives 11 and 12 not as favourable as rock revetment.
	External cable protection - Cast iron shells	Discounted	Unable to deliver all Core and Secondary Project Objectives.

7. Stage 4 - Test 2 Imperative Reasons of Overriding Public Interest (IROPI)/Derogation

7.1 TEN-E and IROPI

Recital 28 of the TEN-E Regulation provides that: *"Projects of common interest should be considered by competent authorities as being in the public interest. Authorisation should be given to projects which have an adverse impact on the environment, for reasons of overriding public interest, when all the conditions under Council Directive….are met".*

Section 6 confirms that there are no alternative solutions to Greenlink and Section 8 confirms that a Habitat Compensation Plan will be in place for Greenlink. This meets the conditions for the Council Directive. Therefore, authorisation should be given to Greenlink because it is in the public interest.

Without prejudice to this position, the remainder of Section 7 further demonstrates how Greenlink meets the IROPI test.

7.2 Introduction

Stage 3 (documented in Section 6) of the HRA process has established that there are no less damaging alternative solutions to the Proposed Development. Therefore, the process should continue to Stage 4 and examine whether there are imperative reasons of overriding public interest (IROPI) for allowing the Proposed Development to proceed; recognising that it will have adverse effects on the Primary Feature of a European site, prior to the delivery of the Habitat Compensation Plan.

The type of IROPI that can be considered depends on the nature of the European site affected and whether the affected feature is a Priority Habitat or Species. Priority Habitats and Species are marked with an asterix in Annex I of the EC Habitats Directive. Although Reef is a Primary Feature of the Pembrokeshire Marine / Sir Benfro Forol SAC, Reef is not a Priority Habitat.

Defra (2012) states (paragraph 15) if the site does not host a priority habitat or species *"…the competent authority can consider other imperative reasons of overriding public interest including those relating to social or economic benefit in addition to those of human health, public safety, or beneficial consequences of primary importance to the environment."*

Defra (2012) also states that *"When identifying IROPI a competent authority must consider whether all three elements of IROPI are met:*

- Imperative: the plan or project is necessary (whether urgent or otherwise) for one or more of the reasons outlined above (paragraph 15).
- Overriding: the interest served by the plan or project outweighs the harm to the integrity of the site as assessed in light of the weight to be given to the protection of such sites under the directive.

- Public Interest: a public good is delivered rather than a solely private interest."
- This section provides GILs justification as to how Greenlink and the Proposed Development meet the three elements of IROPI in addition to the position afforded to it by Recital 28 of the TEN-E Regulations.

7.3 Imperative

7.3.1 Worldwide Imperatives

Action against climate change is high on the global agenda. Under the Paris Agreement countries have agreed to reduce greenhouse gas emissions in order to limit the rise of global temperatures, thereby avoiding the most severe impacts of climate change such as droughts, flooding and severe storms. UN Climate Change (2018) states "The required acceleration of the global shift to low carbon can only be achieved through a combination of clean energy generation, modern transmission technologies and power grid interconnectivity, which all play important roles in the transition."

The IPCC Special Report on Climate Change and Land (August 2019) highlights the impact that climate change is currently having, and could have in the future, on biodiversity, desertification and extreme weather events across the globe and reinforces the need for sustainable development and decarbonisation.

Greenlink will provide vital interconnectivity between the UK and Ireland, enabling both countries to tackle the challenge of integrating renewable energy and facilitating the decarbonisation of the energy sector playing an important role in the fight against climate change. Thus, supporting the fulfilment of both the UK's and Ireland's obligations under the Paris Agreement.

7.3.2 European Imperatives

Greenlink successfully qualified as a European Commission Project of Common Interest (PCI) in November 2015.

European Commission (2020) state that "*PCIs are key cross border infrastructure projects that link the energy systems of EU countries. They are intended to help the EU achieve its energy policy and climate objectives: affordable, secure and sustainable energy for all citizens, and the long-term decarbonisation of the economy in accordance with the Paris Agreement.*" To become a PCI, "*the project must have a significant impact on energy markets and market integration in at least two EU countries, boost competition on energy markets and help the EU's energy security by diversifying sources as well as contribute to the EU's climate and energy goals by integrating renewables.*"

The 'Energy Union' launched by the European Commission in February 2015, and endorsed by Member States in October 2015, is driving a fundamental transition towards more innovative ways to produce, transport and consume energy, and to address different approaches to design, implement and, where needed, enforce

energy policy. A range of actions will be required to make this happen, including improvements to the physical interconnectedness of energy grids (both gas and electricity) to meet a 10% interconnection target by 2020 and to possibly reach 15% by 2030.

Its status as a European PCI means that Greenlink is of strategic importance to Ireland and the UK; is in line with EU policy; aligns with Planning Policy Wales; and supports the UK's commitment to the EU Renewable Energy Directive and the UK target of 15% of energy from renewables by 2020. It also means it is considered imperative infrastructure necessary for Europe to meet its climate objectives; a beneficial consequence of primary importance to the environment. The TEN-E Regulation recognises this importance where it states that:

1. This Regulation lays down rules for the timely development and interoperability of trans-European energy networks in order to achieve the energy policy objectives of the Treaty on the Functioning of the European Union (TFEU) to ensure the functioning of the internal energy market and security of supply in the Union, to promote energy efficiency and energy saving and the development of new and renewable forms of energy, and to promote the interconnection of energy networks; and
2. It is essential for the development of trans-European networks and their effective interoperability to ensure operational coordination between electricity transmission system operators (TSOs).

An interconnected European energy grid is vital for Europe's energy security, for more competition in the internal market resulting in more competitive prices, as well as for better achieving the decarbonisation and climate policy targets, to which the European Union (EU) has committed.

An interconnected grid will help to deliver the ultimate goal of the Energy Union i.e. to ensure affordable, secure and sustainable energy, as well as growth and jobs across Europe.

Greenlink's PCI status demonstrates the important contribution it will make to delivering affordable, secure and sustainable energy, as well as growth and jobs across Europe.

7.3.3 UK Imperatives

7.3.3.1 UK Energy Policy

In the UK, the Office of Gas and Electricity Markets (Ofgem) considers electricity interconnection to have many benefits:

- improving competition by creating larger effective markets, thereby making electricity market prices more efficient;
- making electricity supply more secure by increasing access to generation in periods of system or energy shortage;

- making electricity generation dispatch more efficient by providing access to the most efficient units over a larger area. This can also help to reduce the greenhouse gas emissions; and
- improving integration between variable generation and demand (for example, wind and solar renewable energy generation) by harnessing the diversity between output in different locations and improving access to the balancing services and other production flexibility needed to maintain security and quality of electricity supply.

Greenlink will help to realise these benefits by delivering additional electrical interconnection between the UK and Ireland. This will realise these benefits by improving:

- competition and making electricity market prices more efficient in the electricity supply in both the UK and Ireland;
- access to the most efficient units over a larger area by expanding and connecting the UK and Irish markets; and
- integration between generation and demand in the UK and Irish markets.

In the UK, Greenlink Interconnector Limited was awarded an Interconnector Licence by Ofgem on 10 February 2015 and was awarded Initial Project Assessment ("IPA") Status under Ofgem's Cap and Floor Regime on 30 September 2015. This Cap and Floor regime is an arrangement introduced by the regulator to promote the development, financing and construction of interconnection with other European countries where demonstrably beneficial to consumers. By establishing the Cap and Floor structure after a consultation process, Ofgem has encouraged private capital to promote projects and thereby bring innovation, efficiencies and a drive toward cost reduction for the benefit of consumers.

In the UK, there is clear support for further interconnection. The Secretary of State for Energy and Climate Change explained that the UK "must step up the integration of European Energy markets so that countries can buy clean competitive low carbon electricity from where-ever it is cheapest". In 2013 the Department of Energy & Climate Change (DECC) commissioned a study which concluded that "our least regret interconnection analysis (on the basis of net welfare) has shown that incremental increases in interconnection with GB's closest neighbours including France, Ireland and Belgium, with a total new additional GB interconnection reaching 5.0GW by 2040, are likely to be beneficial to GB net welfare under a broad range of future states of the world."

There is broad consensus that, in a post-Brexit world, the efficient cross-border trade in electricity between the UK and the EU should continue. The UK government has stated its commitment to mechanisms to achieve this (BEIS 2019).

In May 2014, Ofgem decided to roll out a cap and floor regulatory regime to new near-term electricity interconnectors. Ofgem recognised that "Before the cap and floor regime was introduced, only a limited number of electricity interconnectors

had been built or proposed. Ofgem therefore created the cap and floor regime to unlock beneficial investment by reducing risks". Following the success of the cap and floor window, Ofgem opened a second cap and floor window on 31 March 2016. In November 2016, the Secretary of State for Energy and Climate Change confirmed that "We remain strongly supportive of new interconnectors".

Against this background, Greenlink has received strong support from the UK regulatory authorities, including receipt of a GB Interconnector Licence on 10 February 2015, award of a cap and floor regime in principle following a successful Initial Project Assessment on 30 September 2015 and is now proceeding to Final Project Assessment.

The energy National Policy Statements (including EN-1 and the NPS for Electricity Networks Infrastructure (EN-5)) set out the most recent Government policy for the delivery of major energy infrastructure.

EN-1 recognises that interconnection will play an important role in a low carbon electricity system within the UK whilst maintaining security of energy supply. EN-1 further recognises the economic and other benefits of electricity interconnection.

The NPS notes that "existing transmission and distribution networks will have to evolve and adapt in various ways to handle increases in demand".

EN-5 highlights that the network will need to be able to support a more complex system of supply and demand and cope with generation occurring in locations of greater diversity.

Greenlink therefore aligns with UK Energy Policy.

7.3.3.2 UK Planning Policy

There is strong planning policy support for Greenlink at a UK level.

The energy National Policy Statements (including EN-1 and the NPS for Electricity Networks Infrastructure (EN-5)) set out the most recent Government policy for the delivery of major energy infrastructure. EN-1 and EN-5 are a material consideration in Wales, including for planning applications pursuant to the TCPA 1990.

EN-1 states that it is critical that the UK continues to have secure and reliable supplies of electricity as we make the transition to a low carbon economy. The NPS notes that "existing transmission and distribution networks will have to evolve and adapt in various ways to handle increases in demand".

EN-5 highlights the new electricity generating infrastructure that the UK needs to move to a low carbon economy, while maintaining security of supply, will be heavily dependent on the availability of a fit for purpose and robust electricity network. That network will need to be able to support a more complex system of supply and demand and cope with generation occurring in locations of greater diversity.

Greenlink is supported by UK Planning Policy

7.3.4 Welsh Imperatives

7.3.4.1 Welsh Energy Policy

In March 2019, Welsh Government published Prosperity for All: A Low Carbon Wales. This document sets the foundations for Wales to transition to a low carbon nation. The Plan identifies the need for low carbon electricity to become the main source of energy in Wales in order to meet targets including for 70% of Wales' electricity consumption to be from renewables by 2030.

Greenlink therefore aligns with Welsh Energy Policy.

7.3.4.2 Welsh Planning Policy

Planning Policy Wales (PPW10) sets out the land use planning policies of the Welsh Government. PPW10 sets out the Welsh Government targets for the generation of renewable energy including for Wales to generate 70% of its electricity consumption from renewable energy by 2030. PPW further outlines that the planning system has an active role to help ensure the delivery of these targets.

PPW10 reaffirms the presumption in favour of sustainable development. Within PPW10, sustainable development is defined as 'the process of improving the economic, social, environmental and cultural well-being of Wales by taking action, in accordance with the sustainable development principle, aimed at achieving the Well-being Goals.'

PPW10 sets out the Sustainable Management of Natural Resources (SMNR) framework as outlined within The Environment (Wales) Act 2016. PPW10 states that, 'amongst other considerations, the planning system can contribute to the SMNR approach through ensuring resilient locational choice for infrastructure and built development, taking actions to move towards a circular economy and facilitate the transition towards economic decarbonisation'.

In terms of the provision of new infrastructure, PPW10 states that, 'planning authorities should, in conjunction with key providers, take a strategic and long-term approach towards the provision of infrastructure as part of plan making. This may involve collaboration between planning authorities and key infrastructure providers to ensure infrastructure provision is sustainable.'

Under the heading of 'Productive and Enterprising Places' PPW10 includes policy specifically relating to economic infrastructure stating that infrastructure, be it physical, electronic or digital, plays a pivotal role in maintaining the economic well-being of Wales. In terms of energy infrastructure more specifically, it sets out that the planning system should secure an appropriate mix of energy which both maximises economic and community benefits whilst minimising environmental and social impacts.'

PPW10 confirms that 'The Welsh Government's preferred position on new power lines is that, where possible, they should be laid underground and that planning authorities should facilitate all forms of renewable and low carbon energy'.

PPW10 also provides guidance on decision making for energy related planning proposals. 'In the determination of planning application for low carbon energy, planning authorities should account for, the contribution the proposal would make to Welsh, GB and European energy targets, its contribution to reducing greenhouse gas emissions and any wider social, economic and environmental economic benefits and associated opportunities'. Where proposals may affect protected landscapes, biodiversity and historical designations, PPW10 states that 'only direct, irreversible impacts on statutorily protected sites and buildings should be considered by local planning authorities.'

Greenlink aligns with the strategies and objectives described in PPW10 in developing Wales' access to a more diverse energy mix including energy from renewable and low carbon energy sources, promoting energy efficiency and enhancing security of supply.

Greenlink therefore aligns with Welsh Planning Policy.

7.3.4.3 Local Planning Policy

Policy GN4 of the adopted and emerging Pembrokeshire County Council Local Development Plan relates to resource efficiency and renewable and low-carbon energy proposals. It states that development proposals should seek to minimise resource demand, improve resource efficiency and that developments which enable the supply of renewable energy through environmentally acceptable solutions will be supported.

Greenlink would serve to enhance energy security by providing a critical link between the Irish and GB energy markets, allowing the further integration of renewable and low carbon energy sources. This would serve to increase competition within the GB and Irish energy markets, facilitating fuel diversity.

It is considered that by improving resource efficiency and promoting low carbon energy, Greenlink directly accords with adopted and emerging Policy GN4.

Greenlink therefore aligns with Local Planning Policy.

7.4 Overriding

Consideration of IROPI necessarily involves a balancing exercise and an exercise of planning judgement by the decision maker, which in the case of Greenlink is the Welsh Ministers.

In case C-239/04 82, the EC summarised this balancing exercise as follows:

"…the choice requires a balance to be struck between the adverse effect on the integrity of the SPA and the relevant reasons of overriding public interest"

For Greenlink, the IROPI outweigh the adverse effect on the SAC because they are fully compliant with international, European, UK and Welsh policy in addressing the global climate emergency, in providing security of energy supply and in addressing human health and public safety matters.

Recital 28 of the TEN-E Regulation states that: "*Projects of common interest should be considered by competent authorities as being in the public interest. Authorisation should be given to projects which have an adverse impact on the environment, for reasons of overriding public interest, when all the conditions under Council Directive….are met*". This demonstrates that the starting point is an assumption that PCIs which satisfy the conditions of IROPI, which Greenlink does, should override any harm where there is an adverse effect.

The TEN-E Regulation goes on to state that: "*Member States that currently do not provide for a legal status of the highest national significance possible that is attributable to energy infrastructure projects in the context of permit granting processes should consider introducing such a status*". Again, this demonstrates the imperative and overriding need at a European level for Greenlink and the onus on Member States to give the highest national significance to Greenlink.

In this case, this means affording Greenlink the greatest weight in the balancing exercise to be undertaken at this Stage.

The HRA process has identified that localised areas of Annex I Reef habitat could be lost if the contingency to use external cable protection is exercised. Although Reef habitat is a Primary Feature of the Pembrokeshire Marine / Sir Benfro Forol SAC it is not a Priority Habitat as defined under the EC Habitats Directive. The effects on the Primary Feature will be localised, affecting 0.02% of the feature within the European Site. While it is accepted that Greenlink will have adverse effects on the Primary Feature of a European site, prior to the delivery of the Habitat Compensation Plan, GIL's HRA concludes that it will not affect the structure and function of the Primary Feature within the European Site as a whole and therefore will not impact the integrity of the designation. Appropriate compensation has been proposed and will be implemented by GIL.

This minimal effect should be weighed up against the public interest and enormous benefits that Greenlink will bring to the environment, human health and national infrastructure security (as described above); especially its role in tackling the climate emergency.

In the UK, there are previous examples of the approach taken to this balancing exercise, including in the context of renewable energy.

On the Able Marine Energy Park DCO, the Secretary of State found that the long term public interests of decarbonising the means of energy production and securing energy supply weighed in the balance and overrode the harm to the European sites (in that case the loss of 45 hectares of a Natura 2000 site). The Able Marine Energy Park case involved far greater harm to the European site in question.

As with the Able Marine Energy Park DCO, Greenlink secures long term objectives in decarbonising energy production and securing energy supply.

Of relevance, it is important to note that IROPI has been concluded in relation to effects on the Pembrokeshire Marine / Sir Benfro Forol SAC previously. An IROPI case was submitted by Pembrokeshire Coast National Park Authority to Welsh

Ministers for consideration 29 November 2013 in relation to the construction of a new offshore lifeboat station at St David's. This case was submitted on the grounds that public interest in maintaining the life-saving service outweighs any damage to the Primary Feature Reef; reported to be approximately 25m^2. The IROPI case was accepted, planning permission granted, and compensatory measures secured. In this case, the IROPI that weighed in the balance were a much smaller and more localised benefit to Wales than the IROPI demonstrated for Greenlink. Greenlink's status as a PCI demonstrates the importance attached to the Project at a European level.

The IROPI, and the long-term public interests of Greenlink, are matters that should be afforded the greatest weight in this balancing exercise.

7.5 Public Interest

Under the TEN-E Regulation status as a PCI is limited to "*projects which contribute the most to the implementation of the strategic energy infrastructure priority corridors and areas*".

Paragraph 28 of the TEN-E Regulation states that: "*Projects of common interest should be considered by competent authorities as being in the public interest.*" This establishes that Greenlink is in the public interest.

Greenlink will secure a long-term public interest. Each IROPI identified above is a long-term UK interest that is a public interest: decarbonisation, security of supply, provision of low-cost energy and protecting the human species and the environment.

Greenlink will be capable of providing clean energy generation and security of supply for around 40 years and construction is scheduled to commence in the early 2020s. The TEN-E Regulation recognises at paragraph 25 that PCIs should be implemented as quickly as possible.

At the end of those 40 years, Greenlink could be repowered (subject to appropriate consents). This demonstrates the long-term public interest served by the project.

In addition to the IROPI Greenlink will have for the environment in tackling the climate emergency it has a number of additional public benefits namely:

- The potential to power 380,000 homes.
- It will facilitate better energy price competition by putting downward pressure on electricity bills.
- It is a €400/£350 million project which represents valuable investment in Ireland and Wales.
- It will create jobs around 250 direct jobs during construction in both Ireland and Wales.
- It is expected to create around 5 permanent jobs in Pembrokeshire and 20 permanent jobs in Ireland once operational.

- It will provide security of supply, by diversifying energy sources and providing additional import and export capacity in Wales.
- It will improve the integration of renewable technologies in Wales, supporting the growth of the green energy sector; which offers significant economic and environmental benefits.

The beneficial consequences of Greenlink was confirmed by the Irish utility regulator (the Commission for Regulation of Utilities Water and Energy, CRU) when in October 2018 it determined, after a detailed consultation, that Greenlink is in the public interest, with "the potential to provide a net benefit to Irish consumers and Ireland as a whole."

In the UK, Ofgem recognised the beneficial consequences of Greenlink when it awarded Greenlink Initial Project Assessment ("IPA") Status under Ofgem's Cap and Floor Regime on 30 September 2015. This Cap and Floor regime is an arrangement introduced by the regulator to promote the development, financing and construction of interconnection with other European countries where demonstrably beneficial to consumers. During the assessment process it was recognised that Greenlink would result in a net benefit to UK consumers by creating a downward pressure on UK electricity prices.

Ofgem's August 2015 document 'Cap and floor regime: Update on our Initial Project Assessment of the Greenlink interconnector' indicates that Greenlink will generate £183 million in GB consumer benefit (NPV 2013/14 prices, base year 2019) which is equivalent to £199 million (NPV 2018/19 prices, base year 2022. These figures relate to the 25-year Cap and Floor period.

7.6 Test 3 - Compensation Package

7.6.1 Introduction

Without prejudice to NRWs determination of the Greenlink Interconnector Marine Licence Application and decision with respect to adverse effect on site integrity, a Habitat Compensation Plan has been produced to describe the compensatory measures that could be implemented by GIL to ensure the coherence of the European Site Network and specifically Pembrokeshire Marine / Sir Benfro Forol SAC.

Revision 0 of the Habitat Compensation Plan (the 'Plan') has been provided as Appendix D.

Revision 0 of the Plan explicitly addresses three requests for clarification from NRW Technical Experts (TE), namely:

- Additional information with respect to evidence gaps relating to the success of colonisation of cable protective measures is presented by the applicant;
- A more detailed monitoring strategy is proposed by the applicant; and

- A further management strategy is proposed should monitoring demonstrate failure or limited success and compensation is deemed not to be successful.

The Plan has been developed following consultation undertaken with NRW TE and follows guidance issued by the Department for Environment, Food and Rural Affairs (Defra 2012).

The Plan:

1. Sets out the areas where compensatory habitat is required; subdividing it by type of Reef habitat affected; and identifying the conservation objectives, target features and ecological processes/functions to be compensated.
2. Details what compensatory measures will be implemented (including location maps, extent and surface area of habitat to be created).
3. Details the current status and conditions of the habitats within the compensatory area.
4. Outlines the expected results (including timeline) and how the proposed measures will compensate the predicted adverse effect on the integrity of the European site.
5. Identifies how the compensatory measures' effectiveness will be measured.
6. Sets out a monitoring plan for the compensatory measures.
7. Estimates the total cost of implementing the measures and how they will be financed.

7.6.2 Summary of the Plan

The intention of Revision 0 of the Plan is to outline the principles of the compensation and monitoring for agreement with NRW. The preference is to bury the cables in sediment – a process that will not affect the integrity or coherence of the European Site Network. However, soil conditions may not be suitable for burial in all locations, and the deposit of external cable protection may be required. If external cable protection is deposited on the SAC's Primary Feature Reef, NRW Technical Experts have advised that this would be considered a significant loss of Annex I habitat and that compensatory measures will be required.

The compensatory measures described in the Plan follow the precautionary principle and assume the worst-case i.e. the largest area of compensation will be required. In reality, the level of compensatory measures required will depend on the location and quantity of external cable protection and consequently the area of habitat loss. It is feasible that not all locations indicated in Revision 0 of the Plan will require compensatory measures. The refinement of the locations and quantities for the deposit of external cable protection will be an iterative process following the below sequence, which will not be concluded until the cables have been installed:

1. Selected Installation Contractor undertakes Burial Assessment Study (BAS) and determines potential external cable protection locations.
2. Installation Contractor undertakes planned trenching.
3. Locations of external cable protection confirmed.

It is proposed that the Final Plan and the quantity of compensatory habitat required will be agreed with NRW post-installation, but will follow the principles outlined in the Plan.

Analysis of soil conditions ascertained through geotechnical investigations has indicated that external cable protection may be required at four locations. The compensatory measures proposed by GIL for the habitat loss of Primary Feature Reef habitat at these locations are outlined in Table 7-1.

Table 7-1 Method of compensation (should burial not be feasible)

Reef sub-type	Method of compensation (should burial not be feasible)	Expected results
Bedrock Reef	Deposit of up to 1700m^2 of rock revetment across two locations (surface area of approximately 1768m^2) and deposit of 15 reef blocks (surface area of approximately 320.52m^2).	Colonisation of novel bare surface within 3.5 years.
Stony Reef	Up to 80,000m^2 of rock revetment	Colonisation of novel bare surface within 1 year.
Biogenic Reef	Up to 1,100m^2 of rock revetment	Colonisation of novel bare surface within 5 years.

A Monitoring Plan has been proposed; the objective of which is to establish that the compensatory habitat has become colonised by benthic community similar to that of the baseline Reef habitat. Thus, restoring the habitat to a level that is determined to be, at least equal to, if not enhanced from baseline conditions and allows the continued ecological functioning of the area.

The Monitoring Plan proposes that seabed imagery will be acquired and analysed at up to 11 stations. The proposed method follows the below principles:

- At each station, three ~200m long replicate transects will be positioned ~50m apart to intersect the cable route at the mid-point.
- Each transect will be split into three sections for analysis; the rock revetment, a north/west control and a south/east control.
- One station each will be selected in the Bedrock Reef and Biogenic Reef sub-types.
- A maximum of eight stations will be selected within the Stony Reef sub-type; corresponding to one every 1km, or a maximum of two every 1km if external cable protection is not required for the full 8km.

Monitoring will be undertaken in the same season, 1, 3 and 5-years post-installation. The monitoring surveys will be aligned with the Inspection Surveys necessary to

ensure external cable protection is appropriately maintained. Data will be compared against established success indicators (assemblage composition, top 5 taxa, total taxa and abundance) to determine if the monitoring objective has been met. If after five years, monitoring has shown that:

- the objectives for the compensatory habitat have not been met;
- it is clear from analysis of trends in the data the objectives will not be met in the next two years; and
- that there is no downward trend in the condition of the control data which indicates that other environmental factors have contributed to the objectives not being achieved;

Then a course of action will be agreed with NRW to provide additional compensatory habitat. If monitoring has indicated that the Reef Blocks have been successful, consideration will be given as to whether it is appropriate to deposit more structures within the SAC. The number of Reef Blocks to be deposited would depend on the final area of habitat lost to external cable protection. As this cannot be determined until installation it is proposed that a condition of the Marine Licence should be to agree post-installation the quantity of compensatory habitat required should the objectives of the monitoring plan not be met.

Estimate costs for providing the compensation measures outlined in the Plan (including monitoring) are approximately £750,000. GIL is bringing private capital to the project and will assume the majority of the project risks; this includes all costs associated with the compensation plan.

All areas of seabed where compensatory measures are planned are within Welsh territorial waters. The seabed is owned by The Crown and managed on its behalf by The Crown Estate.

GIL is responsible for ensuring that the Plan is implemented.

7.6.3 Revision 1 of the Plan

The Second Request for Clarification / Further Information dated 03 July 2020 states

“NRW TE agree that the compensation plan is broadly suitable to compensate for the Annex I reef type and condition of habitat lost in the SAC. NRW TE considers there to be sufficient precaution built into the plan to address uncertainties with regard to the construction method and potential colonisation success, given that further refinements of the plan will need to be agreed. Although NRW TE do not have any major concerns with the principles of the plan itself, they do have comments which will help refine subsequent revisions to the plan.”

NRW Marine Licensing have confirmed (pers comm. Thomas, J, 07 July 2020) that it will be possible to finalise the compensation plan post-consent. This would be secured through discharge of license conditions.

GIL are committed to continuing to work with NRW TE to close out all comments raised on the Habitat Compensation Plan. The Plan will be updated over the next few months, in consultation with NRW TE. It will address all comments received from NRW TE. A Revision 1 of the Plan will be submitted for written approval from NRW, acting on behalf of the Licensing Authority, prior to commencement of the Licensable Activity.

8. Conclusion

The Proposed Development has been subject to the HRA process as it crosses the Pembrokeshire Marine / Sir Benfro Forol SAC (site code: UK0013116), the West Wales Marine / Gorllewin Cymru Forol SAC (site code: UK0030397), Skomer, Skokholm and the Seas Off Pembrokeshire / Sgomer, Sgogwm a Moroedd Penfro SPA (site code: UK9014051) and the landfall is within the Castlemartin Coast SPA (site code: UK9014061) and the Limestone Coast of South West Wales / Arfordir Calchfaen de Orllewin Cymru SAC (site code: UK0014787). The Proposed Development consists of the following features:

- Two high voltage direct current (HVDC) electricity power cables;
- A smaller fibre-optic cable for control and communication purposes; and
- All associated works required to install, operate, maintain, repair and decommission the aforementioned cables.

A detailed screening assessment has been conducted on the Proposed Development which concluded that significant effects are likely or uncertain on the Primary Features and conservation objectives of two sites:

- Pembrokeshire Marine / Sir Benfro Forol SAC; and
- West Wales Marine / Gorllewin Cymru Forol SAC.

The assessment concluded that there was no potential for cumulative effects with other plans or projects.

- Further to screening, Stage 2 - Information to Inform Appropriate Assessment has been provided, which concludes:
- Pembrokeshire Marine / Sir Benfro Forol SAC - Primary Feature Reef
- The preferred cable protection method (burial in seabed) will not adversely affect the long-term achievement of conservation objectives.
- If the deposit of external cable protection, the alternative cable protection method, is required, areas of Primary Reef Feature will be lost. As it is uncertain that the integrity of the European site will not be adversely affected, **Stage 3 Assessment is required**.
- Pembrokeshire Marine / Sir Benfro Forol SAC - Primary Feature Grey Seal
- If the detonation of UXO is required, there is the potential that animals could be injured or disturbed by a brief but significant change in underwater noise. The significant effects can be reduced to levels whereby the long-term achievement of the conservation objectives of the European Site is not adversely affected by the implementation of Industry Best Practice mitigation i.e. avoid the requirement for UXO detonation, neutralisation of UXO, the use of acoustic deterrent devices, soft-start and passive acoustic monitoring.
- West Wales Marine / Gorllewin Cymru Forol SAC – Primary Feature Harbour Porpoise

- If the detonation of UXO is required, there is the potential that animals could be injured or disturbed by a brief but significant change in underwater noise. The significant effects can be reduced to levels whereby the long-term achievement of the conservation objectives of the European Site is not adversely affected by the implementation of Industry Best Practice mitigation i.e. avoid the requirement for UXO detonation, neutralisation of UXO, the use of acoustic deterrent devices, soft-start and passive acoustic monitoring.

Evidence and information which demonstrates that NRW can be satisfied that there are no feasible alternative solutions to the Greenlink Interconnector and the application to use external cable protection (as a contingency) within Pembrokeshire Marine / Sir Benfro Forol SAC has been provided to inform the Stage 3 assessment to be undertaken by NRW.

Alternatives have been assessed against the Project Need, Core Project Objectives and Secondary Project Objectives to ensure that there is no feasible alternative to the option selected that would perform better on technical or environmental grounds. Cost is also a relevant factor in assessing whether alternative solutions are feasible solutions. However, one of the principles applied in the assessment is that additional costs associated with an alternative solution should not be such that the alternative becomes undeliverable or unviable.

The key decisions made in selecting Pembroke as the connection point, and therefore Wales as the national connection point; Freshwater West as the landfall; and the Proposed Development as the offshore route, has led to the requirement to cross the Pembrokeshire Marine / Sir Benfro Forol SAC. Although the preferred installation technique is to bury the cables in sediment it is recognised that this may not be technically feasible for the entire cable route and the option to deposit rock revetment at specific locations within the European Site has been selected as the preferred technical contingency.

GIL is satisfied that the justifications provided in Chapter 6, demonstrate that there are no feasible alternative solutions to the Greenlink Interconnector and the application to use, as a contingency, rock revetment as external cable protection within the Pembrokeshire Marine / Sir Benfro Forol SAC.

As Stage 3 has demonstrated that there are no less damaging alternatives, the HRA process proceeds to Stage 4 and examines whether there are imperative reasons of overriding public interest (IROPI) for allowing the Proposed Development to proceed; recognising the potential for an adverse effect on the integrity of a European site prior to the delivery of a Habitats Compensation Plan.

Recital 28 of the TEN-E Regulation provides that: *"Projects of common interest should be considered by competent authorities as being in the public interest. Authorisation should be given to projects which have an adverse impact on the environment, for reasons of overriding public interest, when all the conditions under Council Directive….are met"*.

Section 6 confirms that there are no alternative solutions to Greenlink and Section 8 confirms that a Habitat Compensation Plan will be in place for Greenlink. This meets the conditions for the Council Directive. Therefore, authorisation should be given to Greenlink because it is in the public interest.

Without prejudice to this position, Section 7 demonstrates that Greenlink meets the IROPI test. It outlines the imperative environmental, public safety, human health and security of supply reasons; overriding reasons; and public interest for Greenlink to proceed.

A Habitat Compensation Plan has been produced to describe the compensatory measures that could be implemented by GIL to ensure the coherence of the European Site Network and specifically Pembrokeshire Marine / Sir Benfro Forol SAC.

In conclusion, the HRA process documented in this report demonstrates that:

- The deposit of external cable protection, if required, may lead to an adverse effect on the Primary Feature of the Pembrokeshire Marine / Sir Benfro Forol SAC.
- There are no feasible alternative solutions.
- There are Imperative Reasons of Overriding Public Interest for Greenlink to proceed.
- GIL is committed to the implementation of a Habitat Compensation Plan to ensure the continued coherence of the European Site Network and specifically Pembrokeshire Marine / Sir Benfro Forol SAC.

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Appendix A

Greenlink Marine Environment Statement Technical Appendix D – Underwater Noise Modelling (Revision F3)

GREENLINK INTERCONNECTOR LIMITED

Marine Technical Appendix D

Underwater Sound Modelling

Greenlink - an interconnector between
GB and the Republic of Ireland

P1975F10_R4484_RevF3 | August 2020

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1. Introduction

Revision F1 of this Technical Appendix was submitted with the Greenlink Marine Environmental Statement (ES) and Greenlink Marine Habitats Regulations Assessment (HRA) by Greenlink Interconnector Limited (GIL) on 24 June 2019, accompanying a Marine Licence Application (MLA, reference CML1929). The examination of the MLA by Natural Resources Wales (NRW) is currently in progress.

On 24 February 2020, NRW issued a Request for Clarification/Further Information relating to the ES, HRA and MLA. Revision F2 of this Technical Appendix, dated May 2020, has been prepared in response to the Request for Clarification, with specific reference to comments made by NRW Technical Experts (NRW TE), the Joint Nature Conservation Committee (JNCC) and the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

A key change between the revisions is that underwater sound propagation modelling has been used for impulsive noise sources rather than the conservative Intertek in-house geometric spreading calculation to define the zone of influences. This has refined the zones of influence and caused major changes to Section 3; which has been re-written. For clarity all new text added during Revision F2 is highlighted in yellow.

Revision F3 of this Technical Appendix has been prepared in response to a second Request for Clarification relating to the HRA and MLA, with specific reference to comments made by NRW TE, JNCC and Cefas. All changes to the report during Revision F3 have been highlighted in blue.

1.1 Objective

One of the most important environmental concerns related to the installation, operation (including maintenance and repair) and decommissioning of Greenlink is the potential effects of underwater sound. Sound inputs to the marine environment will be generated by geophysical survey, vessel movements, sand wave preparation (pre-sweeping), cable trenching, rock placement and if required, unexploded ordnance (UXO) deflagration ~~detonations~~.

To determine the zone of influence for each activity (the spatial extent over which the activities are predicted to have an effect on the receiving environment) an assessment has been conducted which combines literature review with underwater sound modelling. This Technical Appendix presents the findings of the assessment. It has informed the EIA process and assessment of significant effects presented in Chapter 8 – Fish and Shellfish and Chapter 10 – Marine Mammals and Reptiles.

1.2 Underwater sound

Sounds in the ocean originate from natural causes such as wind, waves, earthquakes, rainfall, and animal noises; and anthropogenic activities such as shipping, fishing activities, seismic survey, research activities, sonars and recreation activities. As sound waves travel through water, they spread, dissipate

and reflect off the sea surface and seabed. The local oceanographic conditions will affect the path of the sound in the water column, how much sound is transmitted, and the levels received by the receptor at distance from the source. Variables such as water depth, source and receiver depths, temperature gradients, salinity, seabed ground conditions and many other factors can affect received levels.

Although some sound sources (e.g. from nearby activity) can be identified, the sources of others cannot, and they are considered part of the background sound. How a receptor is affected by a change in underwater sound is linked to the current exposure levels and associated background sound levels.

1.2.1 Background sound

Background sound levels in the vicinity of the project will influence how marine species react to the introduction of new sound as part of the installation and then maintenance of the marine cables.

Measurements of low frequency anthropogenic sounds were recorded to quantify background sound levels in the UK, as part of the response to the requirements of the European Union (EU) Marine Strategy Framework Directive (MSFD) (Merchant et al. 2016). These were taken across locations in the Celtic Sea, southern North Sea (SNS) and northern North Sea (NNS). Recordings were taken at four frequency ranges (63Hz, 125Hz, 250Hz and 500Hz). Sound levels in the Celtic Sea ranged from 99.9dB (500Hz) to 102.9dB re1 µPa (250Hz) (RMS[1]) (Merchant et al. 2016). These levels are lower on average than the NNS and SNS, noting that only one location was recorded in the Celtic Sea in comparison to ten in the NNS.

A literature review of baseline noise relating to sites in UK waters undertaken for Pembroke Dock Infrastructure (RPS 2019) concluded "that baseline underwater noise levels in high-tidal coastal areas and estuaries are likely to be in the range 91 to 121 dB re 1 µPa (RMS).

Underwater noise monitoring of the tidal stream at Ramsey Sound, Pembrokeshire concluded that during neap tide noise levels ranged from 95 to 125 dB re 1 µPa (RMS), with spring tide levels ranging between 100 and 127 dB re 1 µPa (RMS) (Broudic et al. 2014).

In addition to natural ambient sound, parts of the Proposed Development are close to the approach route to Milford Haven, with significant vessel traffic (e.g. ferries and oil tankers). Consequently, parts of the Proposed Development will already experience elevated levels of anthropogenic sound in addition to natural ambient sound levels.

1.2.2 Sound categories

Underwater sound is classified between two distinct types: impulsive and continuous (i.e. non-pulse).

[1] The EU MSFD recommends the use of root mean square (RMS) noise levels as environmental indictor.

Impulsive sound derives from a discrete event or a series of events, for example an explosion or a seismic survey. Produced impulsive sounds are generally transient and brief; peak sound pressure has a rapid rise and a rapid decline. Single pulse sound results from a single event, such as UXO detonation and pile strike. A repetition of pulses is considered as a multiple pulse sound source and is a series of discrete acoustic events within a 24hr period, for example a seismic survey. Through consultation with JNCC, Cefas and NRW TE it has been agreed to treat geophysical survey activities as impulsive noise.

Continuous sound, e.g. from shipping ~~noise, produce~~ is non-pulsed ~~sound~~ and ~~are generally~~ can be broadband, narrowband or tonal. Continuous sound can either be intermittent or constant, within a 24hr period (NMFS 2018). Cable installation activities include trenching, rock placement, pre-sweeping and the use of thrusters for dynamically positioning (DP) on vessels; all of which will produce continuous sound of varying intensity and duration.

2. Receptor Sensitivity to Underwater Sound Changes

2.1 Introduction

Research has largely focused on effects of underwater sound on marine mammals, but in the last few years evidence of effects in other species such as fish (Popper *et al*. 2014), crustaceans (Solan *et al*. 2016, Tidau and Briffa 2016) and zooplankton (McCauley *et al*. 2017) have been reported. Most research has described changes in behaviour or damage (or not) to hearing; however, in addition to effects mediated by hearing, the very rapid and extreme changes in pressure associated with underwater explosions can cause severe and extensive damage, particularly to species with internal air spaces, e.g. marine mammals, marine reptiles and fish with swim bladders, with impacts inversely related to the size of the receptor organism (Keevin and Hempen 1997). It should be noted that the potential for blast damage is not dependant on the auditory range of the species concerned.

2.2 Marine mammals

Both cetaceans and pinnipeds have evolved to use sound as an important aid in navigation, communication and hunting (Richardson *et al*. 1995). It is generally accepted that exposure to anthropogenic sound can induce a range of behaviour effects and, in extreme circumstances, to permanent injury in marine mammals. Loud and prolonged sound above background levels may be considered noise and may have a negative effect on marine life. In marine mammals, this may mask communicative or hunting vocalisations, inhibiting ~~preventing~~ social interactions and effective hunting.

High intensity noises such as from seismic survey, explosions and pile driving can cause temporary or permanent changes to animals' hearing if the animal is exposed to the sound in close proximity and, in some circumstances, can lead to the death of the animal (Richardson *et al*. 1995). Where the threshold of hearing is

temporarily damaged, it is considered a temporary threshold shift (TTS), and the animal is expected to recover. If there is permanent damage, it is considered a permanent threshold shift (PTS), where the animal does not recover, social isolation and a restricted ability to locate food may occur, potentially leading to the death of the animal (Southall *et al*. 2007).

Behavioural disturbance from underwater sound sources is more difficult to assess than injury and is dependent upon many factors related to the circumstances of the exposure (Southall *et al*. 2007, NMFS 2018). An animal's ability to detect sounds produced by anthropogenic activities depends on its hearing sensitivity and the magnitude of the noise compared to the amount of natural ambient and background anthropogenic sound. In simple terms for a sound to be detected it must be louder than background and above the animal's hearing sensitivity at the relevant sound frequency. The direction of the sound is also important.

~~Behavioural responses caused by disturbance may include animals changing or masking their communication signals, which may affect foraging and reproductive opportunities or restrict foraging, migratory or breeding behaviours; and factors that significantly affect the local distribution or abundance of the species. An animal may swim away from the zone of disturbance and remain at a distance until the activities have passed. Behavioural disturbance to a marine mammal is hereafter considered as the disruption of behavioural patterns, for example: migration, breeding and nursing.~~

Introduced sound may cause behavioural responses in animals, such as individuals moving away from the zone of disturbance and remaining at a distance until the activities have passed. There may also be changes in foraging, migratory or breeding behaviours; all factors that can affect the local distribution or abundance of a species. Introduced sound may also cause masking or disruption of the animal's own signals, whether used for communication, foraging or other purposes. This may in turn affect foraging and reproductive opportunities. Behavioural disturbance to a marine mammal is hereafter considered as the disruption of natural behavioural patterns, for example: feeding, migration, breeding and nursing.

2.3 Sea turtles

Sea turtles are known to be able to detect (Ridgway et al. 1969, Bartol et al. 1999, Bartol & Ketten 2006) and respond to acoustic stimuli (Lavender et al. 2014, Martin et al. 2012, O'Hara & Wilcox 1990, DeRuitter & Doukara 2012), which they may use for navigation, prey location, predator avoidance as well as general environmental awareness (Piniak et al. 2016). Sea turtles have adapted their hearing for use underwater. It is likely that their body serves as a receptor while the turtle is underwater (Lenhardt 1983, 1985).

Electrophysiological and behavioural studies have demonstrated that sea turtles are able to detect low-frequency sounds both underwater and in air (Piniak et al. 2016). Sea turtles respond to aerial sounds between 50 and 2000 Hz and vibrational stimuli

between 30 and 700 Hz, with maximum sensitivity values recorded between 300 and 500 Hz for both sounds (Ridgway et al. 1969).

Green turtles respond to underwater signals between 50 Hz to 1600 Hz, with maximum sensitivity between 200 and 400 Hz (Piniak et al. 2016). These values are similar to findings by Bartol & Ketten (2006).

Similarly, adult Loggerhead sea turtle responded to underwater stimuli between 50 and 800 Hz with best sensitivity at 100 Hz using behavioural response techniques, while between 100 and 1131 Hz with best sensitivity between 200 and 400 Hz when using AEP techniques (Martin et al. 2012).

Overall, the biological significance of hearing in sea turtles remains poorly understood, but as low-frequency sound is most prevalent and travels the farthest in the marine environment there may be some advantage to sea turtles in specializing in low-frequency sound detection. It is therefore believed that acoustic sound may provide important environmental cues for sea turtles (Piniak et al. 2016).

Popper et al. (2014) provide sound exposure guidelines for injury to sea turtles.

2.4 Fish

In general, most fish hear well in the range within which most energy from anthropogenic noise sources is emitted, i.e. relatively low frequency sound below 1 kHz, with peak perception between approximately 100-400 Hz.

Several features of a fish's anatomy, life cycle and habitats will determine the potential effects of sound on fish. Popper et al. (2014) classified sensitivity of fish species to underwater sound based on the presence or absence of swim bladder; the otolith organ acts as a particle motion detector and where linked to the swim bladder, converts sound pressure into particle motion, which is detected by the inner ear. Specialist hearing species include species such as herring, sprat, twaite shad and allis shad.

Swim bladder are used by certain fish species for buoyancy control, hearing, respiration etc. Pressure changes for fish with a swim bladder, in particular from impulsive sound, can result in physiological trauma.

Popper et al. (2014) provide sound exposure guidelines for injury to fish, which have been used in the modelling presented in Section 3.

2.5 Crustaceans

Little is known about how crustacean species are impacted by underwater sound changes (Tidau and Briffa 2016). Recent studies identified that crustaceans, both freshwater and marine species, are likely to be ~~impacted~~ affected by underwater sound changes. Unlike fish species, crustaceans do not have an air-filled chamber; therefore, they are unlikely to detect sound pressure but can be sensitive to particle motion (Tidau and Briffa 2016).

Studies have considered the impact and the behavioural responses of crustaceans to airgun sounds. Results from these studies produced varied results. A field study on shrimp species and American lobster did not identify an avoidance behaviour while a behavioural response was identified during laboratory test (Andriguetto-Filho et al. 2005; Parry and Gason, 2006 in Tiday and Briffa 2016). A stress response to noise (airguns) was noticed (increase in food intake). Impacts of impulsive pile driving on Norway lobster showed a change in behaviour, as such reduced burrowing and mobility (Solan et al. 2016).

These studies identified a large array of responses to underwater sound pressure, from changes ~~an increase~~ in behaviour (for example an increase in food intake in lobsters), stress responses, slower or reduced behaviour, change in foraging habitats etc. The current knowledge on how these reactions are displayed however is based on a limited range of studies (Tidau and Briffa 2016).

2.6 Zooplankton

Zooplankton are highly mobile at small scales or across small scales (McManus & Woodson 2012, Bianco et al. 2014, Visser 2007); however, research suggest that they cannot move away from an approaching air gun array (i.e. an impulsive sound) produced during seismic surveys. Recent scientific evidence also suggests that low-frequency impulse sound leads to significant mortality to local zooplankton populations (McCauley et al. 2017).

A decrease in zooplankton abundance was recorded during experimental air gun signal exposure when compared to the absence of air gun signal, as measured by sonar (~3–4 dB drop within 15–30 min) and net tows (median 64% decrease within 1 hour). In addition, this caused an increase in mortality for adult and larval zooplankton (McCauley et al. 2017). The impacts of air guns on zooplankton have been observed out to the maximum 1.2 km range sampled (McCauley et al. 2017).

Further studies on larval invertebrates also showed significant malformations to scallop veliger larvae from simulated air gun exposure (de Soto et al. 2013), while no impacts were detected on larval hatching success or viability immediately after hatchment for lobster eggs exposed to an air gun in the field (Day et al. 2016).

The knowledge of effects from underwater sound on zooplankton communities is very sparse with little scientific evidence, besides from recent research by McCauley et al. (2017) described above.

3. Results and Discussion

3.1 Approach

The propagation of sound from a source to a receiver can be modelled in a variety of ways, from simple calculations assuming spreading according to set principles e.g. spherical or cylindrical, to full acoustic models that account for bathymetry, salinity, sediment characteristics etc, all of which effect how noise attenuates.

Generally, however the principle is to calculate the distance at which the sound pressure level attenuates to below set peer-reviewed thresholds. This is then used to define the zone of influence – the spatial extent - over which injurious or disturbance level effects may be experienced by a sensitive receiver.

For Revision F1 of this Technical Appendix the underwater noise assessment used a highly conservative approach based on an in-house geometric spreading calculation to calculate the distance sound will propagate from impulsive and continuous noise sources. Advice from JNCC, Cefas and NRW TE suggested that this method should be refined for impulsive noise to provide a more accurate picture of the distances at which injury and disturbance thresholds will be reached.

Two types of modelling have been therefore undertaken and are presented in this Section. As continuous noise is generally perceived as a lower risk to sensitive receptors, a simple in-house geometric spreading model has been used to calculate attenuation distances. For impulsive noise, given the sensitivity of receptors in the region and the high source levels, a more complex assessment has been undertaken; using the BOUNCE & BELLHOP models, implemented through AcTUP v 2.2L (Maggi & Duncan 2006). This approach follows advice from JNCC, Cefas and NRW TE.

Section 3 describes the injury and disturbance thresholds used in the assessment, presents the methodology and findings of the modelling and establishes the zones of influence for each activity.

3.2 Injury and disturbance thresholds

Effects of underwater sound changes range from no effect, through disturbance to injury or mortality. ~~injury through to disturbance.~~ To calculate the zone of influence for disturbance or injury~~ both levels of effect~~, sound propagation modelling has been used to determine the range at which the received sound attenuates to levels below a defined threshold. The thresholds used in the calculations are explained below.

3.2.1 Marine mammals

3.2.1.1 Injury thresholds

The assessment has used the recently published Southall et al. (2019) thresholds for the onset of PTS and TTS. The approach separates marine mammals into five groups based on their functional hearing, namely: low-frequency cetaceans; high frequency cetaceans; very high frequency cetaceans; pinnipeds (Phocid) in water; and other carnivores in water (e.g. otter). Table 3-1 presents the species identified as present ~~along~~ on or near the Greenlink route according to their functional hearing category.

Table 3-1 Marine mammal auditory bandwidth

Group	Low-frequency cetaceans (LF)	High-frequency cetaceans (HF)	Very High frequency cetaceans (VHF)	Pinnipeds (Phocid) in water (PCW)	Other non-phocid marine carnivores in water (OCW)
Generalised hearing range (NMFS 2018)	7Hz - 35kHz	150hz - 160kHz	275Hz - 160kHz	50Hz - 86kHz	60Hz - 39kHz
Species	Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	True seals	Otter
Species observed along Greenlink route	Minke whale Humpback whale Fin whale	Short-beaked common dolphin Common bottlenose dolphin Striped dolphin Risso's dolphin Atlantic white-sided dolphin White-beaked dolphin Long-finned pilot whale Killer whale	Harbour porpoise	Grey seal Harbour seal	Common otter

Source: NMFS (2018)

The thresholds for the onset of PTS and TTS, as published in Southall et al. (2019) are provided in Table 3-2. These reflect the current peer-reviewed published state of scientific knowledge.

Table 3-2 Injury thresholds for marine mammals from impulsive (SPL, unweighted) and continuous (SEL, weighted) sound

Auditory Group	Impulsive noise		Continuous noise	
	SPL (unweighted) - dB re 1 µPa (peak)		SEL (24 hr, weighted) - dB re 1 $\mu Pa^{-2}s$	
	PTS onset	TTS onset	PTS onset	TTS onset
LF	219	213	199	179
HF	230	224	198	178
VHF	202	196	173	153
PCW	218	212	201	181
OCW	232	226	219	199

Source: NMFS (2018) and Southall *et al.* (2019) Table 6: non-impulsive sound and Table 7: impulsive sound.

3.2.1.2 Disturbance thresholds

There are no published guidelines on behaviour thresholds due to the complexity and variability of the responses of marine mammals to anthropogenic disturbance. This includes habituation to continuous sound, response to changes in sound (e.g. due to a rapidly approaching vessel) and varying responses to single or repetitive impulsive sound events. It is also likely that frequency and waveform (e.g. square wave, sine wave or beat notes) affect response.

Impulsive sound - For the purposes of this assessment the threshold for behavioural disturbance has been assessed as 140dB re 1 µPa for impulsive noise. This is based on advice from NRW TE which recommended that the sound exposure levels (SEL) threshold for impulsive sound be used as proxy for disturbance, since this is the Southall et al. (2019) threshold for TTS onset in very high frequency cetaceans. It can therefore be assumed that disturbance would also occur at this sound level. The limitation with using a SEL threshold for impulsive noise it that SEL assumes exposure for 24 hours. As the animals and source move constantly in relation to each other and the key behavioural change that has been repeatedly observed is a movement away from the source, this movement will occur long before the SEL threshold is reached and before 24 hours. The use of the 140dB re 1 µPa for impulsive noise is therefore a precautionary approach and introduces a level of conservatism into the calculations.

It should also be noted that a single one-off event such as a UXO deflagration is less likely to cause long-lasting behavioural disturbance compared with repeative impulses that last for some time.

Continuous sound - 120 dB re 1 $\mu Pa^{-2}s$ RMS has been used as the disturbance threshold for continuous sound for all cetacean species (Gomez et al. 2016, BOEM 2017, NMFS 2018).

3.2.2 Fish

The thresholds used in the assessment are taken from Popper et al. (2014) which provides different thresholds for recoverable injury and TTS as presented below:

- Impulsive sound: UXO deflagration – mortality and potential mortal injury threshold of 229 – 234 dB re 1 µPa (peak) (source Table 7.2 Popper et al. 2014)
- Impulsive sound: Geophysical survey – recoverable injury threshold of 203dB re 1 μPa^2-s SEL_{cum} or 207dB re 1 µPa (peak) and a TTS threshold of 186 dB re 1 μPa^2-s SEL_{cum} (source Table 7.4 Popper et al. 2014)
- Continuous sound - recoverable injury threshold of 170 dB re 1 $\mu Pa^{-2}s$ RMS for exposure of 48 hours, and a TTS threshold of 158 dB re 1 $\mu Pa^{-2}s$ RMS for exposure of 12 hours. (source Table 7.7 Popper et al. 2014)

3.2.3 Sea turtles

The thresholds used in the assessment are taken from Popper et al. (2014) which provides different thresholds for mortality and potential mortal injury as presented below:

- Impulsive sound: UXO deflagration – mortality and potential mortal injury threshold of 229 - 234dB re 1 µPa (peak) (source Table 7.2 Popper et al. 2014)
- Impulsive sound: Geophysical survey – mortality and potential mortal injury threshold of 210dB re 1 μPa^2-s SEL_{cum} or 207dB re 1 µPa (peak) (source Table 7.4 Popper et al. 2014)

- Continuous sound - Table 7.7 (Popper et al. 2014) does not provide a threshold for continuous sound but instead states that the relative risk is low.

3.2.4 Crustaceans

There is no threshold for the assessment of sound exposure for crustaceans (Tidau and Briffa 2016).

3.2.5 Zooplankton

There is no threshold for the assessment of sound exposure for zooplankton (Solan *et al*. 2016, McCauley *et al*. 2017).

3.3 Modelling results and discussion

3.3.1 Impulsive noise

Intertek have modelled acoustic propagation using the BOUNCE & BELLHOP models, implemented through AcTUP v 2.2L (Maggi & Duncan 2006). BELLHOP (BH) is a beam tracing model for predicting acoustic pressure fields in ocean environments (Porter 2011). This model has been rigorously tested and is well accepted (Ainslie & Sertlek 2013; National Physics Laboratory 2014; Defence R&D Canada 2005; Hovem 2013), and BH (or variations of BH) have been used to model underwater acoustics for various environmental impact studies and risk assessments (e.g. Miller et al. 2015; Ward & Needham 2014; JASCO Applied Sciences 2016).

BH is suitable for high frequency sound sources, allows for range dependent bathymetry, altimetry and sound speed profiles, and can model directional sources. These features make it an ideal choice for modelling sub-bottom profilers and other geophysical survey equipment, as they are high frequency and highly directional sound sources. BH is also suitable for modelling Unexploded Ordnance (UXO) detonations as these have a high frequency component.

The BOUNCE model computes reflection coefficients for layered seabeds; these coefficients can be used as inputs for BELLHOP, thereby allowing accurate modelling of seabed interaction.

3.3.1.1 BELLHOP

Ray tracing models work by assuming that acoustic pressure has the following form:

$$p = A\, e^{i\varphi}$$

where A is the amplitude and φ is the phase, both of which are functions of the distance between the source and the receiver. This can be applied to the wave equation:

$$c^2\, \nabla^2 p - \frac{\partial^2 p}{\partial^2 t} = 0$$

to generate two separate equations:

$$c^2\, \nabla^2 p - \frac{\partial^2 p}{\partial^2 t} = 0$$

$$2\,\nabla A\,\nabla\varphi\ + A\,\nabla^2\varphi\ =\ 0$$

Assuming that the amplitude of the acoustic field varies very slowly in comparison with the phase (this is particularly true at high frequency), the first equation can be simplified by ignoring the second derivative of the amplitude with respect to distance. This leaves a partial differential equation that can be solved numerically to produce a ray trace. The second equation is used to determine the amplitude.

BH is a beam tracing model, it uses the same rays as in ray tracing, but applies a beam width associated with each ray to determine the amplitude of the pressure. BH is only applicable for high-frequency sound sources due to the high-frequency approximation used in deriving the acoustic field and can be used with confidence in any situation where the water depth is greater than 20 wavelengths. For the scenarios modelled in this assessment, BH requires a minimum water depth of 20m for the geophysical survey equipment and 3m for the UXO.

3.3.1.2 Modelling inputs

Modelling was undertaken at two locations for this study, as shown in Figure 3-1 (Drawing P1975-UWS-001). Location 1 is representative of the range of environments (i.e. bathymetry and water depth) present along the Proposed Development and is close to both the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC) and West Wales Marine / Gorllewin Cymru Forol SAC. Location 2 is within the Castlemartin Firing Range. As the bathymetry within and near to where the Proposed Development crosses the European Marine Sites gently varies, it is reasonable to assume that the extent of sound propagation throughout the remainder of the area will be similar to that modelled. The Castlemartin Firing Range location (location 2) was selected as the most likely place to find small UXO along the cable route. Whilst the bathymetry at this inshore location varies more significantly than at location 1, the modelled bathymetry still captures the range of environments well. At the locations, two underwater sound propagation models were run; one to represent summer; and one to represent winter. The details of the chosen locations are given in Table 3-3 below.

Table 3-3 Location details

Detail	Location 1	Location 2
Area	Offshore, near the European Marine Sites	Castlemartin Firing Range
Easting (UTM30N)	333234	354502
Northing (UTM30N)	5724674	5723411
Longitude (°) WGS84	-5.41053	-5.10281
Latitude (°) WGS84	51.6483	51.64286
Water Depth (m)	52	31
Sediment Depth (m)	2	0 - 10
Sediment Type	Medium sand	Medium Sand
Seafloor Type	Weathered mudstone	Weathered mudstone

Seafloor RMS Roughness (cm)	0	0

Table 3-4 Transect lengths

Location 1	Length (km)
Transect 1	40.0
Transect 2	40.0
Transect 3	40.0
Transect 4	40.0

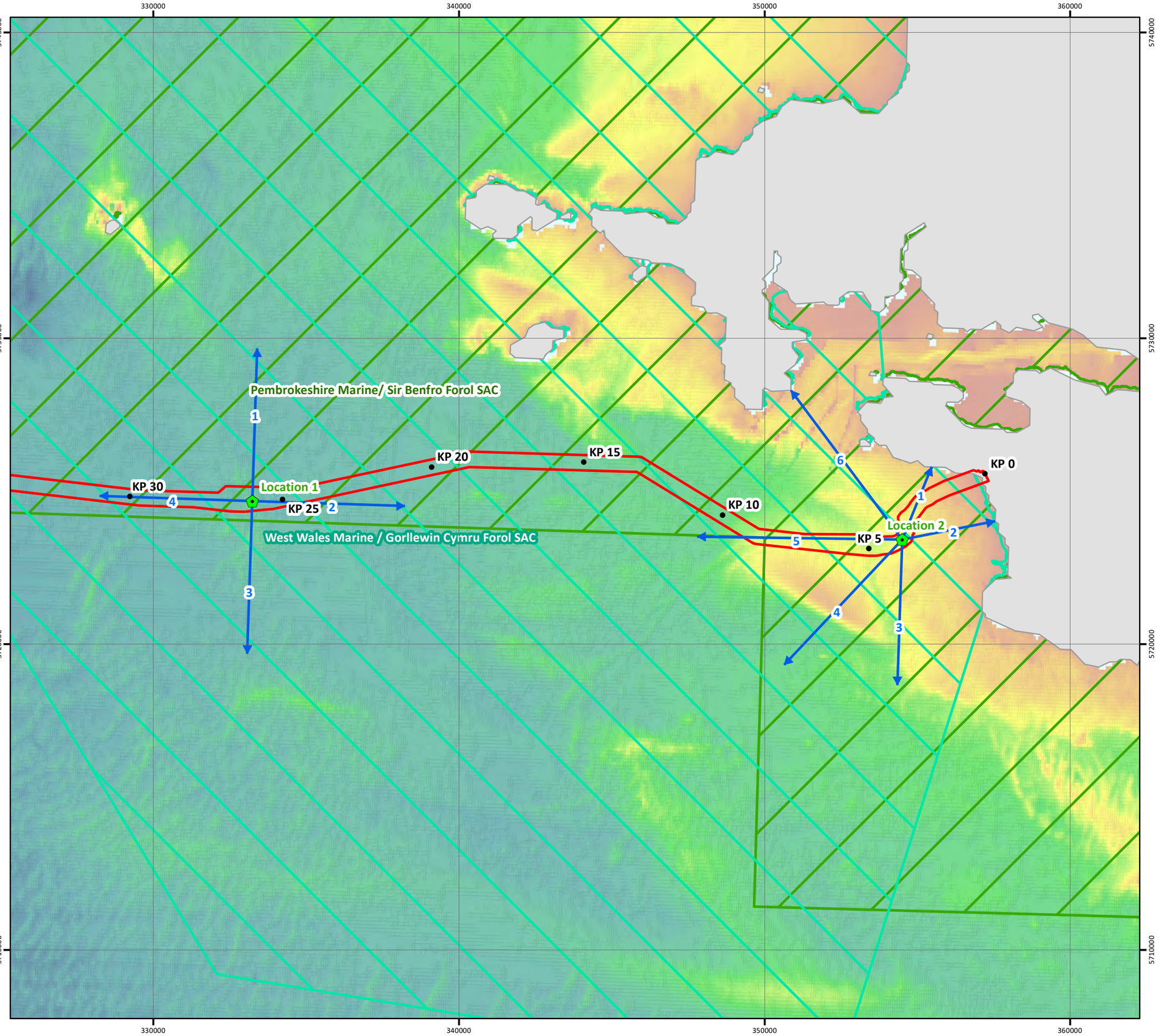
Location 2	Length (km)
Transect 1	2.6*
Transect 2	3.1*
Transect 3	50.1
Transect 4	50.0
Transect 5	50.1
Transect 6	6.1*

* Transect reaches land

GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Locations

Drawing No: P1975-UWS-001	A



Legend

- KP
- Noise Modelling Location
- Bathymetry Transect Location
- Greenlink Aplication Area

Marine SAC's

- Pembrokeshire Marine/ Sir Benfro Forol
- West Wales Marine / Gorllewin Cymru Forol

Bathymetry

Depth Below LAT (m)

High : 0

Low : -75

N
W E
S



NOTE: Not to be used for Navigation

Date	28 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	JNCC; EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

Greenlink

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intertek

0 2 4 6 8 km

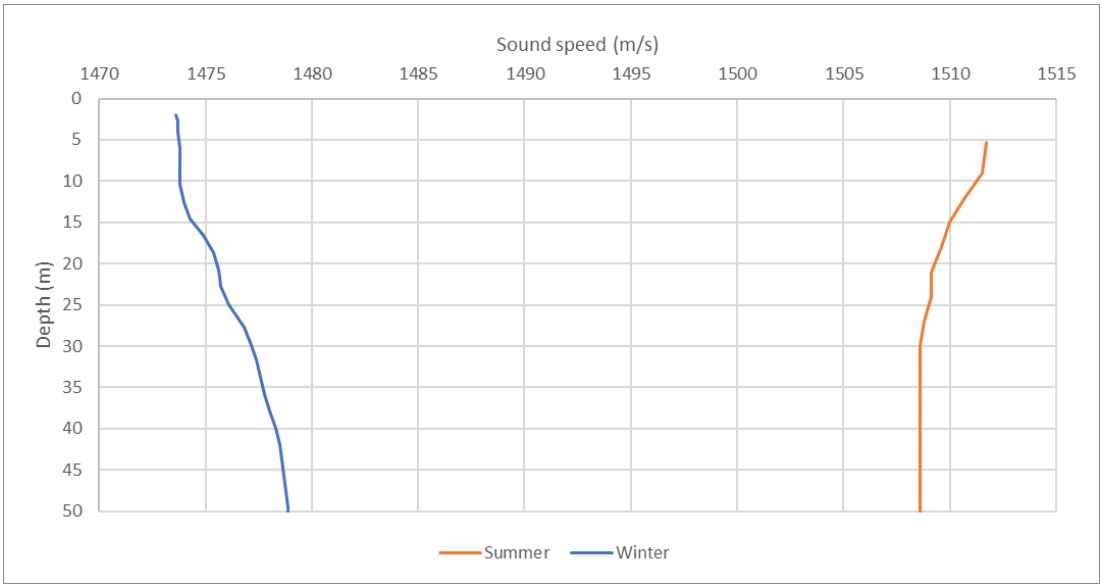
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Contains Joint Nature Conservation Committee data © copyright and database right [2018]. Contains Natural Resource Wales data © copyright and database right [2018]. Contains UK Hydrographic Office data © copyright and database right [2018]. Contains Ordnance Survey data © copyright and database right [2018]. Contains public sector information licensed under the Open Government Licence v3.0.; The bathymetric metadata and Digital Terrain Model data products have been derived from the EMODnet Bathymetry portal - http://www.emodnet-bathymetry.eu.; ©Esri; © The GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003

The bathymetry information for these locations is from EMODnet's Digital Terrain Model for the European Seas (EMODnet 2018). The sediment information is based on grab sampling and particle size analysis carried out during the Greenlink cable route survey (MMT 2019a) at sites near the modelled location. The seafloor type is based on boreholes drilled at the Welsh cable landing site (MMT 2019b). The geoacoustic properties for sand sediments were estimated using a sediment grain-shearing model that computes the acoustic properties of the sediments from porosity and grain-size (Buckingham 2005).

The acoustic parameters for the water column were derived from temperature and salinity profile data provided by the British Oceanographic Data Centre (BODC) and by Cefas. The profiles were selected based on month (to produce a typical summer and typical winter profile) and location (those closest to the modelling location were preferred). With this data, the relevant acoustic parameters were calculated for the water column (e.g. density, sound speed) using the TEOS-10 Gibbs-SeaWater Oceanographic Toolbox (McDougall & Barker 2011). The sound speed profiles for summer and winter are shown in Figure 3-2. Note that depth is measured in metres from the sea surface (0m) as a positive value i.e. the seabed is at 50m. The sound speed variation between winter and summer is mainly due to changes in water temperature.

Figure 3-2 Summer and Winter sound speed profiles



For the sub-bottom profiler (chirper), details from a typical instrument were used to generate input parameters for modelling. The sound source was taken to be the GeoChirp II sub-bottom profiler, operating with the parameters given in Table 3-5 (these details were obtained from the manufacturers, as referenced in Genesis Oil & Gas Consultants 2011). These parameters were chosen as they give the greatest (and therefore most conservative) exclusion areas. A similar approach was taken for the multi-beam echosounder (MBES), where a typical source level and beam width were used. The sound source was taken to be the Multibeam Kongsberg

(shallow water), operating with the parameters given in Table 3-5 (these details were obtained from the manufacturers, as referenced in Genesis Oil & Gas Consultants 2011).

For the chirper, the maximum sound pressure level (SPL) possible from this device was used (though it is likely to be operated at a lower power). The source level is quoted as a peak sound pressure level (SPL_{peak}) in decibels (dBs) referenced to a pressure of 1 micro Pascal re 1 µPa-2s RMS. The source was modelled as a 55° cone and assumed to be on the sea surface (i.e. source depth = 0m). For the MBES, the source was modelled on the sea surface and as a 150° cone as this represented the worst-case scenario and allows for the orientation of the swath to change without affecting the impact area.

Model results are presented for two UXO charge sizes:

- 1.54kg - The Greenlink UXO desk-based assessment (1st Line Defence 2018) identified 3lb shells (1.54kg charges) as the most likely UXO to be encountered in the Castlemartin Firing Range, based on current and historical use of the area. This weight of charge is also representative of the deflagration method (low order detonation) to be used on all UXO charges to mitigate the effects of a high order detonation.
- 794kg – This charge represents the worst case size of UXO that could be found within the Proposed Development - a World War Two (WW2) sea mine. This has been modelled principally to demonstrate the effect mitigation (in the form of deflagration) will have in reducing the zone of influence for injury and disturbance.

Note that a 50kg charge was modelled in previous revisions of this report, but this charge size is no longer relevant as it would be disposed of using a deflagration charge. Reference to the charge size has been deleted from the report in Revision F3.

Source levels for the UXO scenarios were derived from the mass of the device using an equation from Soloway and Dahl (2014) and assuming that the explosive used was similar to Trinitrotoluene (TNT). The UXO detonation was modelled near the seabed as the most likely location within the water column; and at the sea-surface to cover the worst-case scenario. It was assumed that sound will propagate radially following detonation.

In the case of underwater explosions damage to receptors can occur both as a result of the initial shock wave and as the result of secondary pressure variations caused by bubble formation and decay and by reflections from the water surface and the seabed following the explosion. Injuries caused by the initial shockwave are likely to be more extensive and more likely to result in fatality than those caused by secondary signals, as the changes in pressure are considerably more rapid.

The 10kHz frequency used for the UXO represents the worst case for effects to VHF cetacean hearing from the spectrum of sound emitted by an explosion. Whilst lower frequency sounds would propagate further, they are less damaging to wildlife.

For Revision F3, modelling was also undertaken at the 40kHz frequency to provide an estimate of the potential impacts due to the shockwave, which is more likely to cause damage extending beyond the auditory system (Keevin and Hempner 1997). The 40kHz frequency was selected based on the duration of the initial wave generated by an underwater detonation, i.e. approximately 20 to 25 µs (Meng *et al* 2019) resulting in a frequency of 40 to 50 kHz. The lower value was selected as attenuation (mainly as a result of frictional effects) increases rapidly with frequency. Overall, the attenuation for a 40kHz signal is approximately 13dB per km, while that for a 10kHz signal is approximately 1.2dB per km. This results in the ranges to the thresholds for PTS (assumed to represent the level at which damage to organs outside the auditory system will begin to occur) and TTS decreasing as shown in Table 3-7, suggesting that blast damage occurs over a significantly smaller range than does auditory damage.

It should be noted that the modelling at the 40kHZ frequency was only undertaken for one charge size (1.54kg), at one location (location 1) and in one season (winter). Modelling at this location represents the most likely and realistic scenario. The comparison between the 10kHz and 40kHZ results at this location therefore demonstrate the conservatism that remains within the modelling.

Table 3-5 Input parameters for sound sources

Source type	Frequency (kHz)	Source level SPL (peak) in dB re 1µPa	Beam width (°)	Source depth (m)
Chirper	1.5	211	55°	0.1
MBES	95	235	150°	0.1
UXO (1.54kg)	10/40	275.8	360°	30 / 50 (near seabed)
UXO (794kg)	10	296.2	360°	0 /sea bed

An example of the BH model results are provided for the three models (Figures 3-3, 3-4, 3-5). These transects show the modelled sound field (as received level in dBs) for a depth/range slice. For each figure the bathymetry is shown in black. Note that depth is measured as a positive value from the sea surface.

Figure 3-3 BH results during summer months for a chirper; received sound field for a depth/range slice at location 1. Bathymetry is shown in black.

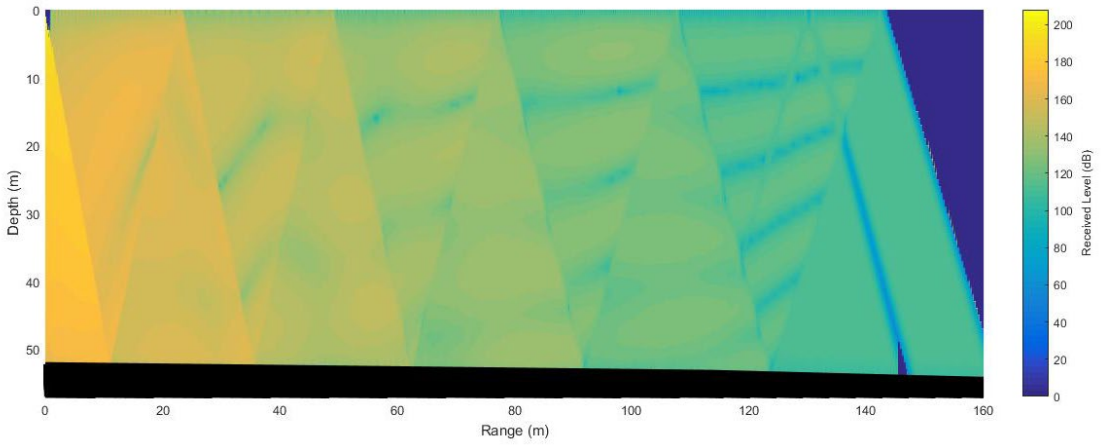


Figure 3-4 BH results during summer months for a multi-beam echosounder; received sound field for a depth/range slice at location 1. Bathymetry is shown in black.

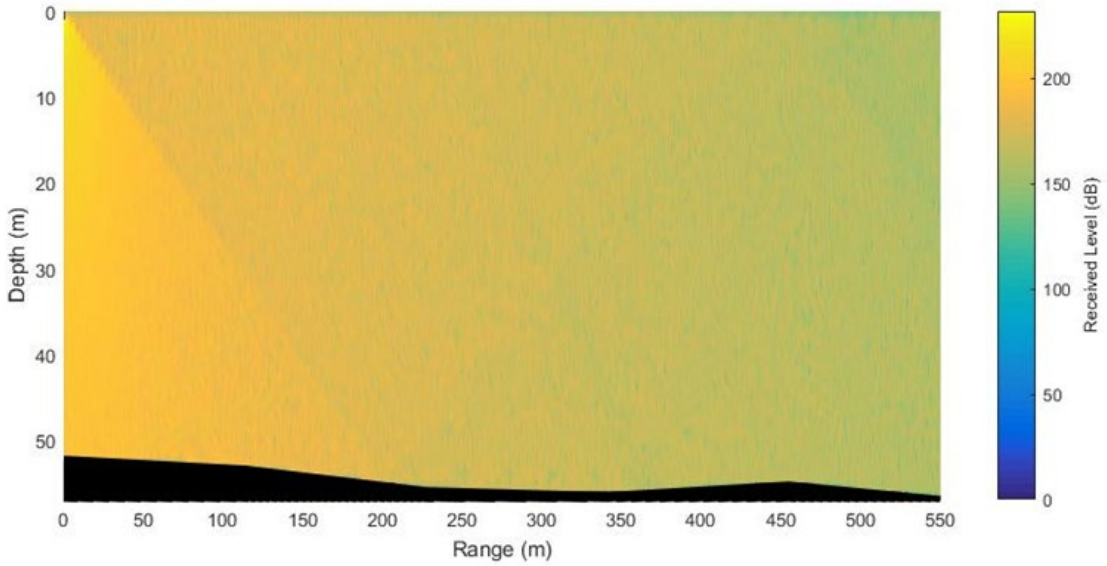


Figure 3-5 BH results during winter months for an UXO at 10kHz; received sound field for a depth/range slice at location 1. Bathymetry is shown in black

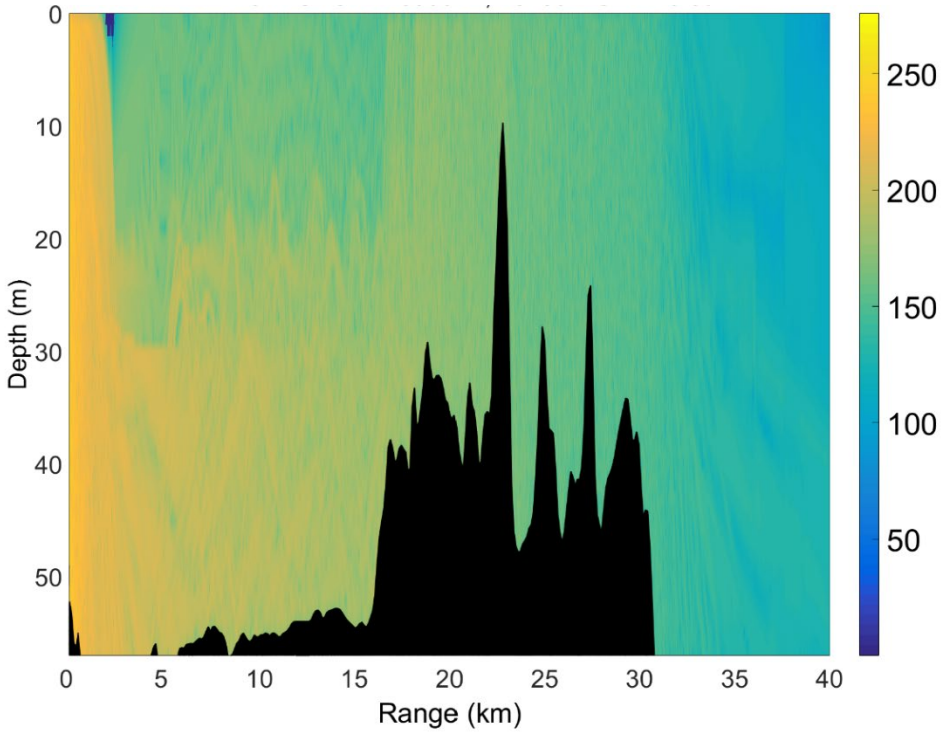
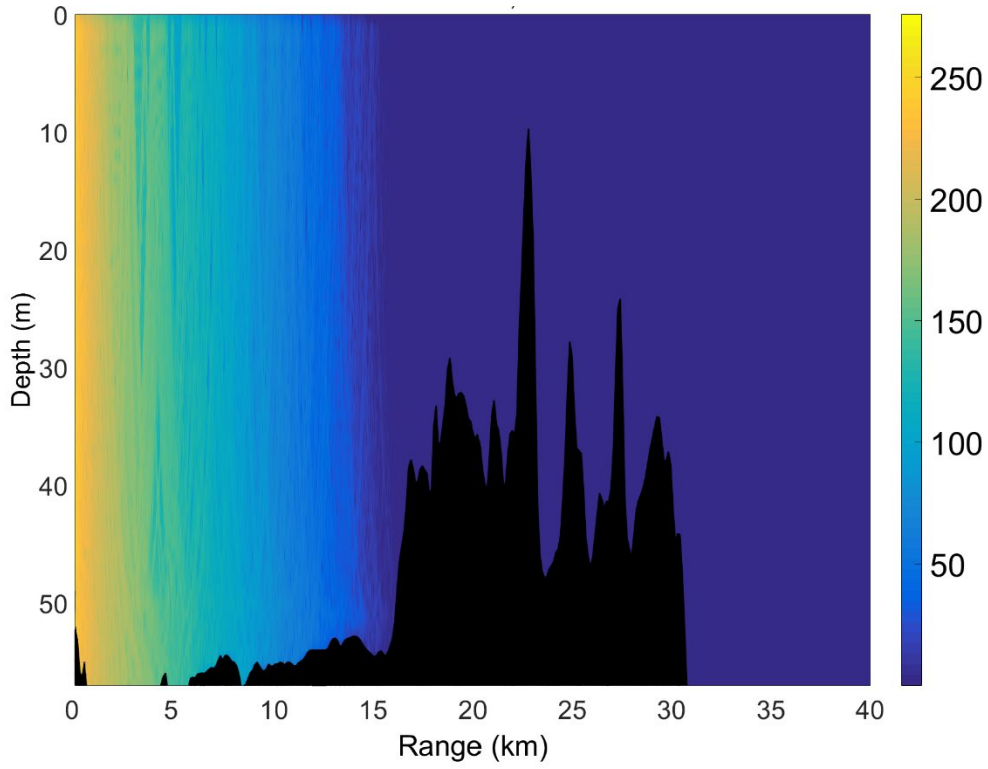


Figure 3-6 BH results during winter months for an UXO at 40kHz; received sound field for a depth/range slice at location 1. Bathymetry is shown in black.



3.3.1.3 Model results

The modelling results for the impulsive sound sources are presented in Table 3-6 (MBES and Chirper), Table 3-7 (UXO, Location 1) and Table 3-8 (UXO, Location 2).

For the BELLHOP model, the results are quoted as the distance at which 95% of the points in the modelled sound field are below the given threshold (R_{95}). This is calculated by considering every point in the depth/range slice which exceeds the threshold and excluding 5% of the most distant points, R_{95} is then taken to be the most extreme distance at which the threshold is exceeded (considering only the remaining 95% of exceeding points). This measure excludes isolated points in the water column where the received level is above the threshold; it is used because these points can extend far beyond the main sonification zone and are not representative. For Location 1, as the environmental conditions were similar along the four transects, averages and maximums were calculated for each scenario's R95 distances. At Location 2, both the seafloor conditions and depth varied significantly so each result is presented separately.

Table 3-6 Modelling results for Location 1 – Chirper and MBES

Auditory group	Threshold		Chirper		MBES	
	Type	Peak SPL (unweighted) dB re 1 µPa (peak)	Summer	Winter	Summer	Winter
			Distance at which threshold is exceeded (m)			
LF	PTS	219	Not exceeded	Not exceeded	5	5
	TTS	213	Not exceeded	Not exceeded	10	10
HF	PTS	230	Not exceeded	Not exceeded	1	1
	TTS	224	Not exceeded	Not exceeded	3	3
VHF	PTS	202	0.7	0.7	36	36
	TTS	196	2.0	2.0	83	85
PCW	PTS	218	Not exceeded	Not exceeded	6	6
	TTS	212	Not exceeded	Not exceeded	11	11
OCW	PTS	232	Not exceeded	Not exceeded	0	0
	TTS	226	Not exceeded	Not exceeded	2	2
All cetaceans*	Disturbance (dB ~~SEL~~)	140	147	181	685	756
All fish species**	Recoverable injury	~~173~~ 207	~~21~~ 0.2	~~21~~ 0.2	~~369~~ 19.5	~~382~~ 19.7
	TTS	~~161~~ 186	~~62~~ 6.9	~~64~~ 7.0	~~553~~ 179	~~586~~ 185

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Auditory group	Threshold		Chirper		MBES	
	Type	Peak SPL (unweighted) dB re 1 µPa (peak)	Summer	Winter	Summer	Winter
			Distance at which threshold is exceeded (m)			

Notes: Thresholds taken from Table 7 in Southall et al (2019); TTS and PTS-onset thresholds for marine mammals exposed to impulsive noise. Peak SPL (unweighted)

* NRW TE advised using a threshold of 140dB re 1 $\mu Pa^{-2}s$ SEL as a proxy for disturbance, since this is the threshold for TTS onset in high frequency cetaceans from impulsive noise. As it is not feasible to compare alternative metrics, a threshold of 140dB re 1 µPa (peak) has been used. Consultation with NRW TW and Cefas confirmed this was acceptable approach.

**Source: Table 7.4, Popper et al. (2014). Notes Popper et al. provide the threshold for TTS as 186 dB re 1 μPa^2-s $SEL_{cum.}$ As the source level is in SPL peak and metrics cannot be cross compared the distances presented are the distance at which a threshold of 186 dB re 1 µPa (peak) is reached. Given the short duration of the signals generated by chirpers and echo-sounders this represents a conservative approach. Recoverable injury includes damage to non-auditory tissue.

Table 3-7 Modelling results for Location 1 – UXO

Auditory group	Threshold (Southall et al 2019)	Peak SPL (unweighted) dB re 1 µPa	1.54kg UXO			794kg UXO	
			Frequency: 40kHz	Frequency: 10kHz		Frequency: 10kHz	
			Winter	Summer	Winter	Summer	Winter
			Distance at which threshold is exceeded (m)				
LF	PTS	219	708 (738)	2,010 (2,761)	2,092 (3,028)	7,380 (8,911)	7,411 (10,212)
	TTS	213	943 (1013)	3,175 (3,615)	3,211 (4,335)	9,760 (11,629)	9,668 (12,529)
HF	PTS	230	354 (364)	622 (760)	753 (894)	3,881 (4,652)	3,989 (5,727)
	TTS	224	542 (574)	1,297 (1,761)	1,403 (1,987)	5,387 (6,702)	5,421 (7,853)
VHF	PTS	202	1441 (1569)	5,960 (7,353)	6,030 (8,570)	14,503 (16,664)	14,512 (17,472)
	TTS	196	1757 (1884)	8,530 (10,137)	8,457 (11,195)	17,194 (19,240)	16,610 (19,582)
PCW	PTS	218	747 (780)	2,218 (2,868)	2,268 (3,134)	7,857 (9,395)	7,754 (10,595)
	TTS	212	986 (1064)	3,410 (3,841)	3,507 (4,760)	10,154 (12,071)	10,025 (12,971)
OCW	PTS	232	302 (307)	533 (614)	624 (694)	3,525 (3,951)	3,604 (4,960)
	TTS	226	472 (495)	978 (1,320)	1,146 (1,494)	4,746 (5,885)	4,847 (7,077)
All cetaceans*	Disturbance (dB ~~SEL~~)	140	4912 (5284)	30,544	26,792	37,239	37,853
All fish species and sea turtles**	Mortality and potential mortal injury	229 - 234	246-385 (257-400)	449 - 683 (520 - 880)	492 - 848 (587 - 1,014)	3,039 - 4,064 (3,508 - 4,960)	3,081 - 4,177 (4,026 - 6,052)
	Notes: Threshold taken from Table 7 in Southall et al (2019); TTS and PTS-onset thresholds for marine mammals exposed to impulsive noise. Peak SPL (unweighted) Figures in the table are presented as Average for the transects, with Maximum presented in brackets. *Source: NRW TE advised using a threshold of 140dB re 1 µPa^{-2}s SEL as a proxy for disturbance, since this is the threshold for TTS onset in high frequency cetaceans from impulsive noise. As the source levels are in SPL peak the table presents that distance at which the emitted sound reduces to below a threshold of 140dB re 1 µPa (peak), as metrics cannot be directly compared. Given the short duration of the signal generated by an explosion this represents a conservative approach. **Source: Table 7.2; Popper et al. (2014)						

Table 3-8 Modelling results for Location 2 – UXO (10kHz frequency)

Auditory Group		LF		HF		VHF		PCW		OCW		All Cetaceans*	All fish species and sea turtles**
Threshold: Peak SPL (unweighted) dB re 1 µPa		PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS	Disturbance (dB re 1 µPa peak ~~SEL~~)	Mortality and potential mortal injury
		219	213	230	224	202	196	218	212	232	226	140*	229 - 234
1.54 kg UXO													
Summer	**Transect 1**	1,998	2,428	689	1,416	2,651	2,760	2,093	2,468	492	1,163	TE	330 - 799
	Transect 2	1,665	2,110	711	1,244	2,503	2,745	1,743	2,167	549	1,062	TE	395 - 791
	Transect 3	3,851	5,685	1,467	2,501	10,137	12,771	4,118	6,119	1,117	2,067	37,663	884 - 1,601
	Transect 4	3,577	5,178	1,351	2,851	9,205	11,231	3,752	5,503	1,101	2,301	33,467	800 - 1,626
	Transect 5	3,902	5,528	1,426	2,676	9,880	12,456	4,127	5,853	1,026	2,276	39,695	875 - 1,676
	Transect 6	3,227	3,831	1,263	2,233	TE	TE	3,337	3,978	990	1,879	TE	767 - 1,412
Winter	**Transect 1**	TE	TE	1,295	TE	TE	TE	TE	TE	1,029	2,006	TE	755 - 1,478
	Transect 2	2,256	2,414	1,192	1,961	2,537	2,575	2,286	2,431	886	1,776	2,796	656 - 1,357
	Transect 3	3,518	5,035	1,300	2,284	10,604	14,021	3,651	5,635	1,050	1,834	TE	767 - 1,401
	Transect 4	3,127	5,653	1,451	2,626	10,305	12,706	3,302	6,103	1,151	2,351	TE	675 - 1,626
	Transect 5	4,177	5,778	1,601	2,977	10,255	13,482	4,352	6,153	1,076	2,501	TE	800 - 1,801
	Transect 6	3,459	4,153	1,329	2,659	5,443	5,646	3,562	4,288	996	2,218	TE	765 - 1,551
794 kg UXO													
Summer	**Transect 1**	TE	TE	2,550	TE	TE	TE	TE	TE	2,486	TE	TE	TE
	Transect 2	TE	TE	2,290	2,466	TE	TE	TE	TE	2,190	2,417	TE	2,076 - 2,327
	Transect 3	11,537	14,555	7,002	9,387	19,373	21,157	12,004	15,022	6,285	8,603	TE	5,519 - 7,302
	Transect 4	10,355	12,256	6,353	8,654	14,257	15,608	10,705	12,481	5,678	7,879	TE	5,003 - 6,728
	Transect 5	11,381	14,057	6,653	9,130	17,884	19,810	11,781	14,532	6,003	8,254	TE	5,378 - 7,104

Auditory Group		LF		HF		VHF		PCW		OCW		All Cetaceans*	All fish species and sea turtles**
Threshold: Peak SPL (unweighted) dB re 1 µPa		PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS	Disturbance (dB re 1 µPa peak ~~SEL~~)	Mortality and potential mortal injury
		219	213	230	224	202	196	218	212	232	226	140*	229 - 234
	Transect 6	TE	TE	4,323	TE	TE	TE	TE	TE	4,033	TE	TE	3,750 – 4,472
Winter	Transect 1	TE	TE	TE	TE	TE	TE	TE	TE	TE	TE	TE	TE
	Transect 2	2,560	2,588	2,466	2,526	2,670	2,724	2,566	2,593	2,436	2,509	2,805	2,401 - 2,480
	Transect 3	12,437	15,939	6,669	9,653	22,374	26,392	13,088	16,639	5,802	8,570	TE	4,735 - 7,219
	Transect 4	11,756	14,157	6,979	9,630	20,310	24,087	12,081	14,557	6,253	8,854	TE	5,403 - 7,454
	Transect 5	11,981	15,608	7,004	9,680	22,036	25,513	12,506	16,308	6,278	8,679	TE	5,603 - 7,479
	Transect 6	TE	TE	4,606	TE	TE	TE	TE	TE	4,341	TE	TE	TE

Notes: Threshold taken from Table 7 in Southall et al (2019); TTS and PTS-onset thresholds for marine mammals exposed to impulsive noise. Peak SPL (unweighted) TE refers to where the Threshold exceeds the length of the transect.

*Source: NRW TE advised using a threshold of 140dB re 1 $\mu Pa^{-2}s$ SEL as a proxy for disturbance, since this is the threshold for TTS onset in high frequency cetaceans from impulsive noise. As the source levels are in SPL peak the table presents that distance at which the emitted sound reduces to below a threshold of 140dB re 1 µPa (peak), as metrics cannot be directly compared. Given the short duration of the signal generated by an explosion this represents a conservative approach.

**Source: Table 7.2; Popper et al. (2014)

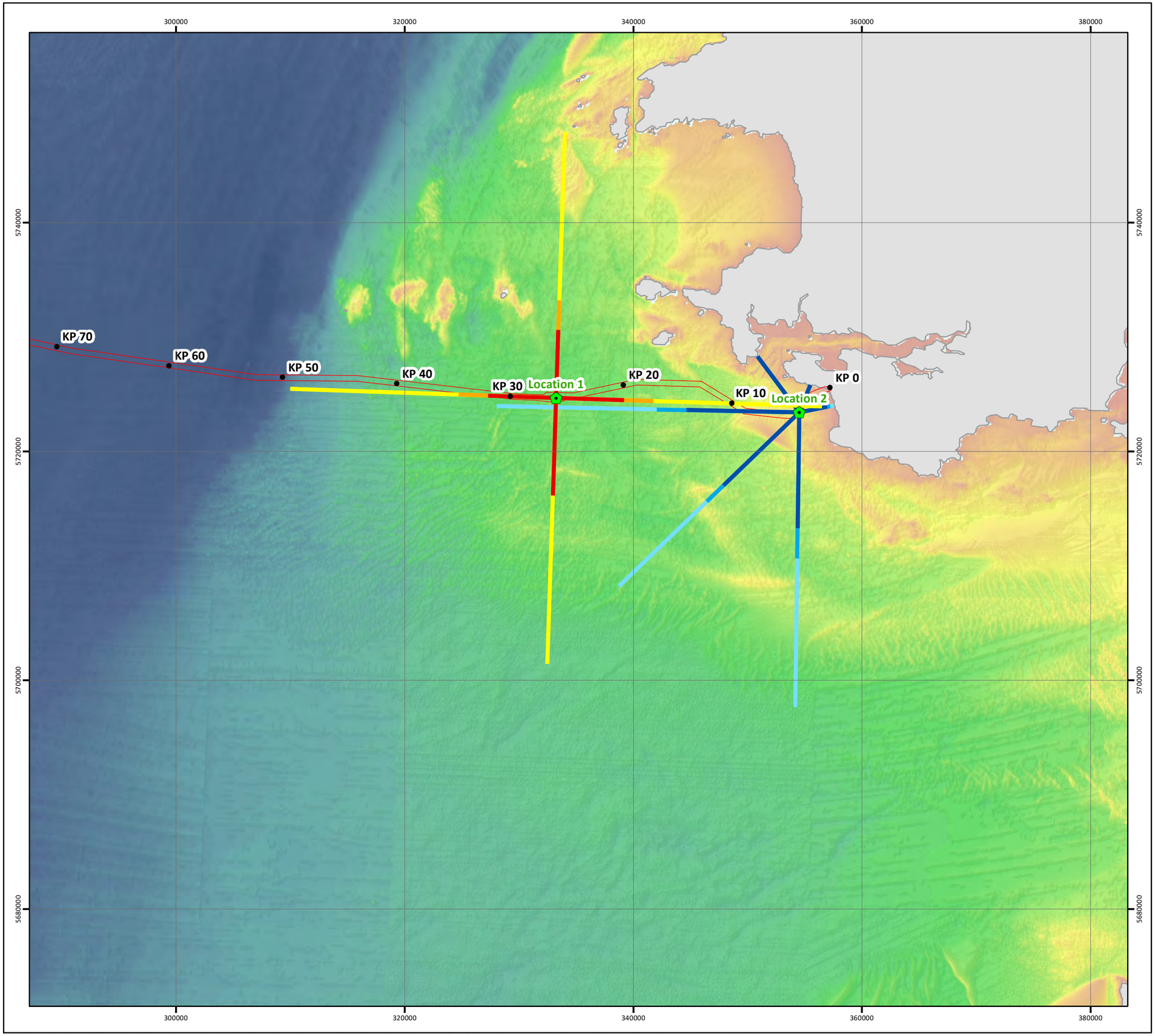
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To help visual the zones of influence for particularly sensitive marine mammal species, plots showing the modelling results have been produced. Two species have been chosen as they are Primary Features of the European Marine Sites that the Proposed Development crosses; harbour porpoise (VHF cetaceans) are a Primary Feature of the West Wales Marine / Gorllewin Cymru Forol SAC; and grey seal (pinnipeds in water) are a Primary Feature of the Pembrokeshire Marine / Sir Benfro Forol SAC. The modelling results for the 1.54kg and 794kg UXO scenarios for 10kHZ frequency for each species are provided in Figures 3-6 to 3-13 (Drawing P1975-UWS-004, Drawing P1975-UWS-005, Drawing P1975-UWS-002, Drawing P1975-UWS-003, Drawing P1975-UWS-008, Drawing P1975-UWS-009, Drawing P1975-UWS-006 and Drawing P1975-UWS-007).

GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Results
Summer, VHF Cetaceans, 1.54kg UXO

Drawing No: P1975-UWS-004 | **A**



Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- Disturbance, 1
- PTS, 2
- TTS, 2
- Disturbance, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N W E S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-004.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

Greenlink

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intertek

0 2.5 5 7.5 10 km

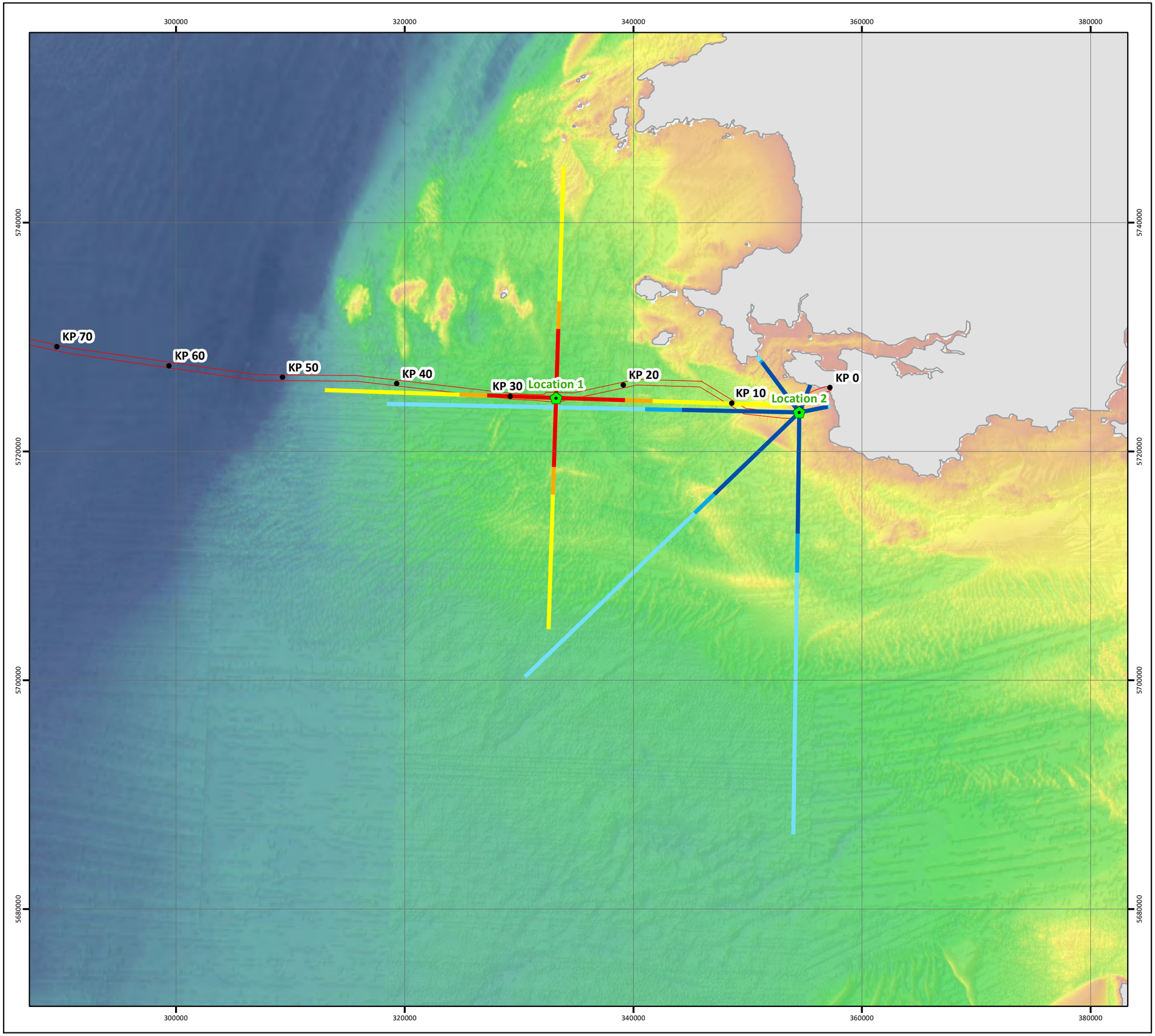
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GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Results
Winter, VHF Cetaceans, 1.54kg UXO

Drawing No: P1975-UWS-005 | **A**



Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- Disturbance, 1
- PTS, 2
- TTS, 2
- Disturbance, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N
W E
S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-005.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

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0 2.5 5 7.5 10 km

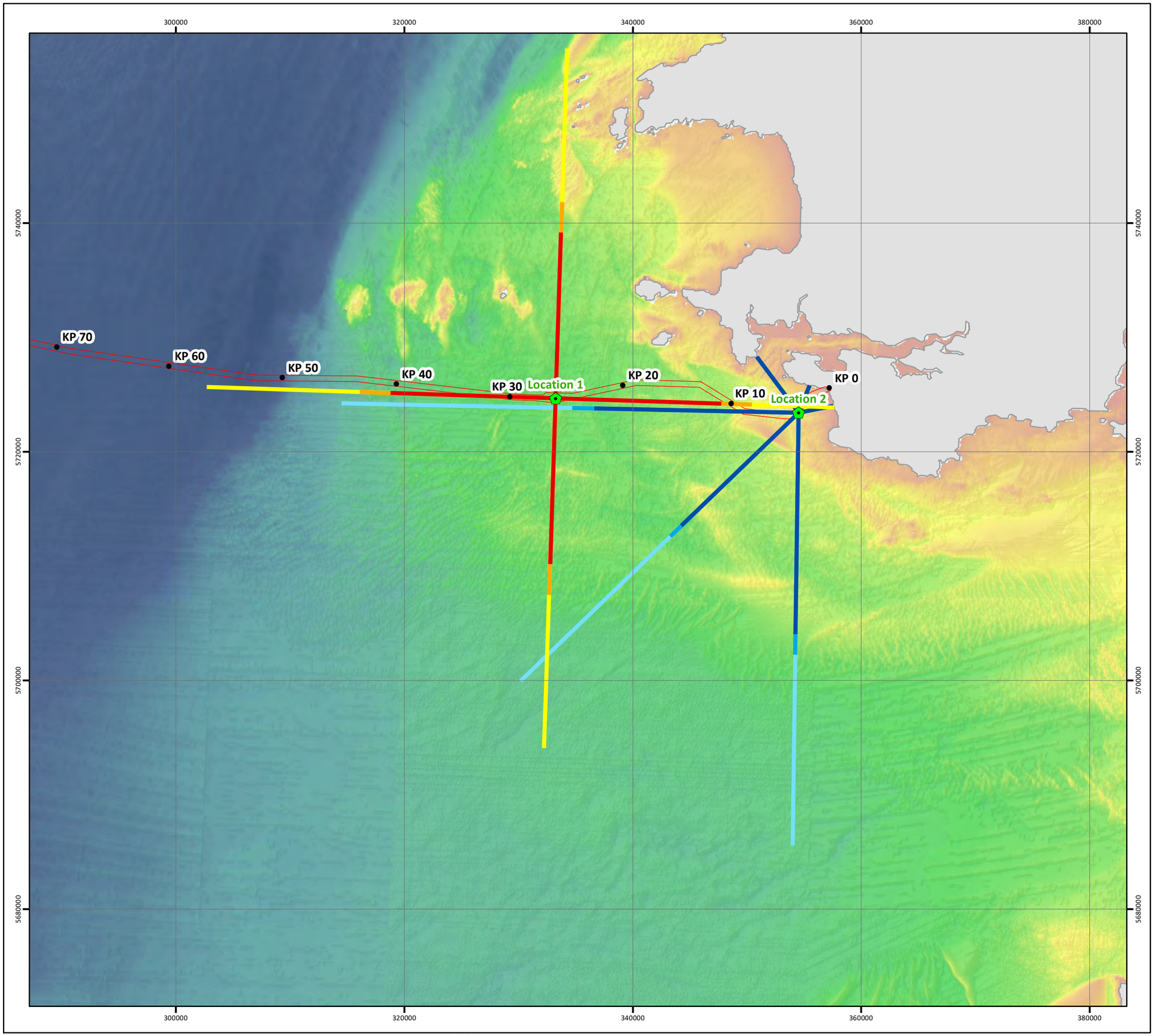
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GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Results
Summer, VHF Cetaceans, 794kg UXO

Drawing No: P1975-UWS-002 | **A**



Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- Disturbance, 1
- PTS, 2
- TTS, 2
- Disturbance, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N
W E
S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-002.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

Greenlink

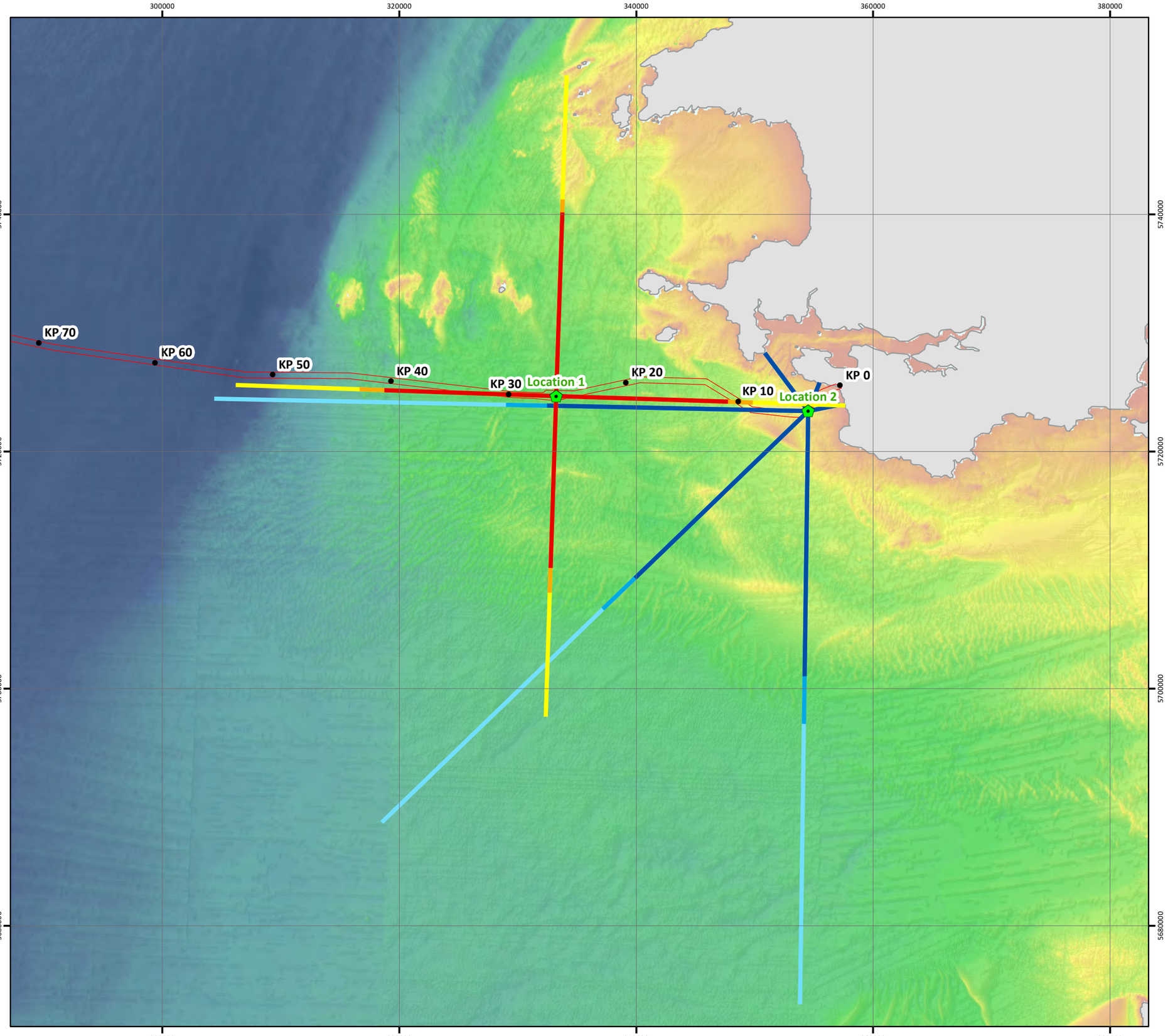
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0 2.5 5 7.5 10 km

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GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Results
Winter, VHF Cetaceans, 794kg UXO

Drawing No: P1975-UWS-003	A

Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- Disturbance, 1
- PTS, 2
- TTS, 2
- Disturbance, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N W E S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-003.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

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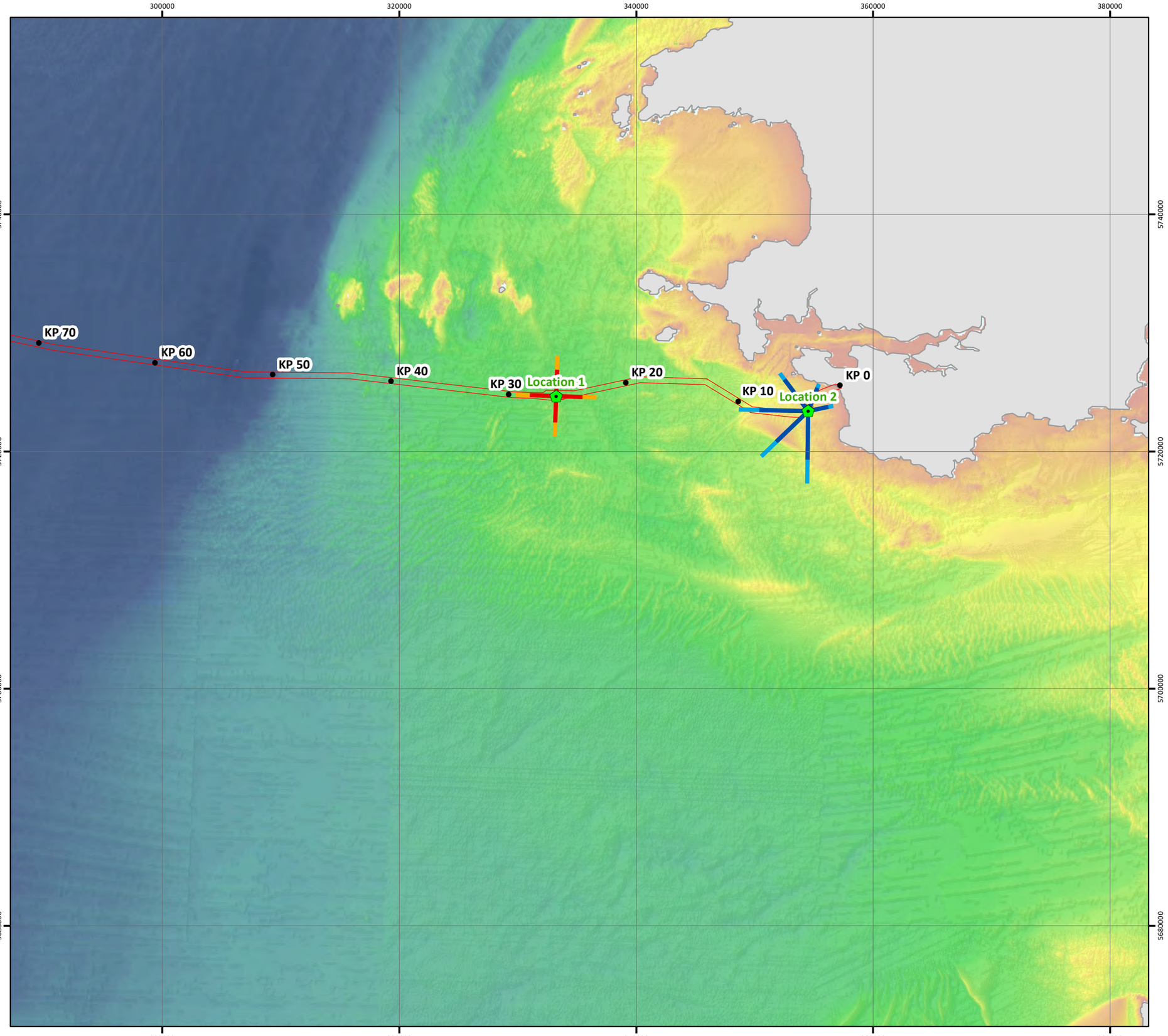
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0 2.5 5 7.5 10 km

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GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Results
Summer, Pinnipeds, 1.54kg UXO

Drawing No: P1975-UWS-008 | **A**

N
W E
S

Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- PTS, 2
- TTS, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-008.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

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0 2.5 5 7.5 10 km

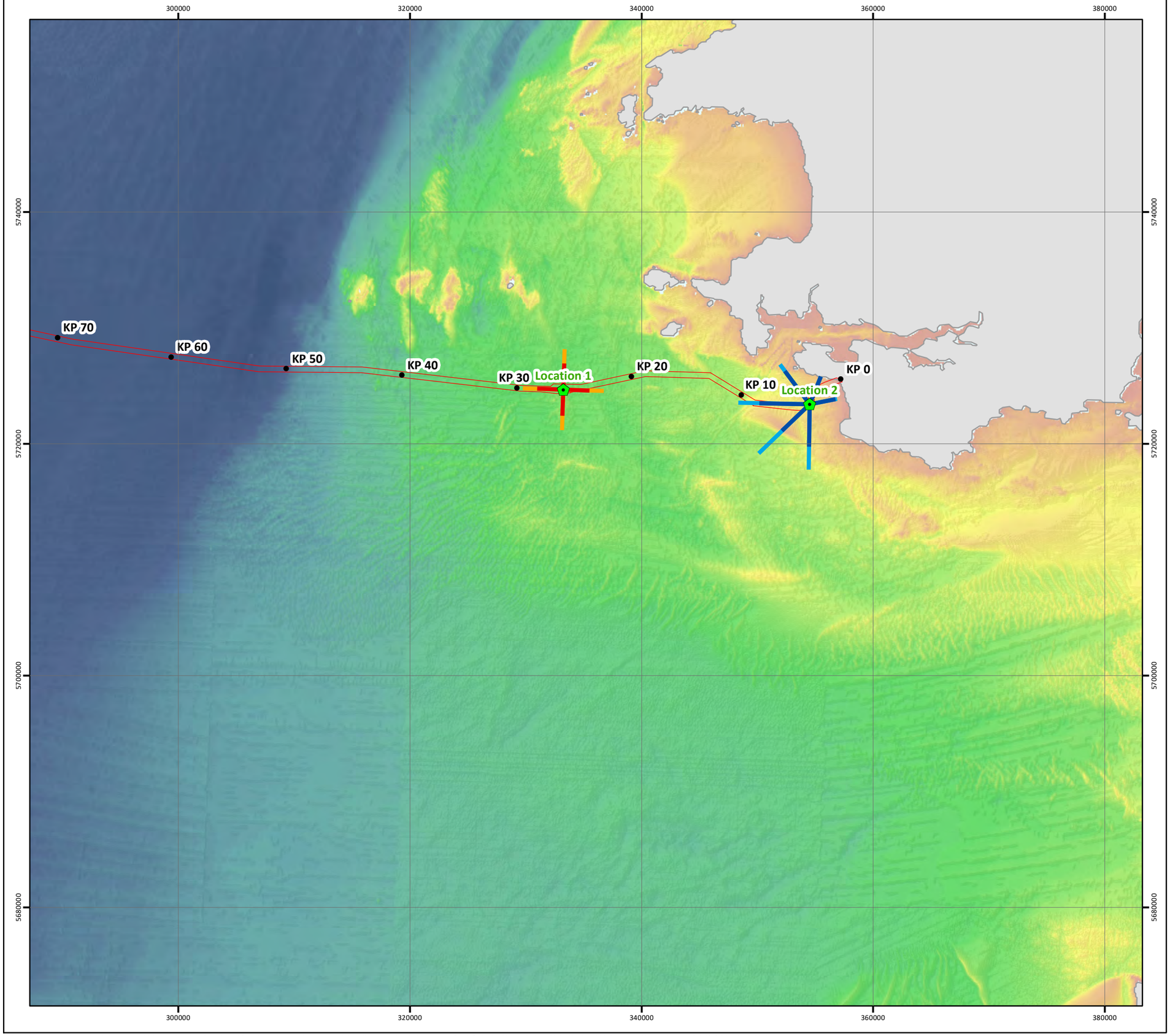
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GREENLINK INTERCONECTOR

UNDERWATER SOUND MODELLING
Noise Modelling Results
Winter, Pinnipeds, 1.54kg UXO

Drawing No: P1975-UWS-009 | **A**



Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- PTS, 2
- TTS, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N
W E
S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-009.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

Greenlink

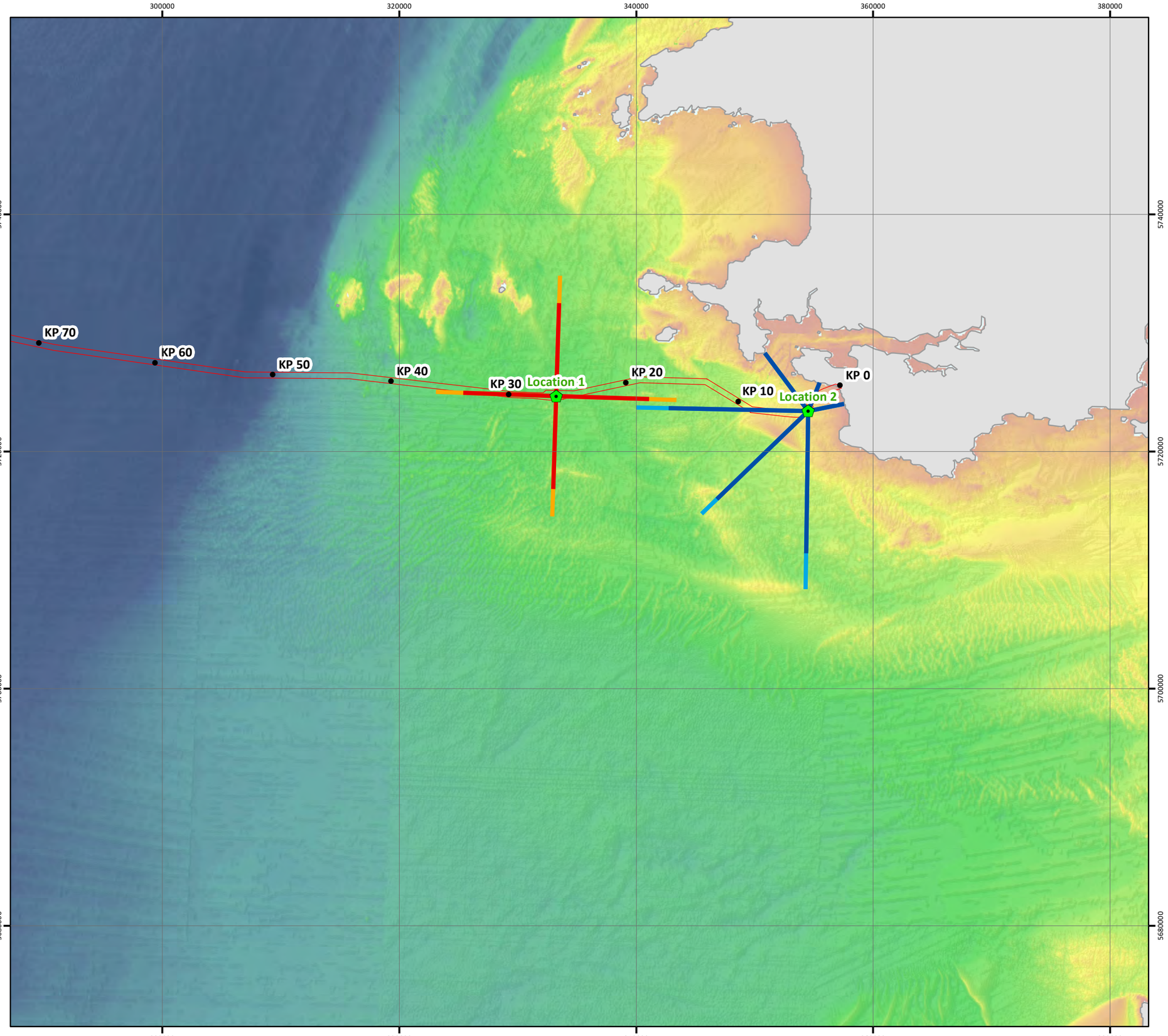
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0 2.5 5 7.5 10 km

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UNDERWATER SOUND MODELLING
Noise Modelling Results
Summer, Pinnipeds, 794kg UXO

Drawing No: P1975-UWS-006	A

Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- PTS, 2
- TTS, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N W E S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-006.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Emily Perkins

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intertek

0 2.5 5 7.5 10 km

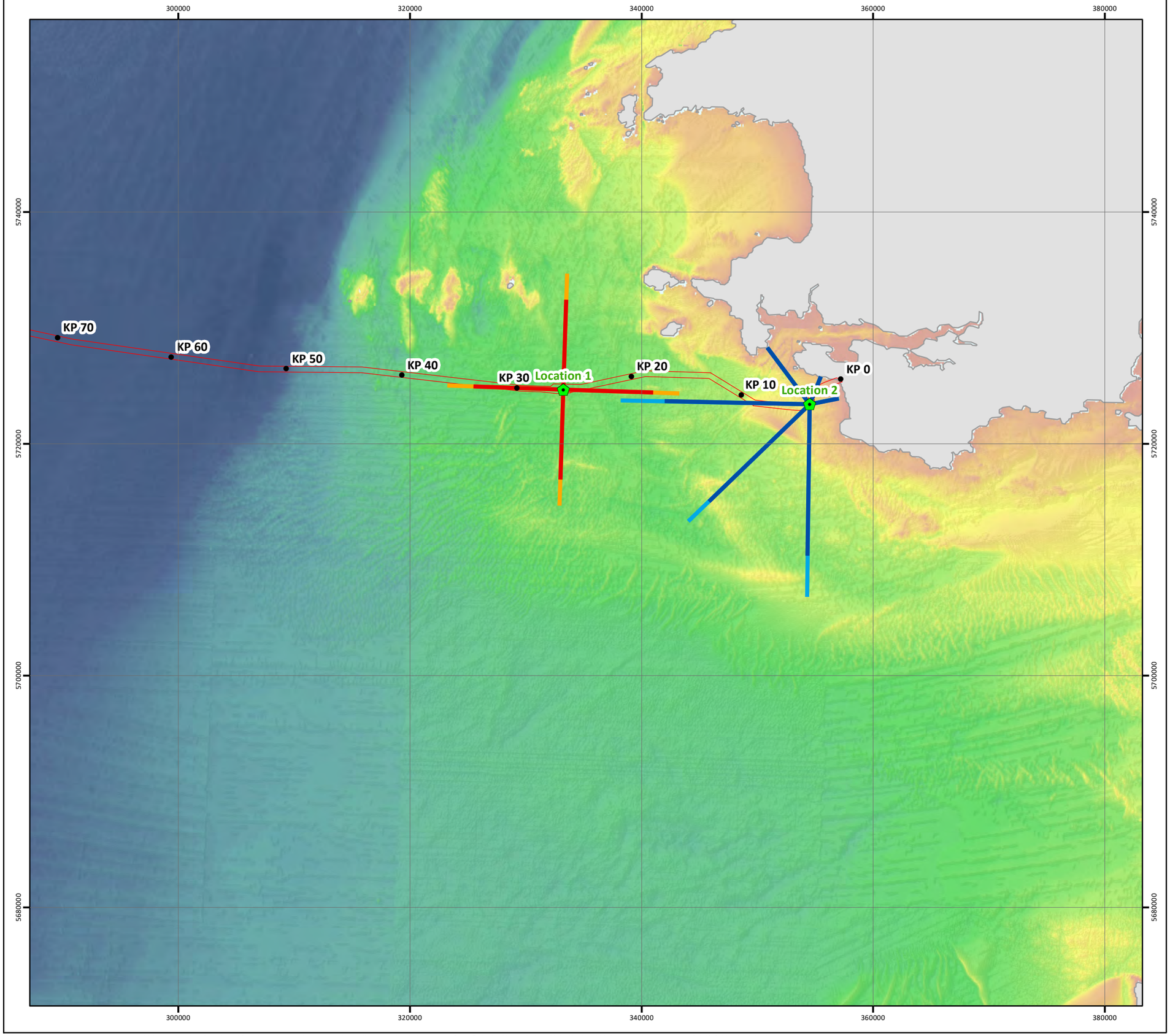
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UNDERWATER SOUND MODELLING
Noise Modelling Results
Winter, Pinnipeds, 794kg UXO

Drawing No: P1975-UWS-007 | **A**



Legend

- KP
- Noise Modelling Location
- Greenlink Aplication Area

Threshold, Location

- PTS, 1
- TTS, 1
- PTS, 2
- TTS, 2

Bathymetry

Depth Below LAT (m)

High : 0

Low : -100

N
W E
S



NOTE: Not to be used for Navigation

Date	29 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	EMODnet; ESRI; GEBCO; Intertek
File Reference	J:\P1975\Mxd\19_UWS\ P1975-UWS-007.mxd
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0 2.5 5 7.5 10 km

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Noise attenuation has been applied to the propagation modelling based on the planned use of a big bubble curtain (BBC) or similar device at water depths of <40m. BBCs have demonstrably reduced sound attenuation by 7dB – 11dB (Verfuss et al. 2019). The modelling at Location 2 (Castlemartin) was re-run assuming a 7dB and a 11dB reduction in source level to gauge the effects of the mitigation on the ranges to thresholds relative to the unattenuated ranges. Table 3-9 presents a summary of the modelling results.

Table 3-9 Modelling results for UXO deflagration at Location 2 during winter with noise abatement

Species	No mitigation SPL(peak) = 275.8 dB re 1 µPa			BBC - 7dB reduction in SPL SPL(peak) = 268.8 dB re 1 µPa			BBC - 11dB reduction in SPL SPL(peak) = 264.8db dB re 1 µPa		
	PTS	TTS	Disturbance	PTS	TTS	Disturbance	PTS	TTS	Disturbance
LF	4.2 km	5.8 km	40 km	2.5 km	4.0 km	32km	1.6 km	3.0 km	30 km
HF	1.6 km	3.0 km	40 km	0.5 km	1.3 km	32km	0.3 km	0.7 km	30 km
VHF	10.6 km	14.0 km	40 km	7.3 km	10.0 km	32km	5.8 km	8.3 km	30 km
PCW	4.4 km	6.2 km	40 km	2.8 km	4.2 km	32km	1.8 km	3.2 km	30 km
OCW	1.1 km	2.5 km	40 km	0.4 km	1.0 km	32km	0.2 km	0.5 km	30 km
Fish	-	1.8 km	-	-	0.6km	-	-	0.3 km	-
Sea turtles	1.8 km	-	-	0.6km	-	-	0.3 km	-	-
Zooplankton	-	-	-	-	-	-	-	-	-
Crustaceans	-	-	-	-	-	-	-	-	-

3.3.1.4 Discussion

It is assumed that all marine mammals except for minke whale will move away at a speed of 1.5m/s (Otani et al. 2000, Lepper et al. 2012) from a source level; and that minke whale will move away at a speed of 3.25m/s. This is a conservative estimate as there is data (McGarry et al. 2017, Kastelein et al. 2018, van Beest et al. 2018) to suggest that animals will swim at much higher speeds e.g. harbour porpoise at 1.9m/s (Kastelein et al. 2018), at least initially.

Marine mammals

Geophysical survey

Table 3-6 (Section 3.3.1.3) indicates that in general sound levels generated by the chirper (sub-bottom profiler) will have a negligible effect on marine mammals, with most values not exceeding the thresholds for injury. VHF cetaceans such as harbour porpoise, would experience noise levels sufficient to cause TTS within 2m of the vessel; but will be very unlikely to be in that zone as evidence (e.g. Stone and

Tasker 2006, Stone et al. 2017) demonstrates animals move away from the survey area. ~~but will be able to flee the area in a few seconds to avoid injurious noise levels.~~

The largest zone of influence will be generated by the MBES. VHF cetaceans may experience sound levels sufficient to cause TTS within 85m of the source level and disturbance within 756m.

For geophysical survey it is best practice to follow the JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys' (JNCC 2017). Adherence to the guidelines constitutes best practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels. Adherence to the guidelines has been incorporated into the Proposed Development as embedded mitigation EM20.

UXO ~~detonation~~

Greenlink have committed to using low order deflagration on all charge sizes. This means that the maximum charge size is comparable to a 1.54kg detonation.

The primary objective will be to avoid encountering potential UXO by micro-routeing within the Proposed Development. Typically, a standoff distance of 15-25m relative to potential UXO and depending on the nature of the UXO and installation method, is considered safe for cable installation purposes.

If re-routeing around a particular potential UXO appears not to be possible, this potential UXO will be investigated. If visual inspection confirms a UXO, then if it is safe to do so the UXO will be removed, or as a last resort deflagration will be undertaken.

There is a higher risk of encountering UXO within the Proposed Development as it passes through the Castlemartin Firing Range, due to the historic and current activity in the area. However, an initial UXO survey has been undertaken within the Range and GIL are confident that the route is deliverable without requiring disposal of UXO. It is less likely that a UXO deflagration would be required further offshore as there if sufficient space within the Application Area to avoid the ordnance.

~~If detonation is required, Greenlink have committed to using low order deflagration on all charge sizes. This means that the maximum charge size is comparable to a 1.54kg detonation. depending on the size of the UXO a neutralisation charge will be used instead of direct detonation. A neutralisation charge will be used for all UXO greater than 50kg. This means that only the neutralisation charge will be detonated, and not the full charge of the UXO. A neutralisation charge is generally within the range of 1.54kg. A UXO greater than 50kg will not be detonated directly i.e. all UXO above 50kg will be neutralised using a 1.54kg charge~~.

It cannot be guaranteed that deflagration will always work, and on rare occasions, the deflagration attempt will lead to detonation.

To understand the potential effects of a UXO detonation on marine mammals ~~three~~ two charge sizes (1.54kg, ~~50kg~~ and 794kg) were modelled at two locations (Location

1 offshore, Location 2 Castlemartin Firing Range). The 1.54kg charge represents both the low order deflagration ~~neutralisation charge~~ and the most likely size UXO expected to be encountered within the Castlemartin Firing Range.

Two frequencies (10 kHz and 40 kHz) were modelled. These frequencies were selected to account for the different types of injury caused by the initial shock wave, resulting from the detonation of the explosive charge, and the subsequent sounds generated by secondary effects of the explosion (e.g. bubble oscillations, reflections). Shock waves, characterised by an extremely rapid, single, pressure peak, are expected to cause injuries which are both more extensive and more severe than those caused by secondary sound waves. However, the shock wave is expected to attenuate more rapidly as a result of frictional effects. This selective attenuation results in changes in signal characteristics with increasing distance from the source (Popper *et al* 2014).

For the **offshore location (location 1),** the sensitivity receptors are harbour porpoise (VHF cetacean) and grey seal (PCW); both are Primary Features of European Marine sites in the area. Table 3-7 concludes that sound would attenuate faster in summer, resulting in marginally smaller zones of influence compared to winter. The following zones of influence were calculated from the modelling and will be used to inform the assessment presented in the EIA and HRA:

~~Low order~~ Deflagration (1.54kg charge)

- VHF cetaceans are at risk from permanent auditory injury (PTS) within 8.6km of the source in winter reducing to 7.4km in summer.
- VHF cetaceans are at risk from temporary auditory injury (TTS) within 11.2km of the source in winter reducing to 10.1km in summer.
- PCW are at risk from permanent auditory injury (PTS) within 3.2km of the source in winter reducing to 2.9km in summer.
- PWC are at risk from temporary auditory injury (TTS) within 4.8km of the source in winter reducing to 3.8km in summer.

The risk of blast related injuries is related to the size of receptor. As the VHF cetaceans include harbour porpoise, which are the smallest species of cetacean found in UK waters, the PTS for VHF cetaceans can be taken as representing the onset of more extensive damage resulting from the initial shock wave following an explosion. Based on the results for the 40kHz frequency, blast damage to harbour porpoise could occur up to 1.6 km from the detonation of a 1.54kg charge. However, the thresholds for serious injury to fish and sea turtles (generally smaller than harbour porpoise and hence likely to be more vulnerable to the impacts of underwater explosions) indicate that the risk of blast damage is likely to be restricted to within 400m of the explosion.

~~50kg charge~~

- ~~VHF cetaceans are at risk from permanent injury (PTS) within 13.4km of the source in winter reducing to 12.5km in summer.~~

- ~~VHF cetaceans are at risk from temporary injury (TTS) within 16.2km of the source in winter reducing to 15.3km in summer.~~
- ~~PCW are at risk from permanent injury (PTS) within 6.7km of the source in winter reducing to 5.5km in summer.~~
- ~~PCW are at risk from temporary injury (TTS) within 9.2km of the source in winter reducing to 7.9km in summer.~~

For the 1.54kg charge the modelled threshold for the onset of disturbance was 30.5km from the source; however, such disturbance, arising from a single, short lived event, will be temporary. ~~and for the 50kg charge it is within 32km of the source. However, the modelling indicated that along certain transects, specifically for the 50kg charge the threshold had not been reached at the end of the transect. Therefore, as a precaution a distance of 64km (calculated using the highly conservative in-house attenuation model) has been assumed~~.

For the **Castlemartin Firing Range (location 2**), the sensitivity receptor is grey seal, although harbour porpoise is still likely to be present. The realistic size of detonation at this location is the 1.54kg charge. This location is close to shore and injurious effects could be experienced up to the shoreline, where this is within the distances given above. The relationship between summer and winter results was also present at location 2 i.e. zones of influence reduced in summer. The following zones of influence, presented in Table 3-8 will be used to inform the assessment presented in the EIA and HRA:

1.54kg charge

- PCW are at risk from permanent auditory injury (PTS) within 4.4km of the source in winter reducing to 4.1km in summer.
- PWC are at risk from temporary auditory injury (TTS) within 6.2km of the source in winter reducing to 6.1km in summer.
- VHF cetaceans are at risk from permanent auditory injury (PTS) within 10.6km of the source in winter reducing to 10.1km in summer.
- VHF cetaceans are at risk from temporary auditory injury (TTS) within 14.0km of the source in winter reducing to 12.7km in summer.

~~50kg charge~~

- ~~PCW are at risk from permanent injury (PTS) within 8.4km of the source in winter and summer.~~
- ~~PCW are at risk from temporary injury (TTS) within 11.2km of the source in winter reducing to 10.7km in summer.~~
- ~~VHF cetaceans are at risk from permanent injury (PTS) within 17.1km of the source in winter reducing to 15.4km in summer.~~
- ~~VHF cetaceans are at risk from temporary injury (TTS) within 20.6km of the source in winter reducing to 18km in summer.~~

The onset of temporary disturbance ~~ranged from~~ was 40km for a 1.54kg charge ~~to 64km for the 50kg charge~~.

Table 3-9 also demonstrates that the use of a big bubble curtain could be effective in attenuating noise levels and reducing the areas within which animals may experience sound levels sufficient to cause injury or disturbance. Zones of influence reduce by as much as 40-50% with the implementation of noise abatement.

Fish

Underwater explosion produces a pressure waveform with rapid oscillations from positive pressure to negative pressure which results in rapid volume changes in gas-containing organs. Damage to visceral organs is most often the cause of fish mortality following exposure to underwater explosions. The most commonly injured organs are those with air spaces that are affected by the explosion's shock wave passing through the body of the fish, these include the body cavity, the pericardial sack and gut, however injuries of the swim bladder are most common. The swim bladders are subject to rapid contraction and overextension in response to explosive shock waveforms. Species which do not possess a swim bladder or have small swim bladders are likely to be more resistant to noise generated from explosions (Keevin and Hempen 1997).

Popper *et al* (2014) also highlighted that there is no data on the effects of an explosion (such as UXO for example) on hearing or behaviour available. It is possible that a detonation can lead to temporary or partial loss of hearing at high sound levels, especially for fish species having a swim bladder which enhances sound detection. The time interval between explosions can also a key factor in fish species resilience to detonation (Popper *et al*. 2014).

If an UXO detonation is required, it is likely that any individual adult and juvenile fish present in vicinity of the explosion zone of influence will be injured or killed.

The zones of influence calculated by the modelling are as follows:

- Location 1 – deflagration 1.54kg charge: fish will experience noise levels sufficient to cause injury within 1km.
- Location 2 – deflagration 1.54kg charge: fish will experience noise levels sufficient to cause injury within 1.8km.
- ~~Location 1 - 50kg charge: fish will experience noise levels sufficient to cause injury within 3.2km~~
- ~~Location 2 - 50kg charge: fish will experience noise levels sufficient to cause injury within 4.4km~~

Sea turtles

The zones of influence calculated for fish also apply to sea turtles.

3.3.2 Continuous sound

3.3.2.1 Approach to determining attenuation distances

Intertek used an in-house geometric spreading calculation to determine the propagation of underwater sound from activities that generate continuous noise.

The spreading model assumes that sound is spread geometrically away from the source with an additional frequency-dependent absorption loss.

Attenuation can be calculated using the equation below:

$$S_R = SL - N \log (R) - \alpha (R)$$

Where:

- S_R = Sound received at distance R from the source
- SL = source level
- N = Spreading related attenuation term, with a recommended value of 15 (MMO 2015) allowing for shallow water and losses to the seabed.
- α = Frequency (f) related attenuation term with a recommended value of 0.036 f1.5, where f is in kHz (MMO 2015)
- R = the distance from a source.

This provides conservative estimates for sound attenuation as it does not take into consideration the conditions within the area, such as bathymetry, water depth or sediment type and thickness; all which increase attenuation.

The values of SR and SL can be in units either of SPL (i.e. based on the peak or RMS amplitude of the source signal, within a time period, expressed as dB re 1µPa^2) or as SEL (i.e. the accumulated energy received over a given time, expressed as dB re 1µPa^{2}s):

SPL = 20log (P/Pr) or 10log(P/Pr)^2 (the equations are mathematically equivalent)

SEL = 10log(P/Pr)^2 + 10log (t)

Where:

- P = the source pressure (peak or RMS) in µPa
- Pr = the reference pressure (1µPa)
- t = the exposure time in seconds

For an exposure time of 24 hours 10log(t) = 49.36dB re 1s

Thresholds given for continuous noise exposure in Table 3-10 are for a weighted 24 hour SEL, i.e. the given sensitivity levels are based on a value 49.36dB lower than the SPL sensitivity; with a further correction related to the auditory range of the receiving species group. Following Cefas guidance the SL values, given as SPL and expressed as dB re 1µPa^2, have been converted to SEL (re 1µPa^{2}s) by adding 49.36dB. Note that the addition of 49dB to the SL and simultaneous subtraction of 49.36dB from the S_R is equivalent to allowing for an increase in sensitivity of 98.73dB, which requires approximately 2.1 million hours, or 240 years, exposure (as each 3dB increase represents a doubling of the exposure time).

The geometric spreading model then calculates the distance (in metres) at which the SEL threshold is exceeded. This distance assumes that to experience the sound levels sufficient to cause injury or disturbance effects the animal must remain within the area for at least 24-hours and that the source level remains continuous

over 24 hours. It doesn't take into consideration likely movement of the animal (usually away from the sound source) or likely variations in the source level as a result of manoeuvring requirements.

3.3.2.2 Input values

A literature review was performed to obtain the source levels to inform this assessment. No project-specific data was available, and the literature review identified appropriate sound sources to use.

Nedwell et al. (2003) provided an unweighted source level for trenching operations at North Hoyle of 178dB re µPa @ 1m; assumed to be SPL RMS. The trenching noise was considered to be a mixture of broadband noise, tonal machinery noise and transients. During trenching at North Hoyle, sound was recorded as highly variable, and assumed to be dependent on the physical properties of the particular area of seabed that was being cut at the time (Nedwell et al. 2003).

Genesis Oil and Gas Consultants (2011) listed the sound levels of DP vessels; a worst-case 184dB re 1 µPa @ 1m was used for the assessment below.

Studies showed that rock placement did not generate a noticeable rise in the level of underwater sound, compared to the presence of vessels (including those using dynamic positioning). This indicates the sound levels are dominated by the vessel noise and not the rock dumping activities (Nedwell and Edwards 2004). Wyatt (2008) recommended the use of 188dB (RMS) 1µPa @1m.

3.3.2.3 Results and discussion

Table 3-8 provides the distances within which animals could experience sound levels sufficient to cause injury or where the threshold for disturbance is exceeded, assuming that the animal remained in the area for at least 24-hours. These results are based on two different assumptions concerning the appropriate source levels for sound generated by vessels working over extended time periods. In the first section (Results based on SPL SL) it is assumed that only the sensitivity needs adjusting for exposure time, with an effective reduction of 49dB representing continuous exposure over 24 hours. In the second section (Results based on SEL SL) it is assumed that both the sensitivity and the source value need adjusting (as advised by Cefas), with the former decreased by 49dB and the latter increased by the same amount. As discussed in Section 3.3.2.1 this presents the mathematical equivalent of exposure over 2.1 million hours.

It is clear from the NMFS User Spreadsheet tool[2] that where the transmitted sound frequency is outside the frequency range of the receiving auditory group the possibility of effect is negligible. The results provided in Table 3-10 have not had a weighting applied to account for hearing sensitivity. However, the grey cells in Table 3-10 indicate where the transmitted sound frequency is outside the auditory

[2] MS Excel spreadsheet available at https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance

frequency range of the receiving auditory group i.e. it is anticipated that the auditory group will not be able to hear the noise.

An evaluation of the results presented in Table 3-10, in the light of information for windfarms (BOEM 2017) suggests that the distances to thresholds presented in the first part of Table 3-10 (results based on SPL SL) are more representative of real zones of influence for vessel generated sound than those presented in the second section (results based on SEL SL). In particular, it appears highly improbable that vessel generated noise associated with a single activity could injure or disturb marine mammals over distances greater than 100km given the high level of general shipping activity in UK waters.

Table 3-10 Results – Continuous noise sources

Inputs	Activity	DP vessel (Genesis 2011)	Trenching (Nedwell, 2003)	Rock placement (Wyatt 2008)
	SL: SPL RMS (dB re 1 µPa^2 @ 1m)	**184**	**178**	**188**
	SL: 24 hr SEL RMS (dB re 1 µPa^{2}s @ 1m)	**233**	**227**	**237**
	Frequency: Hz	**63**	**125**	**10,000**

Auditory group	Injury criteria	SEL Threshold (24-hour exposure) dB re 1µPa^{-2}s	DP Vessel	Trenching	Rock Placement
			Distance in metres at which threshold is exceeded		
Results based on SPL SL					
LF	PTS	199	0	0	0
	TTS	179	3	0	4
HF	PTS	198	0	0	0
	TTS	178	3	0	5
VHF	PTS	173	6	3	10
	TTS	153	120	47	210
PCW	PTS	206	0	0	0
	TTS	186	0	0	2
OCW	PTS	201	0	0	0
	TTS	181	2	0	3
All cetaceans	Disturbance	120	19000	7400	8000
		140**	860	350	1300
Fish***	Recoverable injury	170 dB RMS for 48 hours	9	4	16
	Temporary	158 dB RMS for 12 hours	55	22	99
Results based on SEL SL					
LF	PTS	199	200	78	340
	TTS	179	4300	1700	3900
HF	PTS	198	230	91	400

Auditory group	Injury criteria	SEL Threshold (24-hour exposure) dB re 1μPa^{-2}s	DP Vessel	Trenching	Rock Placement
			Distance in metres at which threshold is exceeded		
	TTS	178	4900	2000	4300
VHF	PTS	173	11000	4200	6300
	TTS	153	210000	85000	18000
PCW	PTS	206	67	27	130
	TTS	186	1500	580	1900
OCW	PTS	201	150	58	260
	TTS	181	3100	1300	3200
All cetaceans	Disturbance	120	3900000	2400000	41000
		140**	970000	470000	27000
Fish***	Recoverable injury	170 dB RMS for 48 hours	17000	6700	7700
	Temporary	158 dB RMS for 12 hours	100000	41000	15000

Notes:

1. Input values taken from Genesis Oil & Gas Consultants (2011), Nedwell *et al.* (2003), and Wyatt (2008).

2. Grey cells = Distance at which threshold is exceeded has been provided but it should be noted that the source frequency is outside the sensitivity range for the auditory group (sensitivity ranges = LF – 7 to 35Hz, HF - 150Hz to 160kHz, VHF – 275Hz to 160khz, PCW 50Hz to 86Khz, NMFS 2018). Therefore, it is unlikely that the species within the group will experience hearing loss or disturbance.

* Thresholds taken from Table 6 in Southall et al (2019); TTS- and PTS-onset thresholds for marine mammals exposed to non-impulsive noise. SEL thresholds in dB re 1μPa^{-2}s.

** NRW TE advised using a threshold of 140dB SEL as a proxy for disturbance, since this is the threshold for TTS onset in high frequency cetaceans from impulsive noise.

*** Thresholds taken from Table 7-7 in Popper et al. (2014)

Marine mammals

For all distances calculated for injurious effects (PTS and TTS) animals will be able to move away from the area where injurious noise levels could be experienced within minutes; therefore, avoiding all injurious effects. For example, the greatest zone of effect for TTS is 210m for VHF cetaceans e.g. harbour porpoise. It will take a harbour porpoise swimming at 1.5m/s less than 2.5 minutes to swim out of the 210m radius area. The SEL exposure thresholds assume that to experience TTS the harbour porpoise would have to remain within 210m of the source level for 24-hours. Therefore, the risk of actual injurious effects from any of the continuous noise sources is negligible.

With respect to disturbance effects, the largest zone of influence relates to the DP vessel. Calculations suggest animals will have to be within 19km of the DP vessel activity for 24-hours for significant disturbance level effects to occur. Assuming a swim speed of 1.5m/s animals could leave the area within 3.5 hours; minke whales would take 1.5 hours. This also assumes that the DP vessel will be operating with

the thrusters operating at 100% power for 24-hours. In reality, vessels will be using thrusters sporadically e.g. to maintain a position, and the SPL will fluctuate only peaking at the 184 dB modelled for short periods within a 24-hour period. The anticipated additional vessel noise associated with DP vessel operations is temporary.

Rock placement is also unlikely to be a continuous activity over 24-hours. At crossings rock placement is likely to take approximately 3 hours. If rock berm is required for external cable protection (due to ground conditions preventing burial in sediment) it is possible that rock placement activities would take longer; potentially with vessel(s) present for days. However, it is likely that the actual deposition would be sporadic, with breaks in the activity as vessel(s) would require re-loading and positioning, rather than continuous.

It should be noted that VHF cetaceans are unlikely to be able to hear the frequencies at which the DP vessels operate and therefore the distance at which onset of disturbance occurs is unlikely to be up to the 19km predicted. The onset of disturbance in VHF cetaceans is assumed to be up to 8km as predicted for the rock placement.

Behavioural impacts to marine mammals from project-related vessel noise are expected but are not extensive, severe or biologically significant. Impacts could include temporary disruption of communication or echolocation from auditory masking; behaviour disruptions of individual or localized groups of marine mammals; or limited, localized, and short-term displacement of individuals of any species from the immediate area around the vessels. These impacts will pass as the vessel moves through the area and normal behaviour will be re-established quickly.

It is important to place the results for disturbance effects in the context of the baseline sound environment. The background sound levels in the region are likely to be in range of 91 to 127 dB re 1 µPa (RMS). Given that the 120 dB (RMS) threshold for disturbance is within this range it suggests that animals in the region are already habituated to higher natural levels of underwater sound; and therefore, the ~~noise~~ additional sound input from the Proposed Development may not be discernible above the natural and anthropogenic sound in the region. Consequently, the predicted ranges for the onset of disturbance should be viewed as very precautionary. It is important to note that the exceedance of the threshold for the onset of disturbance does not mean that disturbance will occur. It is also worth noting that the activities and noise sources modelled are temporary and transitory.

Fish

Popper *et al.* (2014) identified that there is no direct evidence of permanent injury to fish species from shipping and other continuous noise (such as the cable installation). The Oslo and Paris (OSPAR) Commission (2012) considered that the potential for likely significant effects to fish from cable installation activities is ~~considered to be~~ minor.

Different fish species react differently to sound. Behavioural responses may include small movement (e.g. twitches) or escape responses, based on studies conducted in laboratories (The University of Rhode Island 2017).

Continuous sound is detectable by fish species, and it is possible that this could lead to masking. However, the effects (if any) of masking and behavioural changes in fish from continuous sound is currently unknown (Popper *et al*. 2014).

The results presented in Table 3-7 indicate that fish would need to remain within 99m of the rock placement activity (the largest zone of influence) for 12-hours ~~24-hours~~ to experience temporary hearing loss. Given that either the vessels involved in construction activities will move or fish will avoid activity the effects on fish from continuous noise will be negligible.

Sea turtles

A review of sound exposure on sea turtles by Popper *et al*. (2014) identified no existing data regarding the effect of continuous sound.

4. Conclusion

The zones of influence to be used in the EIA process are summarised in the Tables below as follows:

- Table 4-1 - Continuous sound from cable installation;
- Table 4-2 – Impulsive sound from geophysical survey (MBES, SBP); and
- Table 4-3 – Impulsive sound from UXO deflagration
- Table 4-4 – Impulsive sound from UXO deflagration with noise abatement

Table 4-1 Zones of influence for continuous sound – cable installation

Auditory Group	Permanent Injury (PTS)	Temporary Injury (TTS)	Disturbance
LF	Not exceeded	3m	19km
HF	Not exceeded	5m	8km
VHF	10m	210m	8km
PCW	Not exceeded	2m	19km
OCW	Not exceeded	3m	19km
Fish	-	99m	-
Sea turtles	-	-	-
Zooplankton	-	-	-
Crustaceans	-	-	-

Table 4-2 Zones of influence for impulsive sound – geophysical survey

Species	Permanent Injury (PTS)	Temporary Injury (TTS)	Disturbance
LF	5m	10m	756m
HF	1m	3m	756m
VHF	36m	85m	756m
PCW	6m	11m	756m
OCW	Not exceeded	2m	756m
Fish	-	586m	-

Table 4-3 Zones of influence for impulsive sound – UXO deflagration (1.54kg charge, winter season)

Species	Location 1: 10 kHz frequency			Location 1: 40 kHz frequency			Location 2		
	PTS	TTS	Disturbance	PTS	TTS	Disturbance	PTS	TTS	Disturbance
LF	3.0 km	4.4 km	27 km	0.7 km	1.0 km	5.3 km	4.2 km	5.8 km	40 km
HF	0.9 km	2.0 km	27 km	0.4 km	0.6km	5.3 km	1.6 km	3.0 km	40 km
VHF	8.6 km	11.2 km	27 km	1.6 km	1.9 km	5.3 km	10.6 km	14.0 km	40 km
PCW	3.2 km	4.8 km	27 km	0.8 km	1.0 km	5.3 km	4.4 km	6.2 km	40 km
OCW	0.7 km	1.5 km	27 km	0.3 km	0.5 km	5.3 km	1.1 km	2.5 km	40 km
Fish	-	1.0 km	-	-	0.4 km	-	-	1.8 km	-
Sea turtles	1.0 km	-	-	0.4 km	-	-	1.8 km	-	-

Table 4-4 Zones of influence for UXO deflagration using noise abatement (1.54kg charge, winter season, location 2)

Species	No mitigation SPL(peak) = 275.8 dB re 1 µPa			BBC - 7dB reduction in SPL SPL(peak) = 268.8 dB re 1 µPa			BBC - 11dB reduction in SPL SPL(peak) = 264.8db dB re 1 µPa		
	PTS	TTS	Disturbance	PTS	TTS	Disturbance	PTS	TTS	Disturbance
LF	4.2 km	5.8 km	40 km	2.5 km	4.0 km	32km	1.6 km	3.0 km	30 km
HF	1.6 km	3.0 km	40 km	0.5 km	1.3 km	32km	0.3 km	0.7 km	30 km
VHF	10.6 km	14.0 km	40 km	7.3 km	10.0 km	32km	5.8 km	8.3 km	30 km
PCW	4.4 km	6.2 km	40 km	2.8 km	4.2 km	32km	1.8 km	3.2 km	30 km
OCW	1.1 km	2.5 km	40 km	0.4 km	1.0 km	32km	0.2 km	0.5 km	30 km
Fish	-	1.8 km	-	-	0.6km	-	-	0.3 km	-
Sea turtles	1.8 km	-	-	0.6km	-	-	0.3 km	-	-

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Appendix B

Supporting Information – Red-billed chough

B.1 RED-BILLED CHOUGH

Red-billed chough are Qualifying Features of the Castlemartin Coast SPA (of which Broomhill Burrows SSSI and Castlemartin Range SSSI are components), and the Angle Peninsula Coast SSSI. Around 4% of the UK population of chough occur within the SPA. There is regular interchange of the chough from this site and those from the adjacent Angle Peninsula Coast SSSI. The short, grazed maritime grassland turf, which occurs in places along this stretch of coastline is favoured by chough because it supports invertebrate communities that provides good feeding habitat (NRW 2003).

The availability of suitable nest sites and the extent and quality of foraging habitat are the two main limiting factors for chough (Newbery et al 1998 cited in Rylands et al 2012). Their preferred habitat is grazed grassland and heathland close to suitable nesting sites on rock faces and in caves. Chough prefer short pasture less than 5cm in height and soft soil it can probe with its long bill to feed on invertebrates. As such, coastal strips of maritime heath and short grazed pasture are extremely important to them (RSPB 2019 and The Wildlife Trust of South & West Wales 2011).

The breeding season for chough begins in late March to early April when they begin to build nests. In Pembrokeshire, this is usually deep inside an inaccessible sea cave or cliff crevice. Chough are central place foragers whilst breeding, and to improve fledgling success it is critical that they can spend most of their time foraging close to the nest. Where suitable habitat exists, they spend over half their time within 100m of the nest and a major part of the time within 300m of the nest (Kerbiriou et al. 2006 cited in Rylands et al. 2012).

Although found along rocky coastlines they are essentially terrestrial birds which feed onshore.

The CCW Science Report Analysis of Chough productivity and recreational use in Pembrokeshire (Poole 2003) identified that the bulk of the Pembrokeshire red-billed chough population are located away from the Proposed Development, along the south coast of Pembrokeshire; principally, around the Castlemartin Range (Elegug Stacks), St. Govan's Head, Stackpole Head and Lydstep Point.

The report indicates that the nearest nesting roost of the satellite population on the Angle Peninsula is approximately 1.5km to the east in Parsons Quarry Bay. The report also identifies an intermittently held feeding territory, occupied during only two of the nine monitoring years, at the Furzenips on Freshwater West beach; approximately 1.5km to the south of the landfall site (Arup 2018).

Bird surveys were conducted for the Welsh Onshore components of Greenlink and although largely focused on inland areas, they did include the area up to the HDD compound close to the landfall at Freshwater West. The survey methodology was agreed with NRW.

Chough were not recorded during the two breeding bird surveys conducted in May and July 2013 (Arup 2013). Initial discussion with NRW on 18th November 2013, confirmed that specific chough surveys were not required. The only area that is likely to be utilized by chough is the working "compound" above Freshwater West beach.

NRW requested an assessment of the "compound" area for use by wintering birds. A wintering bird survey of this area would show whether chough use the area over winter and therefore provide a year-round chough usage of the compound area. The wintering bird survey results indicated that a maximum of four red-billed chough were observed in the compound area at any given time (assumed to be two pairs) which represents 8% of the wintering Castlemartin Coast SPA population (cited as 24 pairs).

The preliminary onshore HRA (Arup 2018) and the wintering bird survey (Arup 2019) concluded that there would be no likely significant effects on red-billed chough taking into account the distance from individual territories, the limited area affected by the works in relation to the available feeding habitat, combined with the temporary nature of the cable installation works, the subsequent reinstatement of the construction area and maintenance of the existing land management regime post-installation.

With respect to the Proposed Development, the main cause of concern for chough is disturbing them when they are foraging. When foraging, the birds spend a proportion of their time in 'vigilance' behaviour, when they are keeping a look-out for danger. The more time spent on vigilance, the less time spent feeding, which can lead to subtle effects on the amounts and types of food taken back to the nest, with subsequent effects on the development of the nestlings (Poole 2003).

A study by Owen (1988) on vigilance by foraging choughs in relation to tourist disturbance suggested that chough feeding in open areas had a minimum flight distance of 35m i.e. they would take to flight if walkers got to that distance. In areas of medium to heavy cover, the flight distance reduced to 32 and 22m respectively (Poole 2003).

The two closest chough territories to the landfall site (Parsons Quarry Bay on the Angle Peninsula and Furzenips on Freshwater West beach) are both approximately 1.5km from Proposed Development. During the most sensitive time, during the breeding season, chough is likely to spend most their time foraging between 100m to 300m from the nest, over 1km from the Proposed Development. Since most disturbance occurs when people come within 35m of foraging chough it has been concluded that there would be no likely significant effects on red-billed chough.

Appendix C

Greenlink Marine ES – Wales : Chapter 7

Benthic and Intertidal Ecology

7. Benthic and Intertidal Ecology

This Chapter describes the existing baseline environment in terms of benthic and intertidal ecology, identifies the pressures associated with the Proposed Development on the receptor, presents the findings of the environmental impact assessment, and describes how significant effects (if any) will be mitigated.

The Proposed Development comprises the Welsh Marine components of Greenlink from mean high-water springs (MHWS) at the Welsh landfall at Freshwater West, Pembrokeshire to the UK / Republic of Ireland median line. It comprises:

- Two high voltage direct current (HVDC) electricity power cables;
- A smaller fibre-optic cable for control and communication purposes;
- All associated works required to install, test, commission and complete the aforementioned cables; and
- All associated works required to operate, maintain, repair and decommission the aforementioned cables, including five repair events over the 40 year lifetime of Greenlink.

The Proposed Development includes the following phases, all of which are assessed within this chapter:

- Installation;
- Operation (including repair and maintenance activities); and
- Decommissioning.

Where relevant, any limitations related to the baseline conditions, data sources or scientific understanding / interpretation within the process of assessing the effects have been highlighted.

7.1 Data Sources

Greenlink Interconnector Limited (GIL) has commissioned environmental and intertidal surveys to inform the baseline description and assessment. These have been supplemented where necessary by a review of published information and consultation with relevant bodies. The data sources used in this Chapter include, but are not limited to the following:

- Greenlink Interconnector Environmental Survey Report (MMT 2019) – provided as Technical Appendix J;
- Greenlink Interconnector Cable Landfall Locations (Wales and Ireland) – Intertidal Walkover Survey Report 2018 (MarineSpace 2018) – provided as Technical Appendix K;
- Greenlink Marine Habitat Regulation Assessment (HRA) (Intertek EWCS 2019) – provided as Technical Appendix C
- The Marine Life Information Network (MarLIN) website; and

- Other data sources as listed at the end of the Chapter.

7.1.1 Intertidal survey

Data regarding the intertidal area of Freshwater West is not readily available. Therefore, GIL commissioned MarineSpace to undertake a phase 1 intertidal walkover survey of the Freshwater West landfall to inform the baseline description and assessment.

Conducted on the 11 September 2018, it involved surveying all intertidal habitats between MHWS and mean low water springs (MLWS) across a 500m wide area centred on the indicative cable centreline. The Proposed Development lies within the surveyed area.

The intertidal survey was undertaken during spring tides in line with guidance in the Marine Monitoring Handbook (Davies et al. 2001) and Countryside Council for Wales (CCW) Handbook for Marine Intertidal Phase I Survey and Mapping (Wyn et al. 2006). During the walkover survey, biotopes were identified according to the European Nature Information System (EUNIS) classification in line with relevant guidance (Parry 2015) (and correlated to the Marine Nature Conservation Recorder (MNCR) biotopes). Where possible, boundaries of biotopes were tracked using handheld Garmin E-Trex 10 GPS devices and the Phase One Habitat Survey Tool Kit application (v1.4.0).

Soft and hard substrate quadrat sampling was undertaken to gather detailed information on the benthic communities present for biotope mapping purposes. Areas representative of each key soft sediment habitat at different tidal heights were assessed by sampling the upper 10 cm of a 0.04m^2 (0.2 m x 0.2 m) quadrat using a spade and screened on a 0.5 mm sieve. Any macrobenthos retained on the sieve was identified to species level where possible in the field. The quadrats were then dug to approximately 30 cm depth to check for the presence of larger, burrowing species. Any soft sediment samples were subject to a visual inspection and observations of colour, smell, redox potential discontinuity (RPD) depth layer, texture and presence of surface features (accretions, algae, fauna, etc.) recorded.

The survey report is provided as Technical Appendix K.

7.1.2 Offshore survey

As part of the comprehensive survey of the Greenlink cable route, MMT was commissioned by GIL to characterise the benthic ecological conditions and map the distribution and extent of the marine benthic habitats along the route. Marine survey work was undertaken between the 30 September 2018 and the 01 January 2019.

Geophysical, geotechnical and benthic survey techniques were used to:

- Identify obstructions and debris on the seabed;
- Determine whether any features of conservation importance were present;

- Map benthic habitats;
- Characterise burial conditions; and
- Characterise the seabed conditions.

The scope of the geophysical and geotechnical survey is outlined in detail in Chapter 6, Section 6.1.

Geophysical data was used to focus the environmental survey strategy and subsequent data interpretation.

An initial reconnaissance survey along two alternative routes was undertaken to determine the presence of reef habitat prior to the establishment of a cable route. The reconnaissance survey comprised of habitat identification from a 500m swathe geophysical survey, ground-truthed by drop down video transects. The reconnaissance survey identified significant areas of Annex I bedrock and biogenic reef habitat along both routes. Through consultation with Natural Resources Wales (NRW) and additional survey, the final route was developed between the two alternatives, and a benthic survey completed. The work undertaken to define the final route is presented in Chapter 3.

Survey operations were undertaken in accordance with the procedural guidelines contained within the marine monitoring handbook (Davies *et al.* 2001).

Benthic samples were collected using two types of grab samples (Day grab and Hamon grab); selection depended on the sediment size. Sample locations were selected based on the geophysical interpretation, emphasising variations in the seabed characteristics, along with investigation of areas of notable interest (e.g. areas of potential conservation importance).

Prior to grab sampling, seabed still images were collected using a SeaSpyder drop-down video (DDV) system. Images were reviewed by experienced marine biologists on board to confirm the presence/absence of any potentially sensitive habitats or features of conservation importance. Where grab sampling was not possible due to hard seabed or coarse substrates, only video/still photo was used for sampling.

Underwater visibility was generally good, although poor conditions were experienced at KP46.9 (grab sample stations S23 and S24).

Three grab samples were retrieved at each selected site; two samples for macrofaunal analysis; and one sample for particle size and chemical analysis. Sidescan sonar data interpretation was confirmed using selected drop-down video/photo transects and/or grab samples.

A total of 21 sites were sampled within the Proposed Development; Stations S17 to S37. Additional 35 photo transects were completed; of which 13 were along the final route (the remainder were carried out on alternative routes to inform route selection). Sampling locations are shown in Figure 7-1.

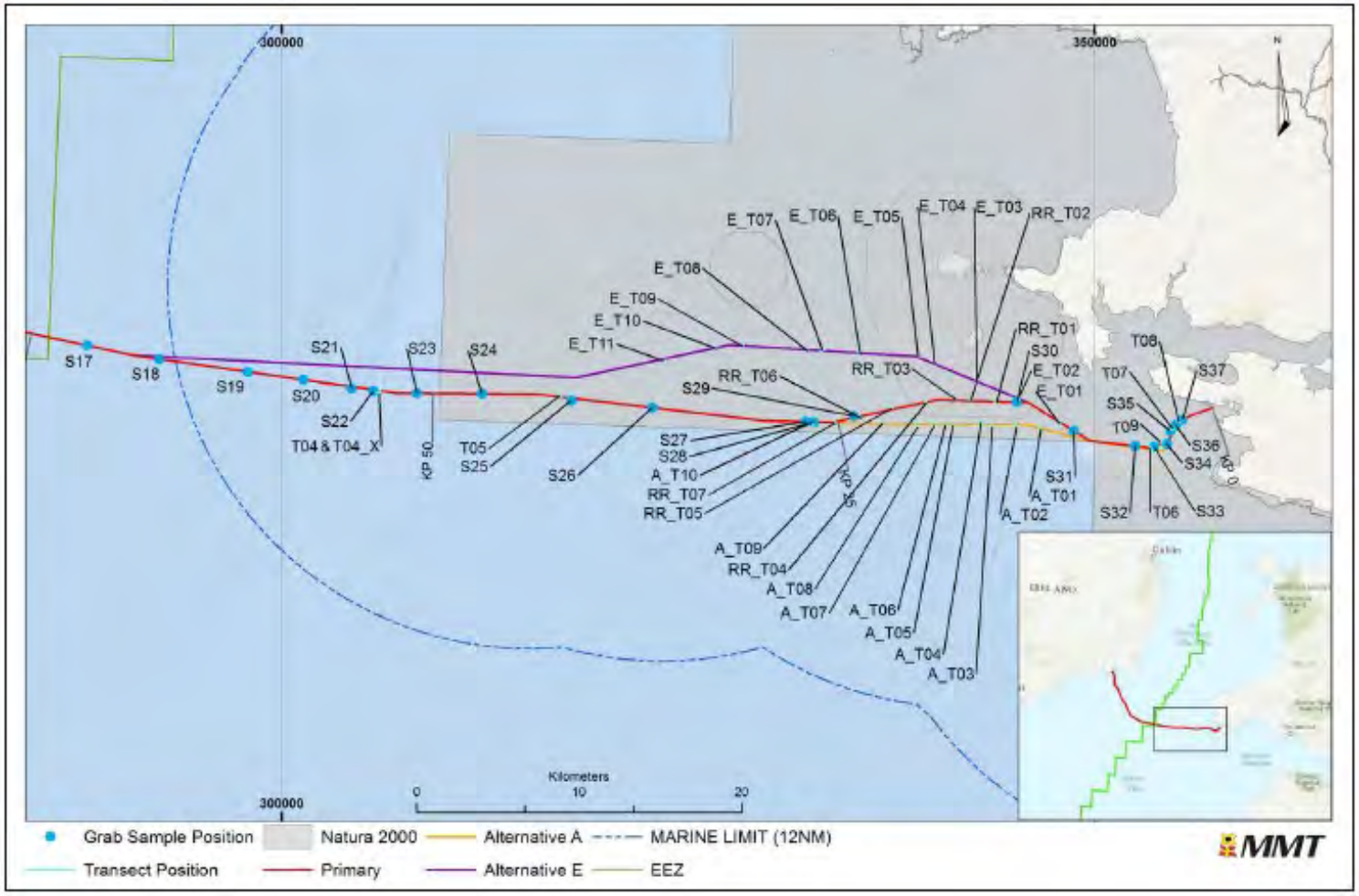
Collectively, information from the grab sampling, video / photo analysis, sidescan sonar and multi-beam echosounder was used to classify habitats and associated

epibenthic communities to biotopes where possible and/or to habitat/biotope complex according to the European Union Nature Information System (EUNIS) classification code and Annex I habitats. Particular attention was paid to habitats above the elevated seabed level, together with their spatial extent, percentage biogenic cover and patchiness, as these are key criteria for evaluating areas of conservation importance and reef structures.

Faunal identification and quantification were carried out for grab samples and still photographs to obtain species density data of individuals per m^2 and percentage cover for colonial species.

The survey report is provided as Technical Appendix J.

Figure 7-1 Grab sample and drop down video transect positions



7.2 Consultation

Table 7-1 summarises the relevant consultation responses on benthic and intertidal ecology. The steps taken to contact stakeholders for comments on the EIA scope is documented in Chapter 5.

Table 7-1 Consultation responses – benthic and intertidal ecology

Stakeholder	Summary of Consultation Response	How response has been addressed
Comments received on Natural Resources Wales (NRW) Scoping Opinion SC1816		
NRW	The EIA must clarify whether a cable joint will be located within a sensitive area, and what the significance of effects from this would be.	A cable joint is not planned to occur within a sensitive benthic habitat.
NRW	If mattressing/use of aggregates is needed in sensitive/designated areas there must be consideration of the effect of this.	External cable protection will be required within the Pembrokeshire Marine SAC due to hard ground conditions. The significance of effects on the habitats and SAC have been assessed in Section 7.6 and the Greenlink Habitats Regulations Assessment (HRA) – Technical Appendix C.
NRW	All available information, including NRWs pre-application advice and the MarLIN's habitat sensitivity assessments must be used to evaluate the significance of effects in the EIA.	This chapter draws on site specific information obtained by the Greenlink cable route survey, as well as the NRW pre-application advice and MarLIN sensitivity assessments.
NRW	NRW TE provided advice on known survey results. If gaps in knowledge exist and there are areas of low confidence, we recommend that an exercise is undertaken in which degrees of confidence in the areas mapped is provided.	The entire Proposed Development has been successfully mapped in full. The survey reports are provided as Technical Appendices I, J and K and have been used to inform the baseline description (Section 7.3) and the significance assessment (Section 7.6).
NRW	Micro-siting to avoid reef features would be preferable to movement of boulders. Boulders may likely form part of the 'Reef' feature of the Pembrokeshire Marine SAC.	Post-survey route development has been undertaken to avoid large boulders. It is anticipated that the Installation Contractor will undertake further micro-routeing but to ensure a robust worst-case assessment, areas where boulder clearance may be required have been assessed in Section 7.6.2.
NRW	The HDD exit hole is considered as a potential impact pathway as Freshwater West intertidal is a SAC habitat with the 'Mudflats and sandflats' feature. This must be appropriately assessed in the ES.	Chapter 6 concluded that trenching within the intertidal zone at Freshwater West has the potential to have a Significant effect on coastal processes. Project Specific Mitigation has therefore been proposed (PS1, PS4) and an

Stakeholder	Summary of Consultation Response	How response has been addressed
		exclusion zone established at Freshwater West. No intrusive works will be undertaken between MHWS and mean low water (LWM). The effects of cable installation on subtidal habitats has been assessed in Section 7.6.
NRW	The ES and HRA should consider the effects of seabed preparation (e.g. pre-sweeping) on the Turbot Bank which is an Annex 1 habitat and is part of the 'Sandbanks which are slightly covered by seawater all the time' features of Pembrokeshire Marine SAC.	The Greenlink HRA (Technical Appendix C) and Section 7.6.2 assess the effect of pre-sweeping on Turbot Bank.
NRW	It is not clear how the habitats identified in Table 5-1 relate to biotopes identified within the surveys and for which sampling locations. We recommend that NRW TE preliminary advice on biotope mapping provided to Greenlink should also be used to establish the biotope maps for the chosen cable route.	The UK Scoping Report was submitted ahead of the cable route survey taking place, and therefore Table 5-1 of the UK Marine Scoping Report provided indicative EUNIS habitats based on broadscale maps of the region. The baseline presented in Section 7.3 has been informed by the cable route survey and provides site specific information, which has taken into consideration recommendations received from NRW.
NRW	There does not appear to be any reference to invasive species in the report or to any biosecurity measures planned. These must be considered within the ES.	The UK Scoping Report had proposed to scope the pressure 'introduction or spread of non-indigenous species' out of the ES but assessment has now been provided in Section 7.6.5.
Comments received on Superseded Scoping Report which are relevant to the Proposed Development		
MMO	The introduction of such external cable protection into an otherwise soft sediment environment needs to be investigated in the ES as this constitutes a permanent seabed effect. In addition, the use of external cable protection could cause significant effect to seabed features, particularly reef habitat.	The introduction of external cable protection and the associated pressures on subtidal habitats has been assessed fully in Section 7.6.
NRW	Grapnel has potential to damage seabed habitats through clearance of sessile organisms. This should be considered for relevant SAC habitats.	The potential damage by seabed clearance (including grapnel) on subtidal habitats has been addressed in Section 7.6.2 under the pressure penetration / and or disturbance of the seabed'.
NRW	The most up to date habitat shapefile should be acquired from JNCC.	The most recent habitat shapefile updates (14-03-19) have been acquired from the JNCC website.

7.3 Existing Baseline

7.3.1 Overview

Benthic ecology describes the assemblages of organisms living in (infauna) or on (epifauna) the seabed, and their diversity, abundance and function. Benthic communities include those found on the sea floor from the intertidal zone to the deepest parts of the marine environment. The structure of benthic communities varies temporally and spatially depending on a wide range of physical factors of which water depth, sediment type, particle size and supply of organic matter are key variables.

The Proposed Development crosses the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC) from KP0 to KP49.59. The SAC supports habitat features of varying individual scale, distribution, significance, quality and sensitivity. Biogeographically, the SAC sits on the boundary between northern and southern species, making the area high in biological diversity. The mixed sediments support burrowing macrofauna living within and on the sediment surface. More specifically, this area is inhabited by rare infauna including, molluscs (Ensis and Arctica); anthozoans (Mesacmea, Peachia, Aureliania); tube living polychaetes and echinoderms. Epifauna includes a relatively isolated population of great scallop (*Pecten maximus*) and various species living on reefs and in stony beds, molluscan shell debris and in association with species consolidating mobile substrates, e.g. Ross coral (*Pentapora folicea*) (CCW 2005).

A primary reason for the selection of the Pembrokeshire Marine / Sir Benfro Forol SAC is the presence of extensive areas of the Annex I listed 'Reef' habitat. Extensive areas of sublittoral rocky reef stretch offshore from the coastline and between the Pembrokeshire islands. These reefs support extensive areas of tide-swept kelp and species-rich red algal populations and, across the large areas of deeper rock reef, a wide range and abundance of invertebrate animal communities, with hydroid, bryozoan, soft coral and anemone species (JNCC 2019).

Other Annex I habitats present as a qualifying feature, but not a primary reason for selection of the SAC include (but are not limited to) 'Sandbanks which are slightly covered by sea water all the time', and 'Mudflats and sandflats not covered by seawater at low tide'[1].

Further offshore at the UK/Republic of Ireland median line, bottom-dwelling communities are dominated by highly abundant and diverse polychaetes. The substrate is predominantly soft sediments containing patches of muddy, sandy gravel (DTI 2005).

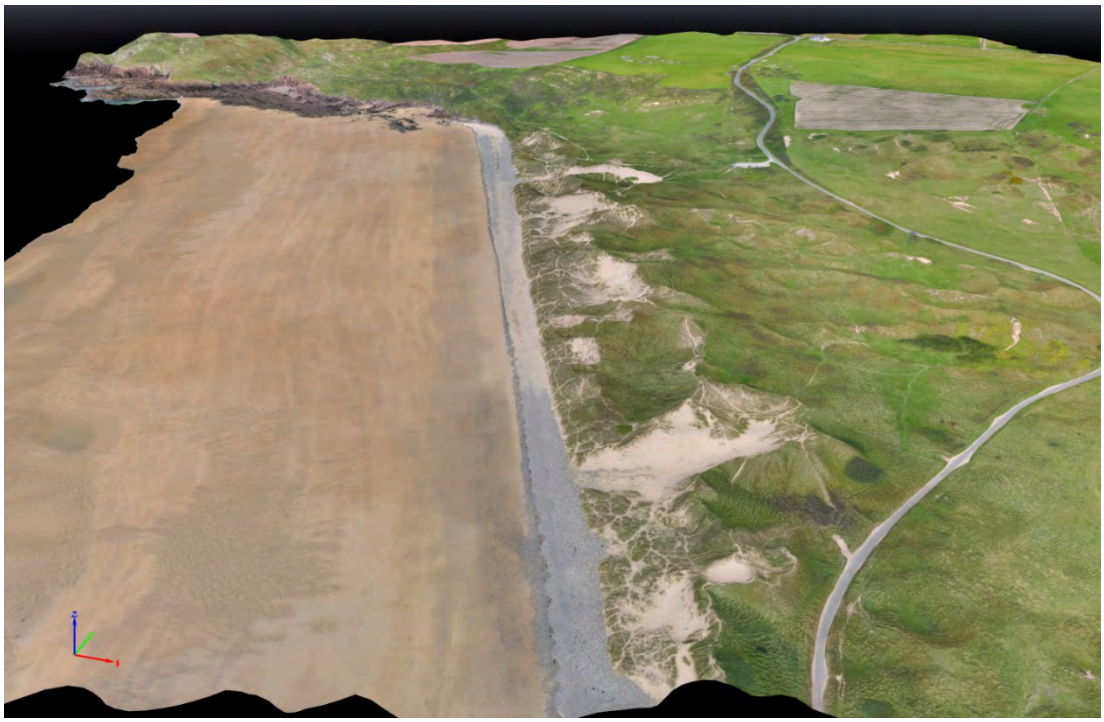
A total of 22 habitats were identified by the benthic survey within the Proposed Development.

[1] The Greenlink Marine HRA (Technical Appendix C) provides details of all qualifying habitat features of the Pembrokeshire Marine / Sir Benfro Forol SAC. The ones mentioned in the text are those relevant to the Proposed Development.

7.3.2 Freshwater West intertidal ecology and habitats

The baseline intertidal ecology at Freshwater West is detailed in the intertidal survey report, see Technical Appendix K. Figure 7-2 shows the beach as seen from the air; the image was taken during the Greenlink drone survey to establish the topography.

Figure 7-2 Aerial image of Freshwater West September 2018



Source: MMT

The habitat map produced by the intertidal Phase 1 walkover survey is provided as Figure 7-3.

Freshwater West consists predominantly of hard rocky substrate, shingle and fine sand habitats. The majority of the intertidal area within the survey area was characterised by barren littoral coarse sand (EUNIS biotope A2.111) (Table 7-2). This dominant biotope was fringed by barren littoral shingle (A2.111) along the upper shore overlain by a narrow strandline biotope constituted by decomposing seaweed supporting sandhopper (Talitrid amphipods) communities (A2.211). The lower extent of the dominant A2.111 biotope was fringed by littoral medium-fine sand supporting amphipods and the polychaete worms *Scolelepis spp.* (A2.223). The north of the survey area extended across a complex mosaic of littoral rock biotopes spanning the full range of the typical zonation expected on an exposed rocky coastline. This included lichen and barnacle dominated biotopes in the supralittoral (B3.111 and B3.1132) and upper shore zones (A1.112, A1.1121, A1.1122) and the typical fucoid dominated biotopes in mid-lower shore areas (A1.212, A1.213 and A1.3141) interspersed with coralline crust-dominated (A1.411) and green and red

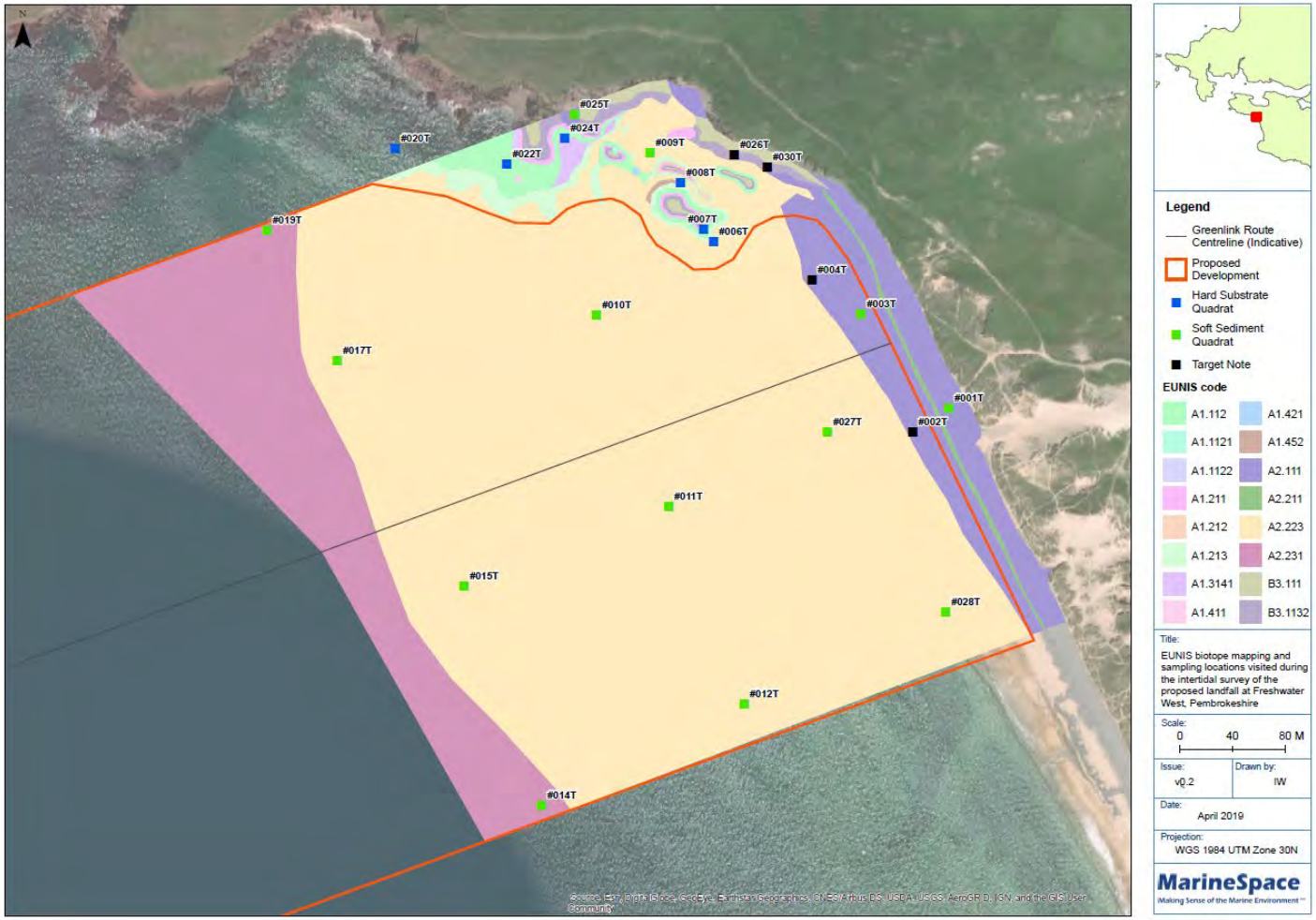
seaweed dominated (A1.421 and A1.452) rock pools. A summary of these biotopes is presented within Table 7-2.

To summarise, Freshwater West was mostly characterised by impoverished sandy shores. The paucity of benthic organisms in these sediments can be explained by the highly mobile nature of sediments in this area due to its exposed location and lack of shelter from prevailing southwesterly winds and swell.

Table 7-2 Key biotopes identified at Freshwater West

Habitat	EUNIS Code	EUNIS Description
A1 - Littoral Rock and other hard substrata	A1.112	*Chthamalus* spp. on exposed upper eulittoral rock
	A1.1121	*Chthamalus montagui* and *Chthamalus stellatus* on exposed upper eulittoral rock
	A1.1122	*Chthamalus* spp. and *Lichina pygmaea* on steep exposed upper eulittoral rock
	A1.211	*Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock
	A1.212	*Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock
	A1.213	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock
	A1.3141	*Ascophyllum nodosum* on full salinity mid eulittoral rock
	A1.411	Coralline crust-dominated shallow eulittoral rockpools
	A1.421	Green seaweeds *Enteromorpha* spp. and *Cladophora* spp. in shallow upper shore rockpools
	A1.452	*Porphyra purpurea* or *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock
A2 - Littoral sediment	A2.111	Barren littoral shingle
	A2.211	Talitrids on the upper shore and strandline
	A2.223	Amphipods and *Scolelepis* spp. in littoral medium-fine sand
	A2.23	Polychaete/amphipod-dominated fine sand shores
B3 - Rock cliffs, ledges and shores, including the supralittoral	B3.111	Yellow and grey lichens on supralittoral rock
	B3.1132	*Verrucaria maura* on very exposed to very sheltered upper littoral fringe rock

Figure 7-3 EUNIS biotope mapping and sampling locations at Freshwater West



7.3.3 Subtidal ecology and habitats

Review of the geophysical data, ground-truthed by video transects and infaunal grab samples identified 22 habitats within the Proposed Development from mean low water springs to the UK / Republic of Ireland median line. These are mapped and presented in Figures 7-4 to 7-9 (Drawing P1975-HAB-003 Sheet 1 to Sheet 6).

Table 7-3 presents a description of each habitat identified, with images underneath. Two Annex I habitats, including three sub-types were identified in the Proposed Development. These are discussed in detail in Section 7.3.4.

Table 7-3 Habitats present within the Proposed Development

EUNIS Habitat code	Indicative KPs	Associated Sample Station(s)	JNCC Equivalent Habitat	Infaunal analyses from grab samples
A4.111, *Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock	KP16 - KP21	Four single camera drops (RR_D01 – D04)	CR.HCR.FaT.BalTub, *Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock	-
A4.13, Mixed faunal turf communities on circalittoral rock	KP2 – KP3	Transects E_T04, E_T05	CR.HCR.XFa, Mixed faunal turf communities	-
A4.138, *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock	KP2 - KP3, KP4 - KP5	Transects DDV_T06-DDV_T09	CR.HCR.XFa.MolI, *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock	-
A4.213, *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	KP10 - KP12, KP24 - KP25	Transect A_T01	CR.MCR.EcCr.UrtScr, *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	-
A4.2212, *Sabellaria spinulosa*, didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock	KP42 – KP43	Transect T05	CR.MCR.CSab.Sspi.As, *Sabellaria spinulosa*, didemnids and other small ascidians on tide-swept moderately wave-exposed circalittoral rock	-
A5.13, Infralittoral coarse sediment	KP0 – KP1	-	SS.SCS.ICS, Infralittoral coarse sediment	-
A5.14, Circalittoral coarse sediment	KP20 - KP24	-	SS.SCS.CCS, Circalittoral coarse sediment	-
A5.141, *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	KP15 - KP23	Transects RR_T01 - RR_T05	SS.SCS.CCS.SpiB, *Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	-
A5.142, *Mediomastus fragilis*, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel	KP24 - KP28, KP33 - KP37	Grab Station: S26, S27	SS.SCS.CCS.MedLumVen, *Mediomastus fragilis*, *Lumbrineris spp.* and venerid bivalves in circalittoral coarse sand or gravel	S26, S27 - The fauna comprised *Lanice conchilegala* tubes, Actiniaria, Hydrozoa, bryzoans and echinoderm *Ophiura albida.* The infaunal assemblage was characterised by the echinoderms *E. pusillus*, and *Amphhipholis squamata*, numerous polychaetes such as *Ampharete lindstroemi*, *A. octocirrata*, *L. cingulata*, a high abundance of the amphipod *Ampelisca spinipes* as well as numerous molluscs

EUNIS Habitat code	Indicative KPs	Associated Sample Station(s)	JNCC Equivalent Habitat	Infaunal analyses from grab samples
				A. alba, *Hiatella arctica, K. suborbicularis, K. bidentate, Thracia villosiuscula*, *T. ovata* and *Diplodonta rotundata.*
A5.143, *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand	KP2 - KP6	Grab station: S36	SS.SCS.CCS.Pkef, *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand	S36, S33 - Infauna was characterised by low abundances of infauna, consisting of polychaetes *P. kefersteini*, *Glycera lapidum, Exogone verugera,* Notomastus and Nematods as well as sipunculid *Phascolion strombus*.
A5.15, Deep circalittoral coarse sediment	KP23 - KP25, KP53 - KP59	Transect RR_T06, Grab station: S22, S29	SS.SCS.OCS, Offshore circalittoral coarse sediment	S22, S29 - The infaunal community was dominated by the echinoderm *Amphiura filiformis* and *E. pusillus, the* polychaetes *Paradoneis lyra* and *Lumbrineris cingulate*, Nemertea and mollusc *Clausinella fasciata.* Small isolated clusters of *S. spinulosa* were present at S29.
A5.24, Infralittoral muddy sand	KP0 – KP1	-	SS.SSa.IMuSa, Infralittoral muddy sand	-
A5.25, Circalittoral fine sand	KP2 - KP4, KP5 - KP11	Grab station: S31, S32, S35	SS.SSa.CFiSa, Circalittoral fine sand	S31, S32, S35- The infauna was characterized by molluscs *A. prismatica, T. ovata*, *Kurtiella bidentata*, *Goodallia triangularis, Asbjornsenia pygmaea,* polychaetes *O. borealis, Lumbrineris cingulate, Glycinde nordmanni, Nephtys cirrosa* and various species of amphipods The infauna was relatively low in species diversity and abundances at S35. The sample was characterized by molluscs *A. alba* and *Timoclea ovata, amphipod Bathyporeia elegans* and different polychaetes
A5.251, *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	KP25 - KP27, KP58 - KP67, KP70 - KP74	Grab station: S17, S19	SS.SSa.CFiSa.EpusOborApri, *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	The infauna at grab stations S17, S19 and S28 included the echinoderms *A. filiformis, E. pusillus, and* polychaetes *O. borealis, G. lapidum* and *L. cingulate, the mollusc C. fasciata* and Nemertea.
A5.252, *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	KP3 - KP4	Grab station: S34	SS.SSa.CFiSa.ApriBatPo, *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	S34 - The infaunal community was relatively low in species diversity and abundances. The community species composition was characterized by molluscs *Abra prismatica*, *T. ovata,* polychaetes *Travisia forbesii, Ophelia borealis* and amphipod *B. elegans.*
A5.261, *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	KP0 – KP3	Grab station: S37	SS.SSa.CMuSa.AalbNuc, *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	S37 - The infauna comprised predominantly of molluscs *A. alba*, *N. nitidosa*, *Fabulina fabula* as well as polychaetes *Magelona filiformis* and *Spiophanes bombyx*.
A5.27, Deep circalittoral sand	KP27 -34, KP41 - KP43, KP48 - KP51, KP52 - KP53	-	SS.SSa.OSa, Offshore circalittoral sand	-

EUNIS Habitat code	Indicative KPs	Associated Sample Station(s)	JNCC Equivalent Habitat	Infaunal analyses from grab samples
A5.272, *Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand	KP65 – KP71	Grab station: S18	SS.SSa.OSa.OfusAfil, *Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand	S18 - The infauna was characterised by echinoderm *A. filiformis,* polychaetes *L. cingulate* and Owenia sp. and Nemertea.
A5.44, Circalittoral mixed sediments	KP6 - KP7, KP8 - KP10,	-	SS.SMx.CMx, Circalittoral mixed sediment	-
A5.45, Deep circalittoral mixed sediments	KP42 - KP43	-	SS.SMx.OMx, Offshore circalittoral mixed sediment	-
A5.451, Polychaete-rich deep Venus community in offshore mixed sediments	KP10 - KP15,	Grab station: S30	SS.SMx.OMx.PoVen, Polychaete-rich deep Venus community in offshore gravelly muddy sand	S30 - High diversity and abundance of infaunal species. The infauna was characterised by numerous polychaetes which were dominated by *Sabellaria spinulosa* and *Syllis armillarisa* as well as molluscs *Kellia suborbicularis*, *Modiolula phaseolina*, *Gari telinella, Venus casina, Hiatella arctica* and *Sphenia binghami*. The sample also contained numerous specimens of echinoderm *Amphipholis squamata*.
A5.611, *Sabellaria spinulosa* on stable circalittoral mixed sediment	KP33 - KP59	Grab station: S20, S21, S23, S24, S25 Transect T04, T04_X	SS.SBR.PoR.SspiMx, *Sabellaria spinulosa* on stable circalittoral mixed sediment	S20, S21, S23 and S24 – Grab samples contained the following infauna: *S. spinulosa*, the echinoderm *A. filiformis, and polychaetes Owenia sp. L. cingulate, A. lindstroemi, Ampelisca spinipes* and *K. suborbicularis.*

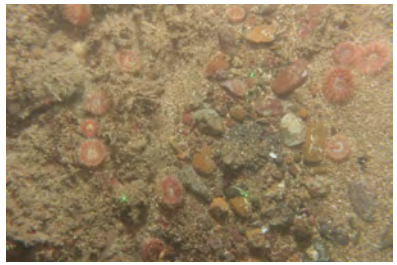
A4.13, Mixed faunal turf communities on circalittoral rock



A4.138, Molgula manhattensis with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock



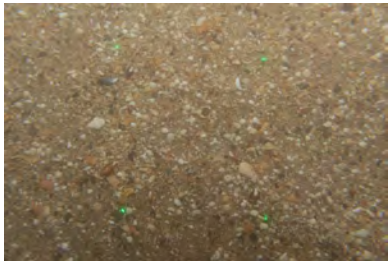
A4.213, *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock



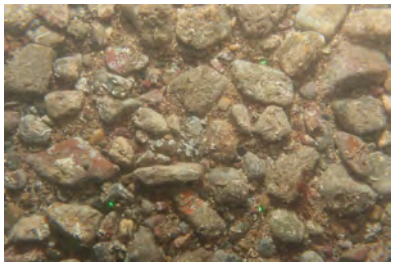
A4.2212, *Sabellaria spinulosa*, didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock



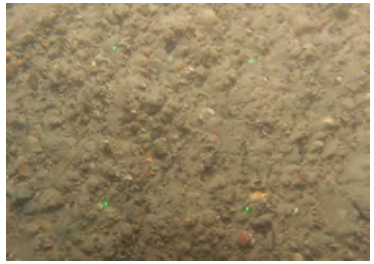
A5.14, Circalittoral coarse sediment



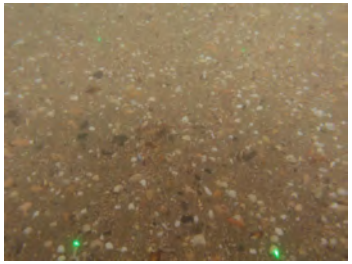
A5.141, *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles



A5.142, *Mediomastus fragilis*, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel



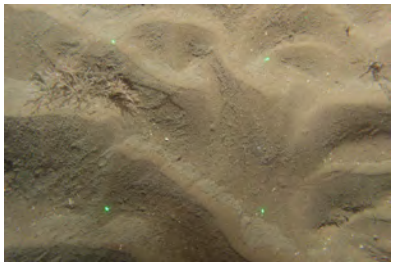
A5.143, *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand



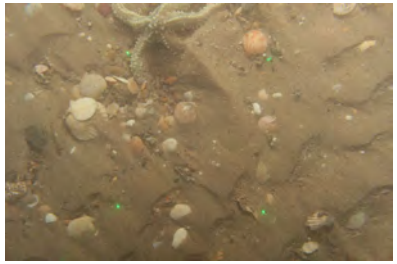
A5.15, Deep circalittoral coarse sediment



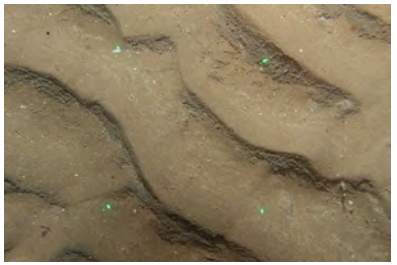
A5.25, Circalittoral fine sand



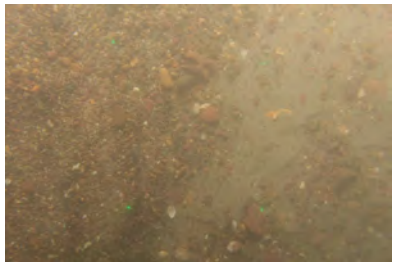
A5.251, *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand



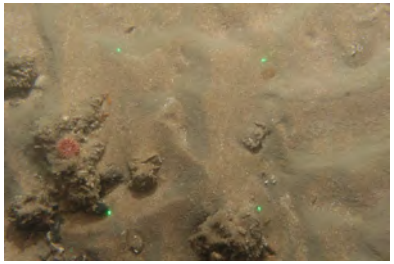
A5.252, *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand



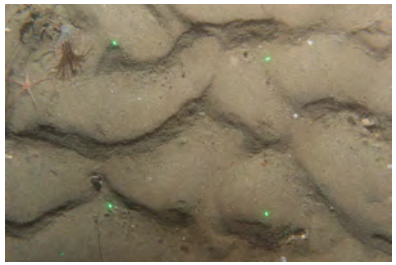
A5.261, *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment



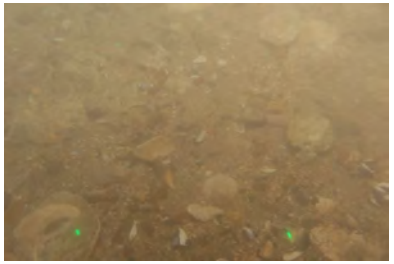
A5.27, Deep circalittoral sand



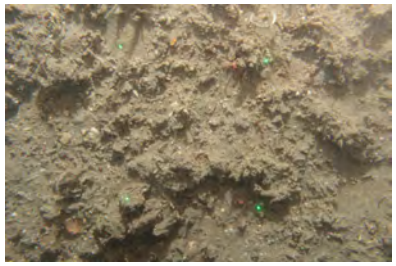
A5.272, *Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand



A5.451, Polychaete-rich deep Venus community in offshore mixed sediments



A5.611, *Sabellaria spinulosa* on stable circalittoral mixed sediment

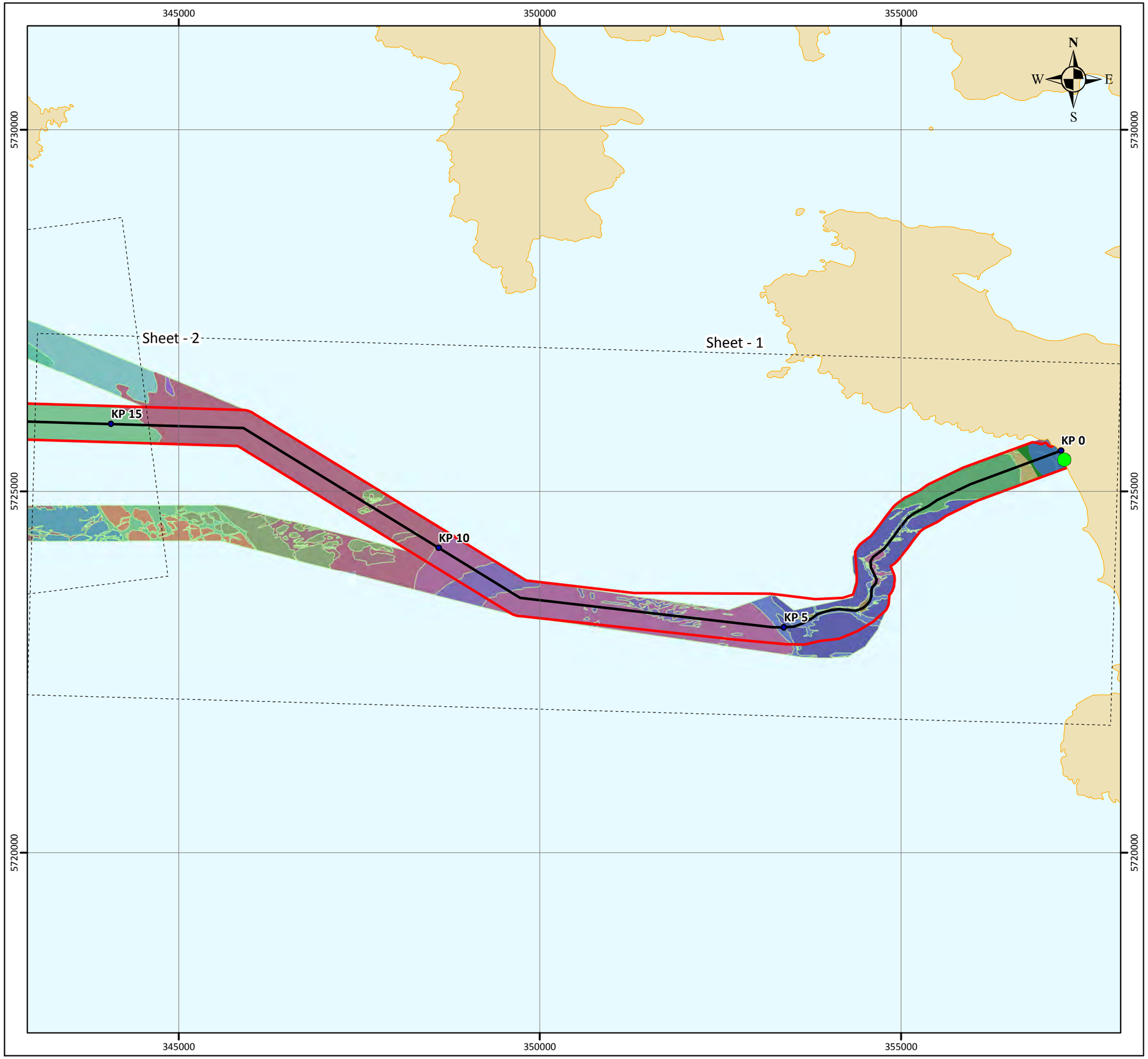


GREENLINK INTERCONNECTOR

BENTHIC HABITATS

Survey Data - Sheet 1

Drawing No: P1975-HAB-003 | **A**



Legend

- Freshwater West
- Greenlink Route Centreline (Indicative)
- Proposed Development

MMT Survey
EUNIS Classification

- A4.13
- A4.138
- A4.213
- A4.213/ A4.241
- A4.221
- A4.241
- A5.13
- A5.14
- A5.141
- A5.143
- A5.15
- A5.24
- A5.25
- A5.252
- A5.261
- A5.44
- A5.451
- A5.611

MarineSpace Survey
EUNIS Classification

- A1.112
- A1.1121
- A1.1122
- A1.211
- A1.212
- A1.213
- A1.3141
- A1.411
- A1.421
- A1.452
- A2.111
- A2.211
- A2.223
- A2.231
- B3.111
- B3.1132



NOTE: Not to be used for Navigation

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Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

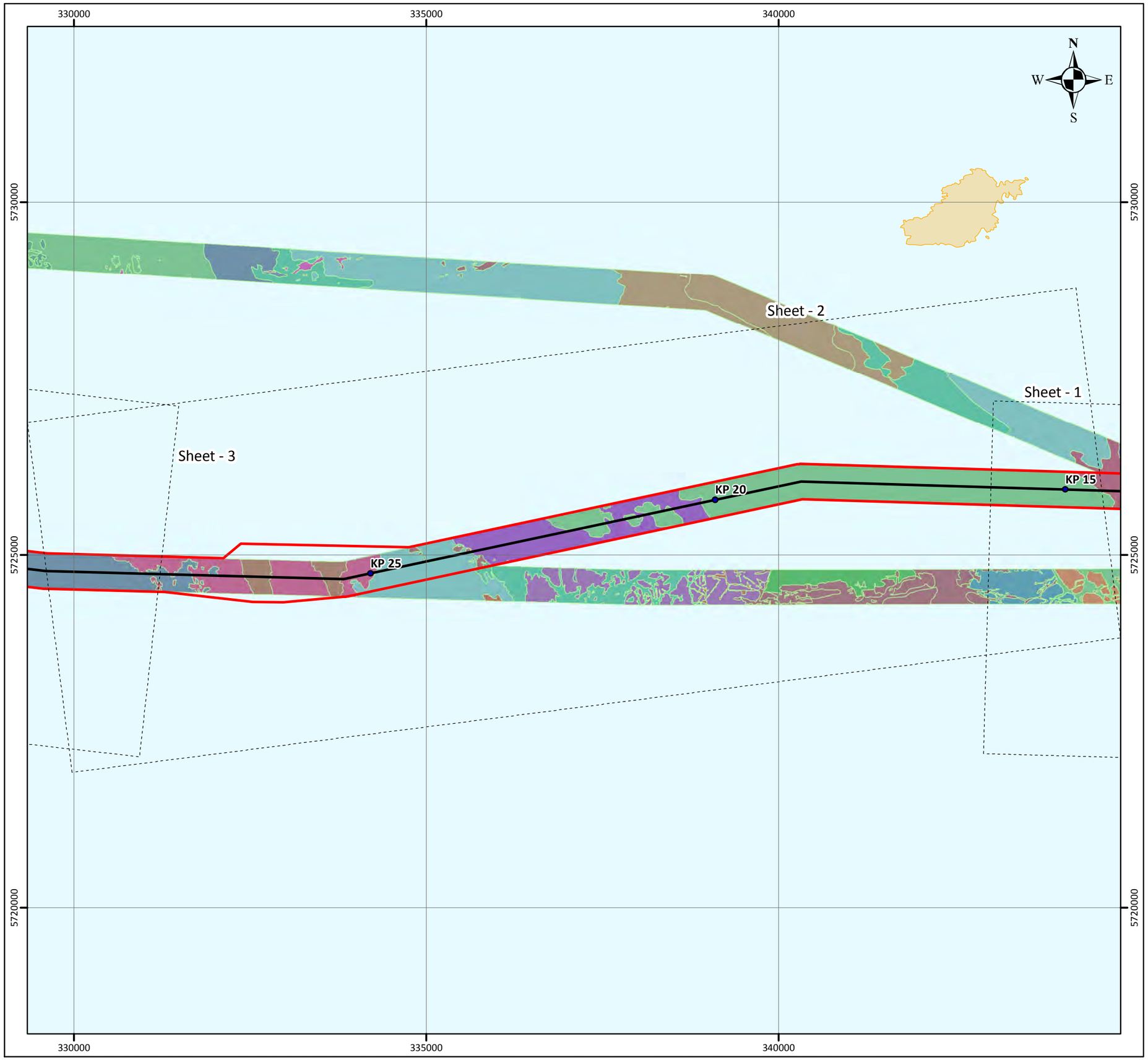
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BENTHIC HABITATS
Survey Data - Sheet 2

Drawing No: P1975-HAB-003	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development

MMT Survey

EUNIS Classification

- A4.13
- A4.1312
- A4.132
- A4.21
- A4.213
- A4.213/ A4.241
- A4.2212
- A4.241
- A5.14
- A5.141
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- A5.27
- A5.45
- A5.451
- A5.611



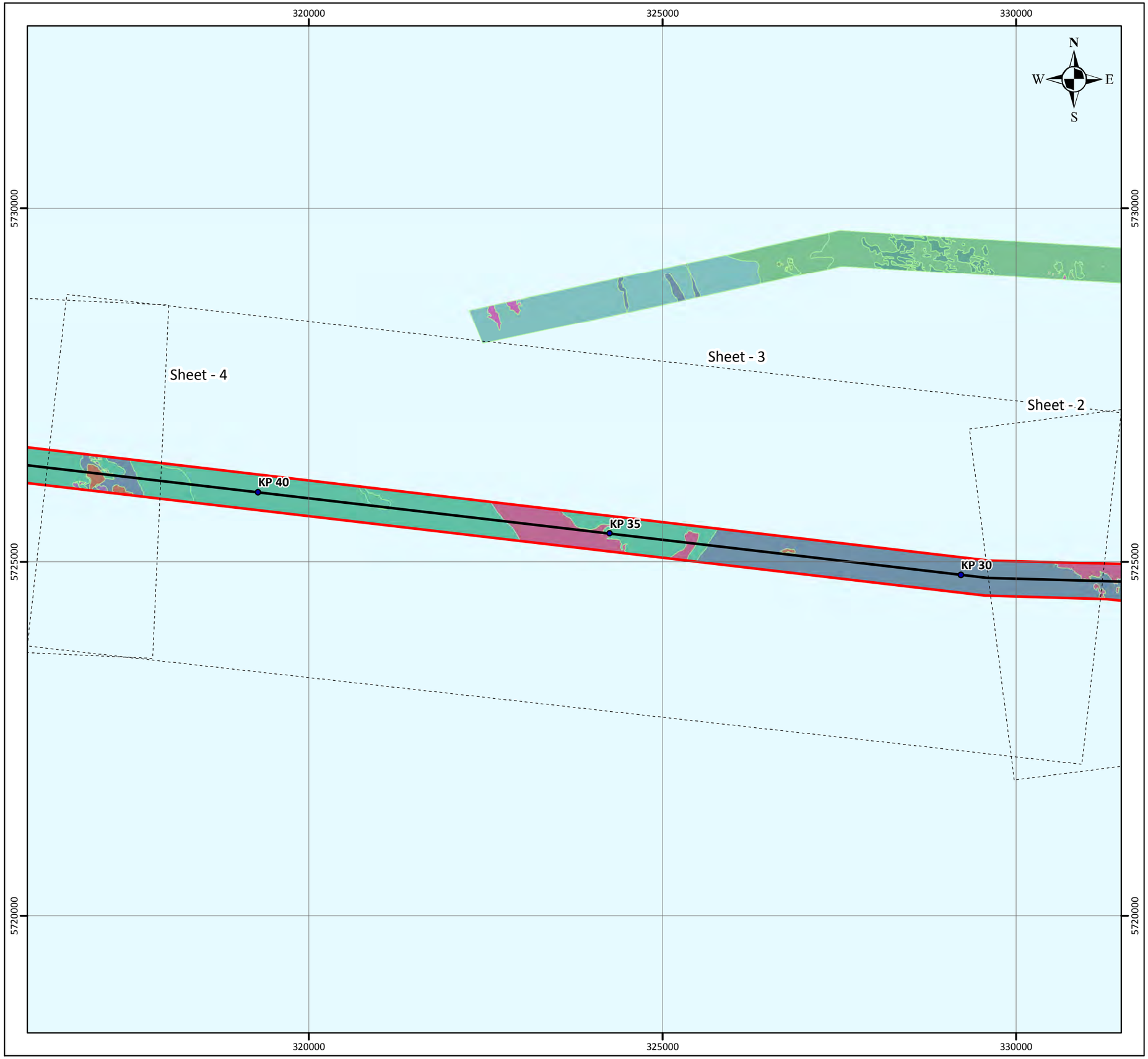
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Created By	Chris Goode
Reviewed By	Emma Langley
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BENTHIC HABITATS
Survey Data - Sheet 3

Drawing No: P1975-HAB-003	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development

MMT Survey

EUNIS Classification

- A4.13
- A4.1312
- A4.221
- A4.2212
- A5.141
- A5.142
- A5.15
- A5.27
- A5.45
- A5.611



NOTE: Not to be used for Navigation

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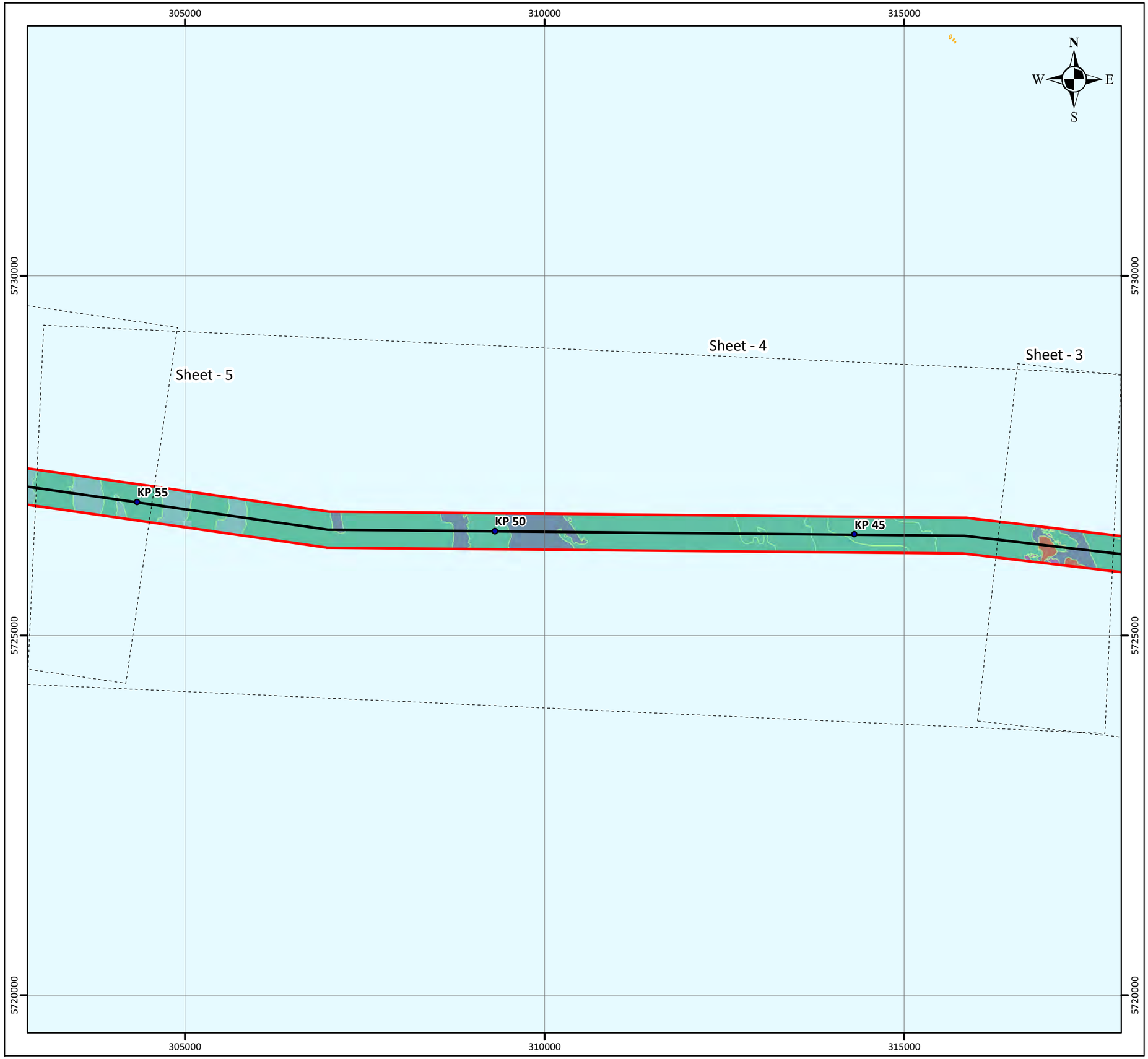
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BENTHIC HABITATS

Survey Data - Sheet 4

Drawing No: P1975-HAB-003	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development

MMT Survey

EUNIS Classification

- A4.221
- A4.2212
- A5.15
- A5.27
- A5.45
- A5.611



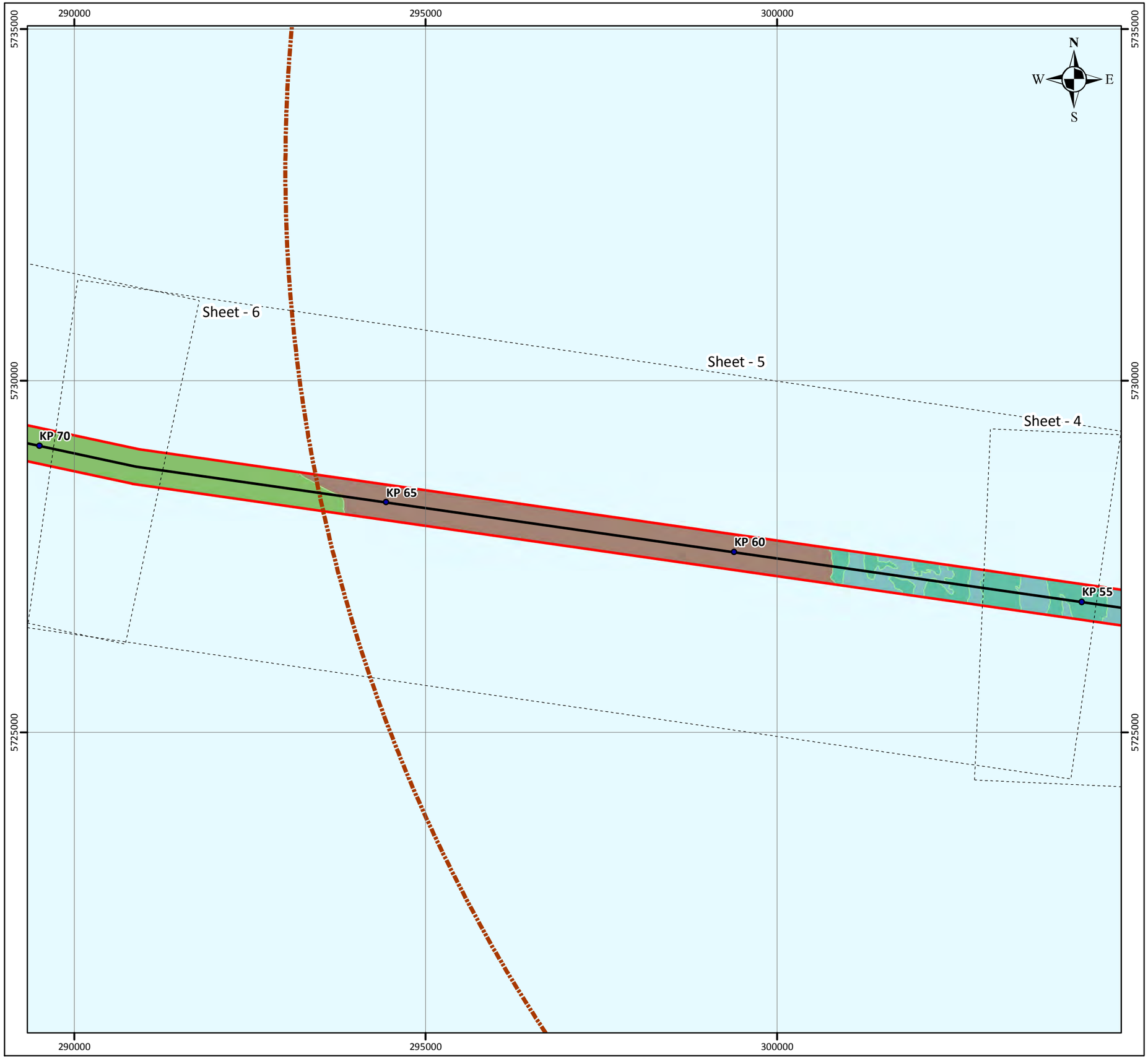
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Created By	Chris Goode
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BENTHIC HABITATS
Survey Data - Sheet 5

Drawing No: P1975-HAB-003	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development
- UK 12nm Territorial Sea Limit

MMT Survey

EUNIS Classification

- A5.15
- A5.251
- A5.272
- A5.611



NOTE: Not to be used for Navigation

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Datum	D_WGS_1984
Data Source	DCCAE; UKHO; CDA; OSOD; OSI; MMT; Greenlink
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Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

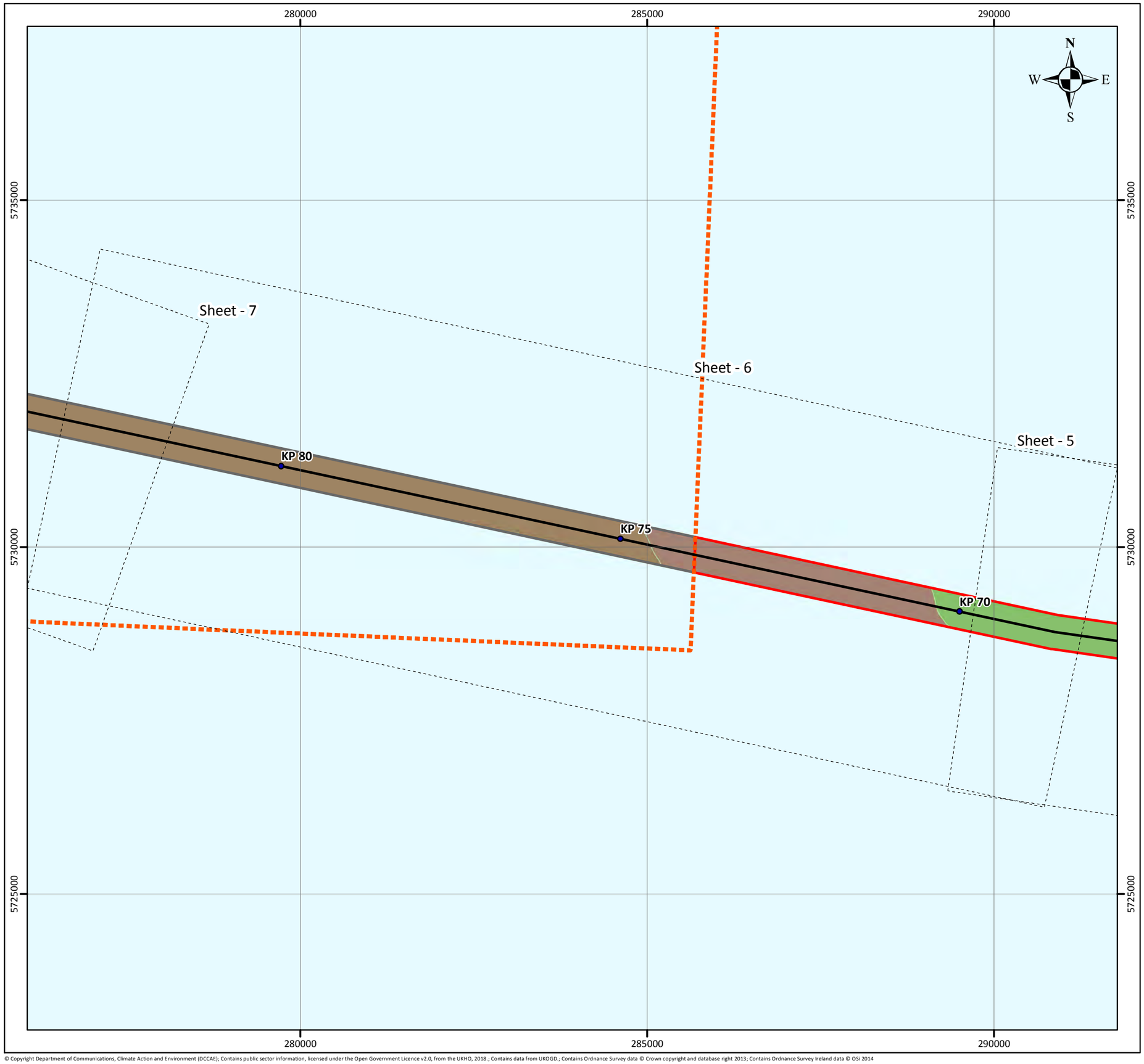
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BENTHIC HABITATS

Survey Data - Sheet 6

Drawing No: P1975-HAB-003	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development
- Irish Offshore
- Median Line

MMT Survey

EUNIS Classification

- A5.251
- A5.252
- A5.272



NOTE: Not to be used for Navigation

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Created By	Chris Goode
Reviewed By	Emma Langley
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Greenlink

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7.3.4 Protected habitats and species of conservation importance

Three EC Habitats Directive Annex I listed habitats were identified in the Proposed Development:

- 1140 - Mudflats and sandflats not covered by seawater at low tide;
- 1110 - Sandbanks which are slightly covered by seawater all the time; and
- 1170 - Reef

7.3.4.1 EC Habitats Directive Annex I – 1140 Mudflats and sandflats not covered by seawater at low tide

The sandy shore biotopes, A2.111 - Barren littoral shingle, A2.211 - Talitrids on the upper shore and strandline, A2.223 - Amphipods and *Scolelepis spp*. in littoral medium-fine sand, and A2.23 - Polychaete/amphipod-dominated fine sand shores, identified in the intertidal area at Freshwater West, are representative of the Annex I habitat 'mudflats and sandflats not covered by seawater at low tide'. This habitat qualifies as a feature of the Pembrokeshire Marine / Sir Benfro Forol SAC but is not a primary reason for the selection of the SAC.

The extent of the habitat within the Proposed Development is approximately 0.18km^2. The reportage coverage of Habitat 1140 within the SAC is 17.807km^2 (1780.7 hectares) (JNCC 2016).

7.3.4.2 EC Habitats Directive Annex I – 1110 Sandbanks which are slightly covered by seawater all the time

From approximately KP5 to KP10 the Proposed Development crosses the northern extent of the Turbot Bank (Figure 7-10, Drawing P1975-HAB-004 Sheet 1). The sandbank is a qualifying feature of the Pembrokeshire Marine / Sir Benfro Forol SAC but is not a primary reason for the selection of the SAC.

Turbot Bank is a sink for glacial till and land-derived sediments from the Cleddau Ddu and Milford Haven Estuary which is being reworked by the strong tidal currents into megaripples and sandwaves across the seabed. These features migrate and move from east to west, with rate of travel in the order of 10s of metres per year. They are aligned with the back of the sandwave to the predominant tidal flow and the steeper face towards the direction of travel. Further details are provided in Chapter 6.

The habitats identified between KP5 and KP10 were identified as A5.25 - Circalittoral fine sand. Sediments comprise of between 95% to 100% sand. The habitat was sampled by grab station S32 which showed the infauna was characterised by the molluscs *Goodallia triangularis*, *Asbjornsenia pygmaea*, and the polychaete *Nephtys cirrosa*. Grab station S31, on the western flank of the bank showed higher diversity and abundance in comparison to S32. Here the infauna was characterised by the molluscs *A. prismatica, T. ovata, Kurtiella bidentata,* the

polychaetes *O. borealis, Lumbrineris cingulate, Glycinde nordmanni* and different amphipods (MMT 2019).

The extent of habitat 1110 within the SAC is reported as 414.12km^2 (41411.55 hectares) (JNCC 2016). Of this area, the Turbot Bank covers approximately 19.10km^2. The Proposed Development covers approximately 3.05km^2 of this extent; equivalent to 15.97% of the Turbot Bank; and 0.74% of the wider habitat in the SAC.

7.3.4.3 EC Habitats Directive Annex I – 1170 Reefs

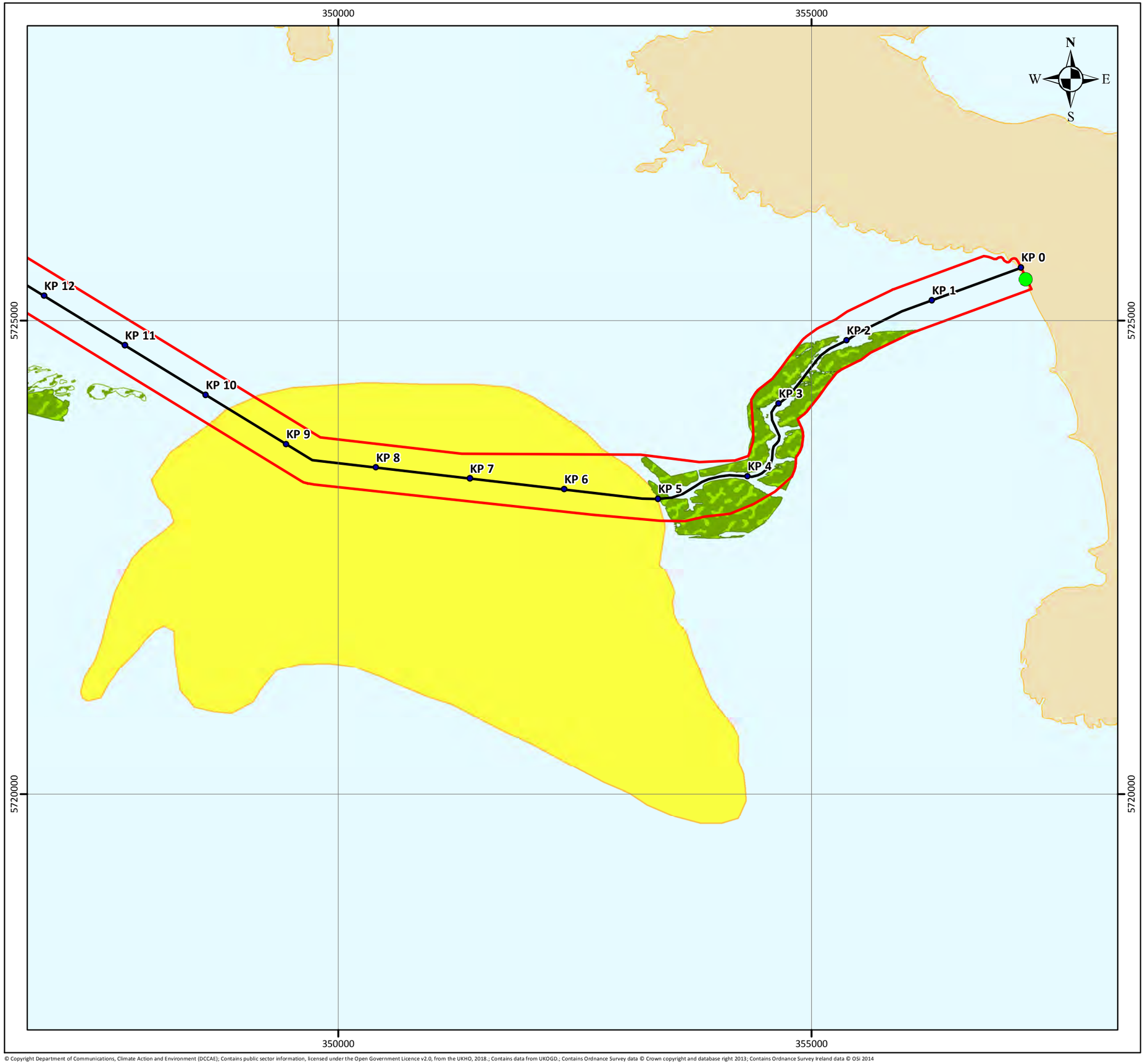
'Reef' is a primary reason for the selection of the Pembrokeshire Marine / Sir Benfro Forol SAC. All three sub-types of Annex I Reef habitat was identified by the cable route survey within the Proposed Development; bedrock reef, stony reef, and biogenic reef. The location of the habitat is displayed in Figures 7-10 to 7-13, (Drawings P1975-HAB-005, P1975-HAB-004 Sheet 2, P1975-HAB-006, and P1975HAB-004 Sheet 5).

The extent of habitat 1170 within the SAC is reported as 409.97km^2 (40997.43 hectares) (JNCC 2016). Maps showing the extent of 'Reef' habitat are available from the JNCC, which classifies the area according to confidence in the presence of the habitat. The JNCC maps indicate a slightly higher estimate of reef in the SAC although confidence in some areas is given as low. The habitat maps indicate Bedrock reef covers an area of 377km^2, whilst stony reef covers 70km^2. In addition, the reef extends outside of the SAC boundaries.

Intertidal

The littoral rock habitat (A1) encountered during the phase 1 intertidal survey at the Freshwater West landfall is representative of Annex I bedrock reef habitat. The habitat lies close to the base of the cliffs at the northern end of Freshwater West. Post-survey the boundary for the Proposed Development was refined to exclude this area.

The cliffs are also a designating feature of the adjacent Limestone Coast of South West Wales / Arfordir Calch faen de Orllewin Cymru SAC and the Broomhill Burrows Site of Special Scientific Interest (SSSI), and Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI.



GREENLINK INTERCONNECTOR

ANNEX I HABITATS

Survey Data - KP 0 to KP 12

Drawing No: P1975-HAB-005	A

Legend

- Freshwater West
- Greenlink Route Centreline (Indicative)
- Proposed Development

Annex I Habitat Classification

- Bedrock Reef
- Potential Bedrock Reef

Protected Sandbank Slightly Covered by Seawater

- Sandbank Area (High Confidence)



NOTE: Not to be used for Navigation

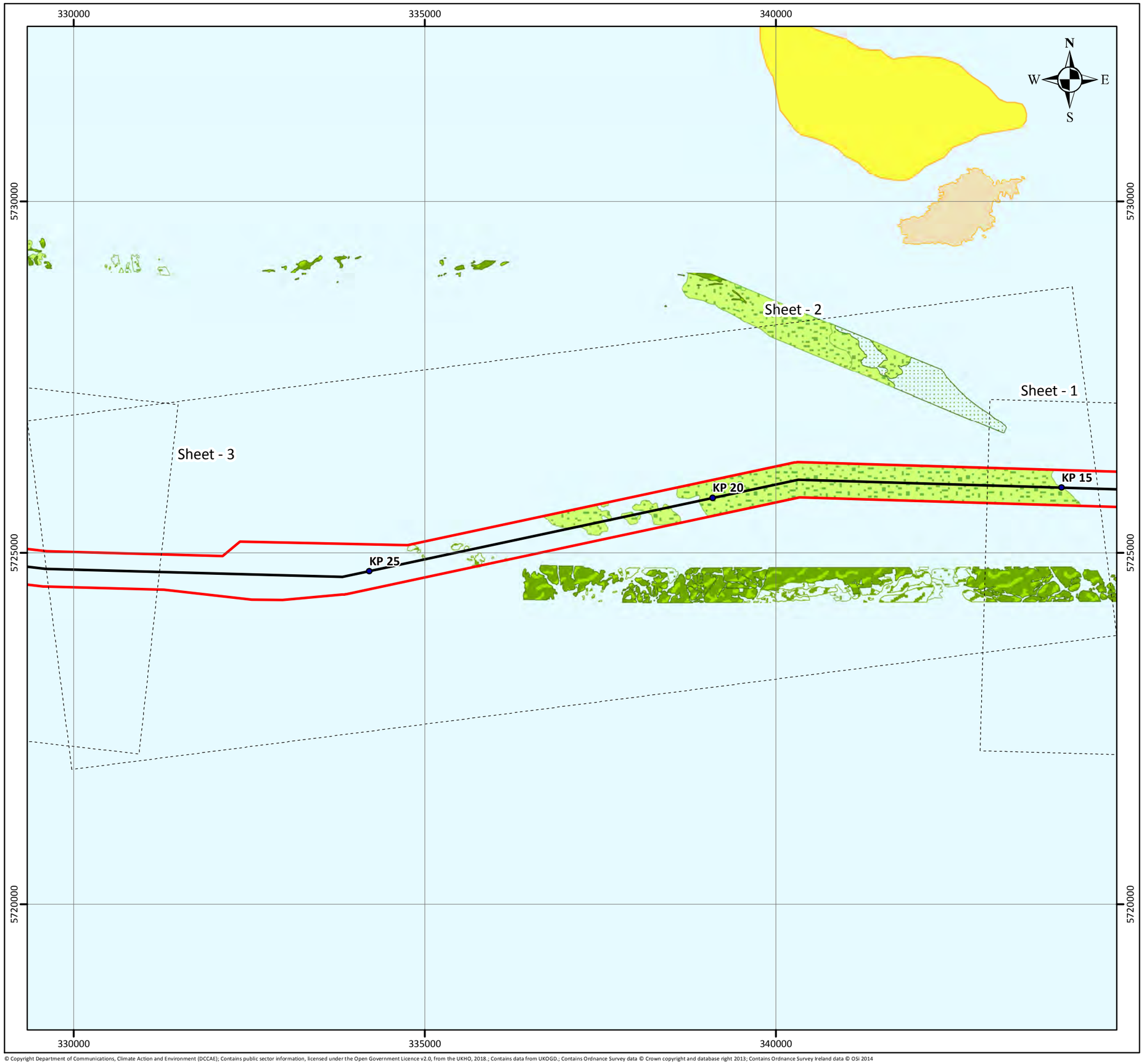
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File Reference	J:\P1975\Mxd\06_HAB\ P1975-HAB-005.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Co-financed by the European Union Connecting Europe Facility

0 0.5 1 1.5 2 km

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GREENLINK INTERCONNECTOR

ANNEX I HABITATS
Survey Data - Sheet 2

Drawing No: P1975-HAB-004	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development

Annex I Habitat Classification

- Bedrock Reef
- Low/Medium Grade Stony Reef
- Potential Bedrock Reef
- Potential Biogenic Reef
- Potential Stony Reef

Protected Sandbank Slightly Covered by Seawater

- Sandbank Area (High Confidence)



NOTE: Not to be used for Navigation

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Projection	WGS_1984_UTM_Zone_30N
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Datum	D_WGS_1984
Data Source	DCCAE; UKHO; CDA; OSOD; OSI; MMT; Greenlink
File Reference	J:\P1975\Mxd\06_HAB\ P1975-HAB-004.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

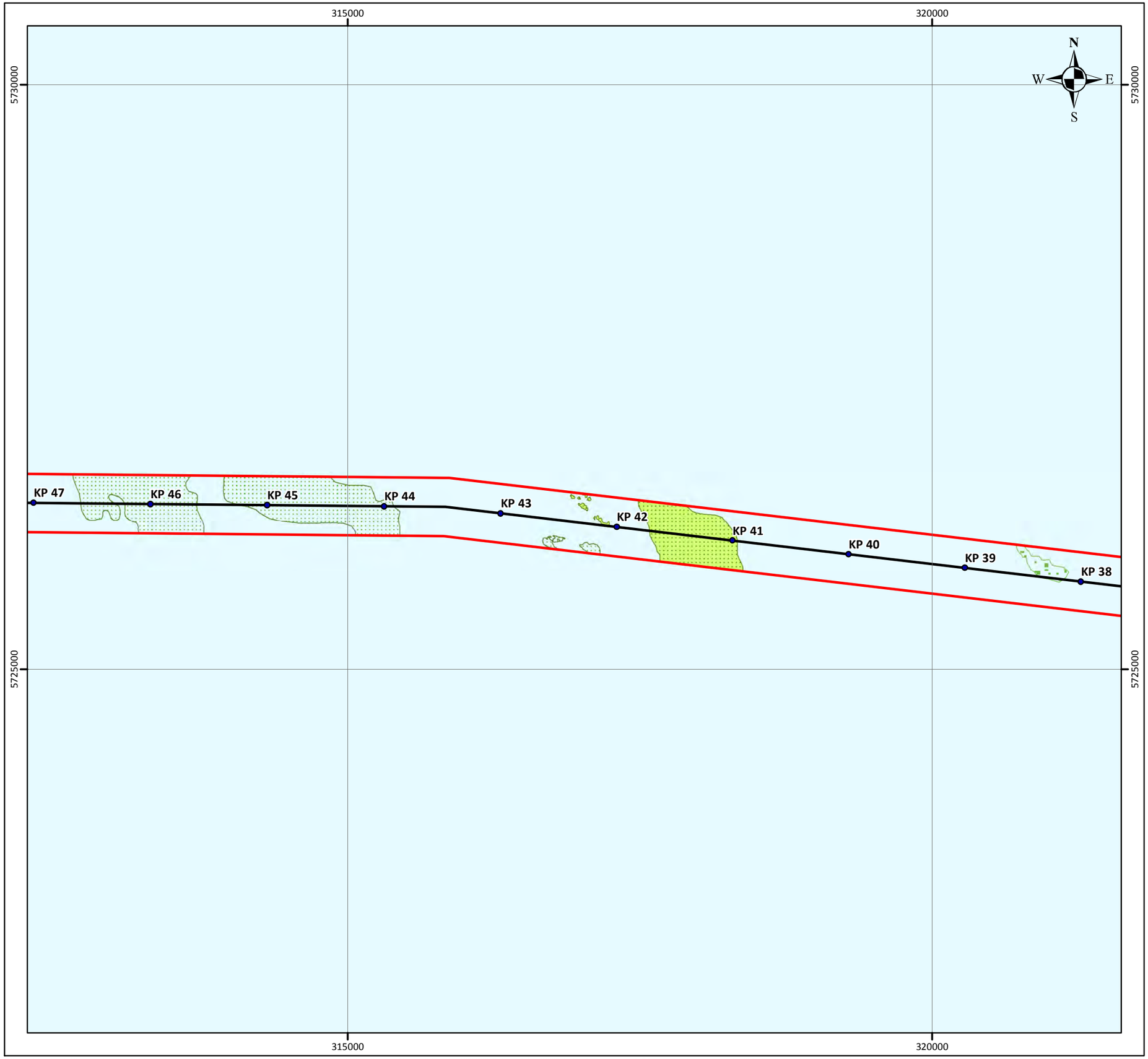
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GREENLINK INTERCONNECTOR

ANNEX I HABITATS

Survey Data - KP 38 to KP 47

Drawing No: P1975-HAB-006	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development

Annex I Habitat Classification

- Low/Medium Grade Biogenic Reef
- Potential Biogenic Reef
- Potential Stony Reef



NOTE: Not to be used for Navigation

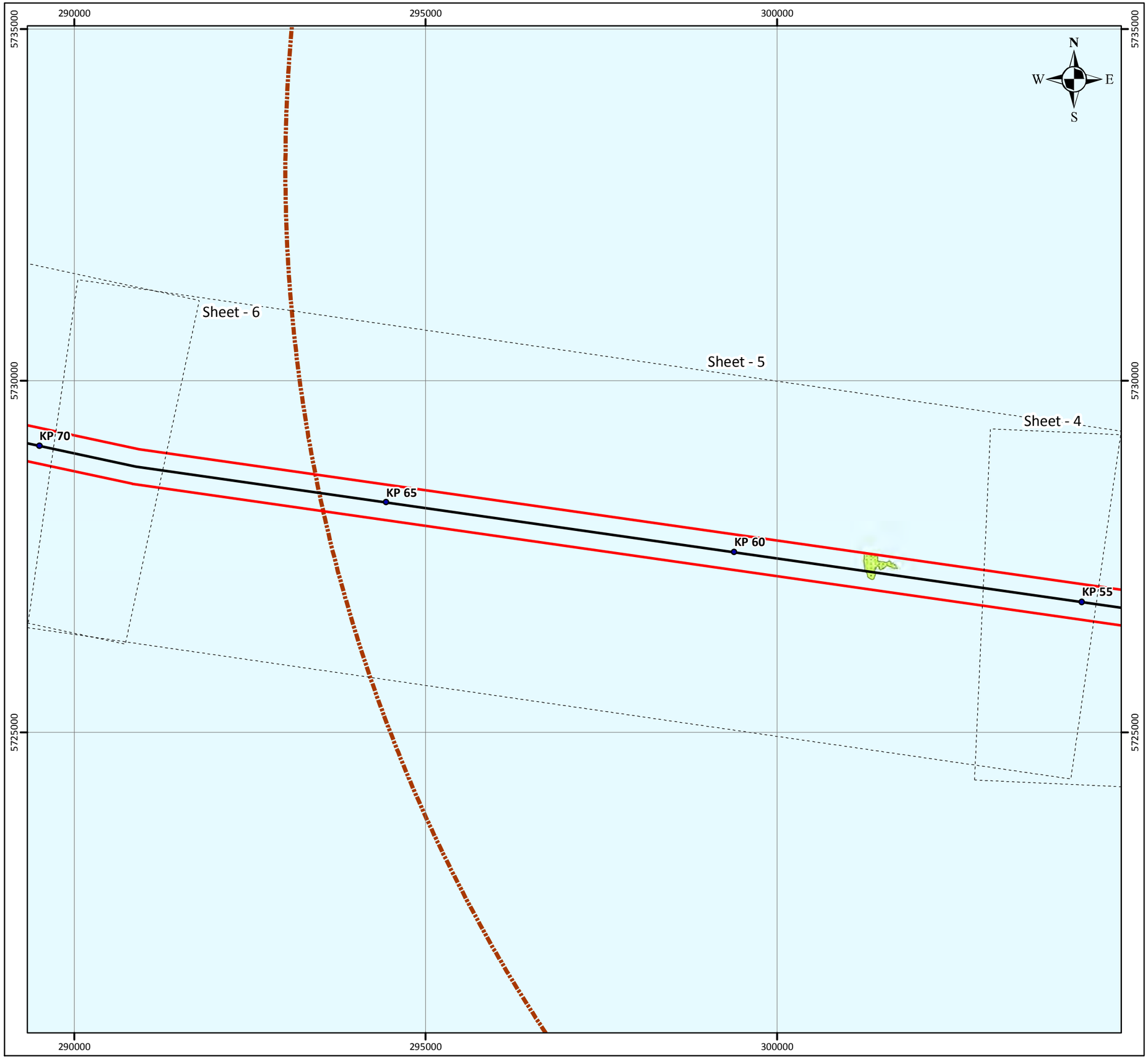
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File Reference	J:\P1975\Mxd\06_HAB\ P1975-HAB-006.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

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0 0.5 1 1.5 2 km

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GREENLINK INTERCONNECTOR

ANNEX I HABITATS
Survey Data - Sheet 5

Drawing No: P1975-HAB-004	A

Legend

- Greenlink Route Centreline (Indicative)
- Proposed Development
- UK 12nm Territorial Sea Limit

Annex I Habitat Classification

- Low/Medium Grade Biogenic Reef



NOTE: Not to be used for Navigation

Date	Monday, April 8, 2019 12:43:10
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	DCCAE; UKHO; CDA; OSOD; OSI; MMT; Greenlink
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Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

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0 0.5 1 1.5 2 km

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Subtidal

Bedrock Reef

Within the Proposed Development bedrock reef (as defined using the Irving 2009 criteria) is present from approximately KP1.5 to KP5.2. As illustrated in Figure 7-10 (Drawing P1975-HAB-005), the cable centreline has been routed through a channel of finer sediments in the bedrock reef between KP2.027 to KP4.998.

The sedimentary bedrock, surrounding the channel, is classified as A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock (Figure 7-14) and is dominated by ascidians and hydrozoans. Image analysis from transects (Transects DDV_T06 to DDV_T09) showed similar composition with high diversity and colonisation by ascidians *Dendrodoa grossularia*, *Polycarpa sp*. and *M. manhattensis*. Other taxa identified include poriferans, *Tubularia sp*., *Caryophyllia smithii* with hydrozoans and bryozoans (Figure 7-15 a-d).

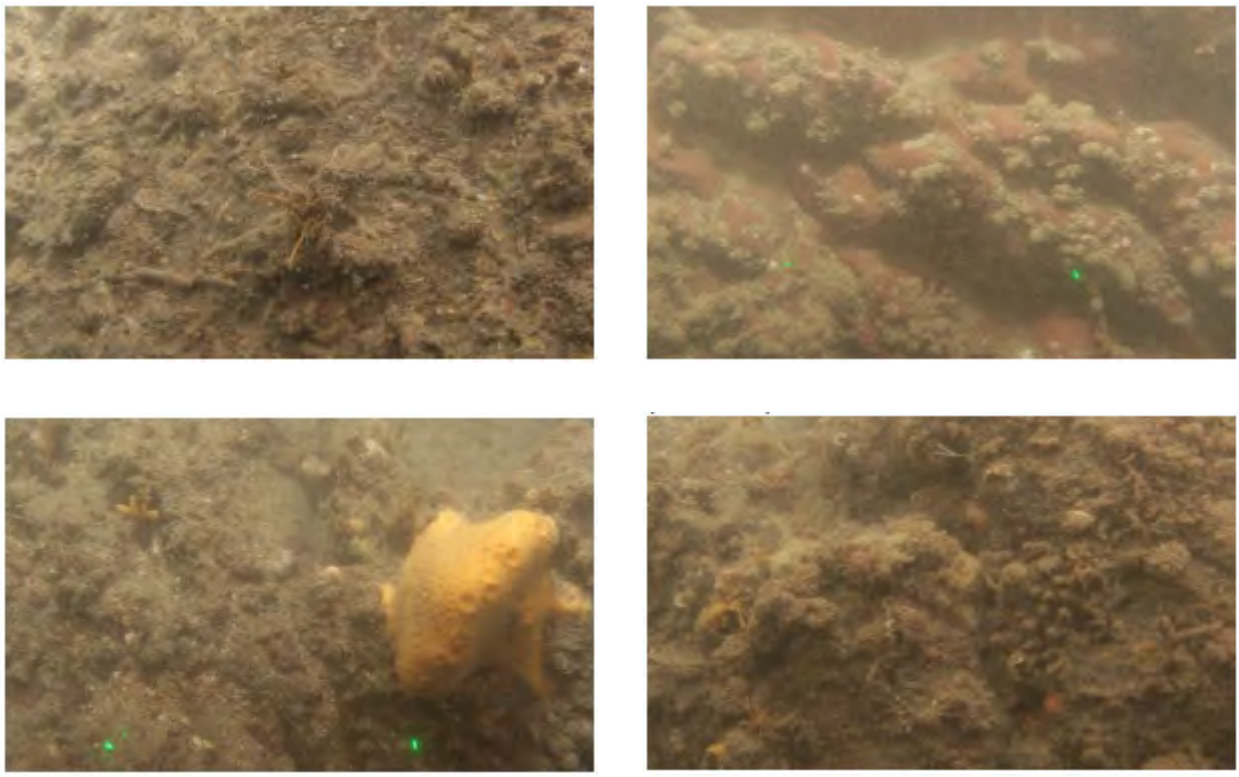
Figure 7-14 Image T06_014 of Annex (1170) - Bedrock reefs



Habitat A4.138 – *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock

Figure 7-15 Bedrock reef communities for from Transects DDV_T06 to DDV_T09

Transects DDV_T06 to DDV_T09 show high diversity and colonisation by ascidians *Dendrodoa grossularia*, *Polycarpa sp.* and sand covered ascidians interpreted to be *M. manhattensis*. Other taxa identified present were poriferans, *Tubularia sp.*, *Caryophyllia smithii* with a hydrozoans and bryozoans.



The EUNIS habitat classification describes the biotope as typically found on slightly sand-scoured, tide-swept, moderately exposed circalittoral bedrock and cobbles. It is commonly recorded around 5m to 15m below chart datum and occurs mostly in very turbid waters. The physical characteristics are usually silted bedrock reefs and cobble, interspersed with patches of clean sand, causing a scour effect on the rock. Dense aggregations of the ascidian *Molgula manhattensis* form a silty mat on the rock and there is a sparse hydroid and bryozoan turf. Hydroid turfs usually consist of *Nemertesia antennina*, *Halecium beanii*, *Hydrallmania falcata*, *Sertularella gaudichaudi*, *Tubularia indivisa* and *Alcyonium digitatum*, in varying abundances, mostly occur on top of boulders and ridges. Bryozoan turfs are also present, but not usually dense and includes *Flustra foliacea*, *Alcyonidium diaphanum*, *Electra pilosa* and the crust-forming bryozoan Conopeum reticulum. The polychaete *Lanice conchilega* thrives in the sandy patches which often occur between the rock ridges. The scour effect tends to reduce the diversity of sponges present with only *Halichondria panicea* occasionally present. Isolated clumps of the polychaete *Sabellaria spinulosa* may be present but they do not occur in dense aggregations (EEA 2019a).

The extent of the habitat within the Proposed Development has been calculated as 1.12km^2. However, it is evident from a combination of the Greenlink and SECAMs bathymetry data that exposed bedrock covers a greater extent. The Joint Nature Conservation Committee (JNCC) data for potential Annex I reefs show the area for the feature covers 7.10km^2; although confidence in the overall extent is given as very poor. This aligns with findings from the Greenlink reconnaissance survey which identified areas of bedrock reef outside of the extent given in the JNCC GIS layer, but also confirmed that reef was not present in certain areas.

Small areas of outcropping bedrock reef have been identified in the sand channel between KP2.38 and KP2.41. Although micro-routeing around these features may be feasible, approximately 30m of the indicative Greenlink centreline will cross the habitat. There are no still photographs of this specific area.

The indicative Greenlink centreline also crosses the Bedrock reef habitat at approximately KP5 for 140m. However in this area, bathymetry data and transect T06 identify a narrow (approximately 20m wide) channel through which installation is feasible. It is possible that this may be a thin veneer of sediment over the bedrock but Figure 7-16 (Drawing P1975-SURV-008) shows that the Bedrock Reef habitat is not present in this channel. Sediments are sandy and similar to those identified on Turbot Bank, directly to the west.

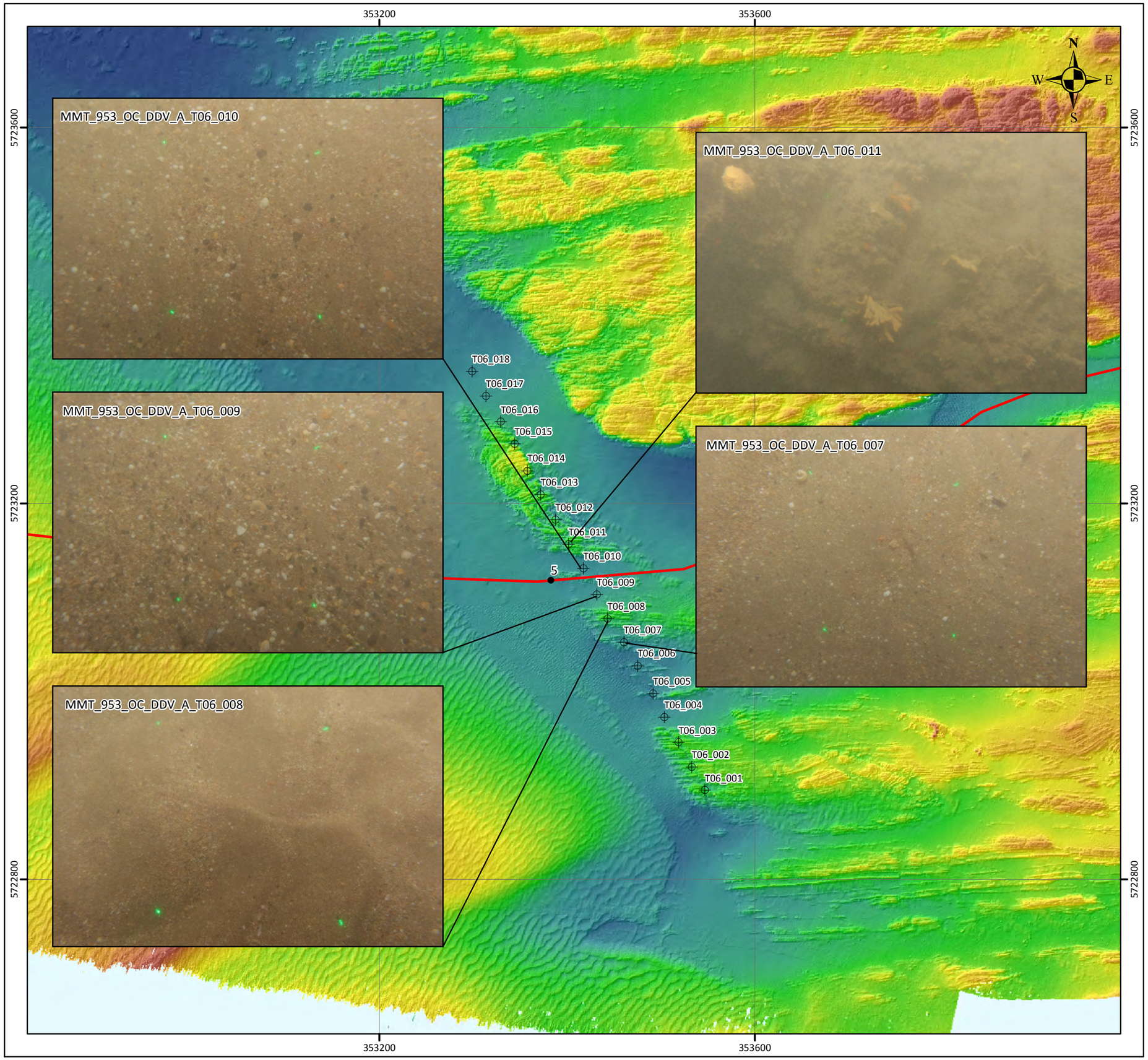
Potential Bedrock Reef

Potential bedrock reef habitats were patchy and identified within the Proposed Development ranging from KP23.5 to KP24.5 (Figure 7-11, Drawing P1975-HAB-004 Sheet 2).

Transect RR_T06 crossed the smaller areas of bedrock that was identified in the geophysical data. The bedrock was largely covered by sediment, with only small outcropping patches. The outcropping bedrock had a sparse epifauna consisting of mainly anemones and hydrozoans, with the biotope classified as A4.213 – *Urticina feline* and sand-tolerant fauna on sand-scoured or covered circalittoral rock. Due to the lack of conspicuous bedrock reef formations, the bedrock was classified as Annex I (1170) – Potential Bedrock Reef.

The EUNIS habitat classification describes the biotope as typically found on tide-swept circalittoral bedrock, and cobbles on gravel and sand. It is characterised by scour-tolerant robust species. The dominant species is the anemone *Urticina feline* which can tolerate the high levels of abrasion associated with the interface between sand and rock. The sponge *Ciocalypta penicillus* is also very characteristic of shifting sand-covered rock. The number of other species found tends to be limited due to the high levels of scour associated with the physical conditions in which the biotope is found (EEA 2019b).

Post-survey the indicative Greenlink centreline has been adjusted to avoid crossing this habitat.



GREENLINK INTERCONNECTOR

SURVEY DATA

Environmental Transect 06

Drawing No: P1975-SURV-008	A

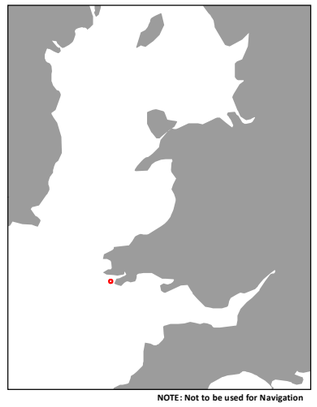
Legend

- KP
- Transect Photo Position
- Post Survey Route

Survey Bathymetry Below LAT (m)

High : 36.13

Low : 26.25



NOTE: Not to be used for Navigation

Date	Tuesday, April 2, 2019 15:10:59
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	ESRI; OSOD; MMT; Greenlink
File Reference	J:\P1975\Mxd\02_SURV\ P1975-SURV-008.mxd
Created By	Chris Carroll
Reviewed By	Chris Goode
Approved By	Anna Farley

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0 50 100 150 m

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Stony Reef

Medium Grade Stony Reef was identified across the extent of the Proposed Development from KP15.0 to KP20.2, and then in wide patches from KP20.6 to KP22.1 (Figure 7-11, Drawing P1975-HAB-004 Sheet 2). It mainly consisted of cobbles and boulders which harboured a rich epifaunal community. The habitat was classified as A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (Figure 7-18).

The EUNIS habitat classification describes the biotope as characterised by a few abundant robust and or fast growing short-lived species which are able to colonise pebbles and unstable cobbles which are regularly moved by wave and tidal action. The main cover organisms tend to be restricted to calcareous tube worms such as *Pomatoceros triqueter* (or *P. lamarcki*), small barnacles including *Balanus crenatus* and *Balanus balanus*, and a few bryozoan and coralline algal crusts. Scour action from the mobile substratum prevents colonisation by more delicate species. Occasionally in tide-swept conditions tufts of hydroids such *as Sertularia argentea* and *Hydrallmania falcata* are present (EEA 2019c).

Imaged by transects RR_T01, RR_T02, RR_T03, RR_T04 and RR_T05, the seabed was covered by cobbles greater than 0.064m in diameter for 50% to 80% of the area. The maximum elevation was 0.2m, and combined with an extent greater than 25m^2 in each transect this led the reef assessment (using Irving 2009 criteria) to conclude that the seabed in the area meets the criteria for a Medium Grade Stony Reef.

Figure 7-17 Image T03_001 of Annex I (1170) – Medium Grade Stony Reef with the habitat A5.141 – *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.



The extent of the habitat within the Proposed Development has been estimated as 3.04km^2. It overlaps two areas identified on the JNCC data for potential Annex I reefs with poor confidence.

A further area of potential stony reef habitat has been identified within the Proposed Development between KP38.15 to KP38.36. The habitat has been classified as A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment. This was interpreted as potential stony reef due to the density of cobbles and boulders interpreted from the geophysical data. The extent of this area is 0.05km^2. It lies within the potential stony reef habitat identified in the JNCC data for potential Annex I reefs.

There is the sufficient area to the south of this habitat for the cable route to avoid the habitat.

Biogenic reef

A number of areas of potential, low-grade and medium grade biogenic reef were identified within the Proposed Development as shown in Figure 7-12 (Drawing P1975-HAB-006), Figure 7-13 (Drawing P1975-HAB-004 Sheet 5) and outlined in Table 7-4. The JNCC Annex I reef habitat map has not identified reef in this area; nor did it identify biogenic reef as potentially occurring within the SAC.

Table 7-4 Areas of biogenic reef

KP Start	KP end	Classification	EUNIS habitat	Extent (km^2)	Can the habitat be avoided
KP43.9	KP45.23	Potential	A5.611	0.515	No – extends across width of Proposed Development
KP45.6	KP46.6	Potential	A5.611	0.426	No – extends across width of Proposed Development
KP42.0	KP42.6	Potential	A5.611	4 small discrete patches = 0.0106	Yes – small area in south of Proposed Development
KP40.9	KP41.7	Low-grade	A5.611	0.352	No – extends across width of Proposed Development
KP57.98	KP58.11	Low-grade	A5.15	0.075	Yes – centreline could be routed to the south
KP42.0	KP42.6	Medium-grade	A5.611	7 small discrete patches = 0.0084	Yes - centreline could be routed to the south

The majority of biogenic reef habitats were identified to be A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment, with the exception of one area of low-grade biogenic reef in habitat A5.15 – Deep circalittoral coarse sediment.

The EUNIS habitat classification for A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment describes the biotope as having high abundances of the

tube-building polychaete *S.spinulosa*. *S.spinulosa* typically forms loose agglomerations of tubes forming a low-lying matrix of sand, gravel, mud and tubes on the seabed. The infauna comprises typical sublittoral polychaete species such as *Protodorvillea kefersteini*, *Pholoe synophthalmica*, *Harmothoe*spp, *Scoloplos armiger*, *Mediomastus fragilis*, *Lanice conchilega* and cirratulids, together with the bivalve *Abra alba*, and tube building amphipods such as *Ampelisca spp.* The epifauna comprise a variety of bryozoans including *Flustra foliacea*, *Alcyonidium diaphanum* and *Cellepora pumicosa*, in addition to calcareous tubeworms, pycnogonids, hermit crabs and amphipods. The reefs formed by *S.spinulosa* consolidate the sediment and allow the settlement of other species not found in adjacent habitats leading to a diverse community of epifaunal and infauna species (EEA 2019d).

S.spinulosa was identified in grab samples S20 through to S27, S29 and S30. The average number of individuals per m^2 ranged from 5 at S22 and S29 to a maximum of 1720 at S20. Average percentage coverage in site photos also ranged from no visible presence at S22, S24, S27 and S30 through to 24% at S20.

Figure 7-18 shows the seabed at grab station S25, located within the low grade biogenic reef identified between KP40.9 and KP41.7. Grab station S25 showed an average abundance of 1495 individuals per m^2. Species coverage ranged between 7% and 17%, with an average coverage of 12%, based on image analysis from the site. The elevation of the tube aggregations was assessed to vary between flat seabed and 5 cm.

Figure 7-18 Annex I (1170) – Low Grade Biogenic reef with the habitat A5.611 – Sabellaria spinulosa on stable circalittoral mixed sediment (Image S25_003).

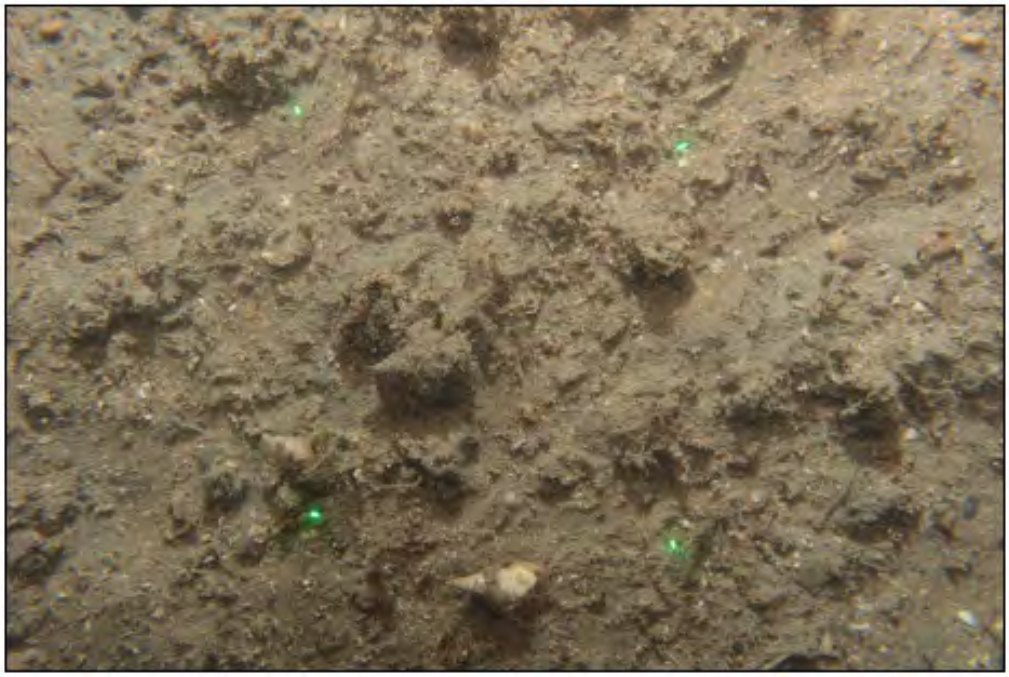
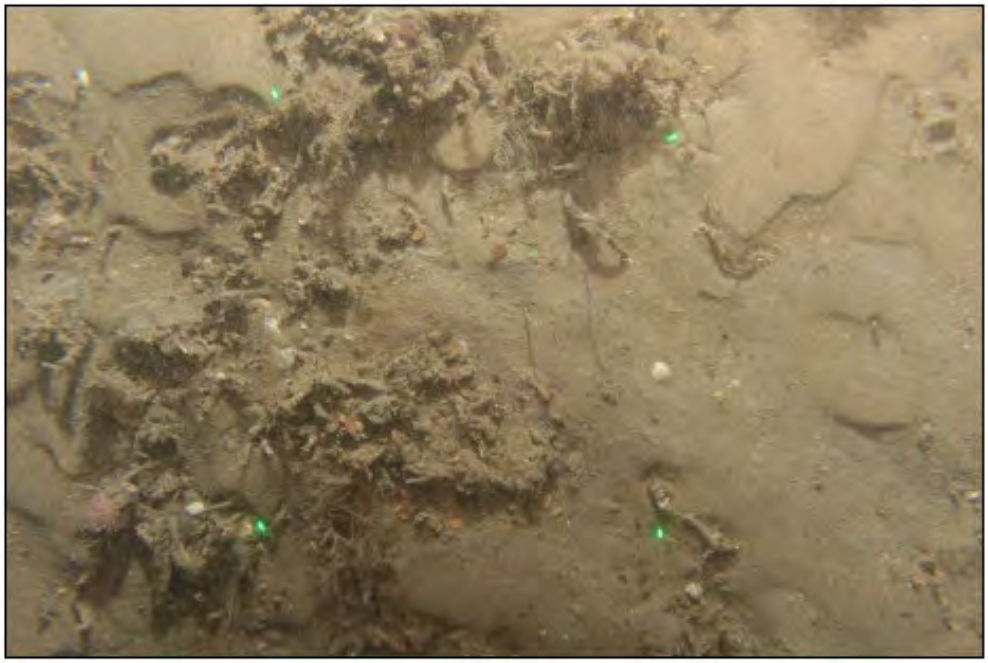


Figure 7-19 shows the seabed at grab station S20, located within the low grade biogenic reef identified between KP57.98 and KP58.11. Grab station S20 showed an average abundance of 1720 specimens per m^2. Imaging analysis of the *S.spinulosa* aggregations revealed a species coverage between 12% and 35%, with an average coverage of 25%. The elevation of the tube aggregations was assessed to vary between flat seabed and 5 cm. Although the patchiness matched a medium grade *S.spinulosa* reef, the generally low elevation of the aggregations resulted in the area being classified as low grade biogenic reef.

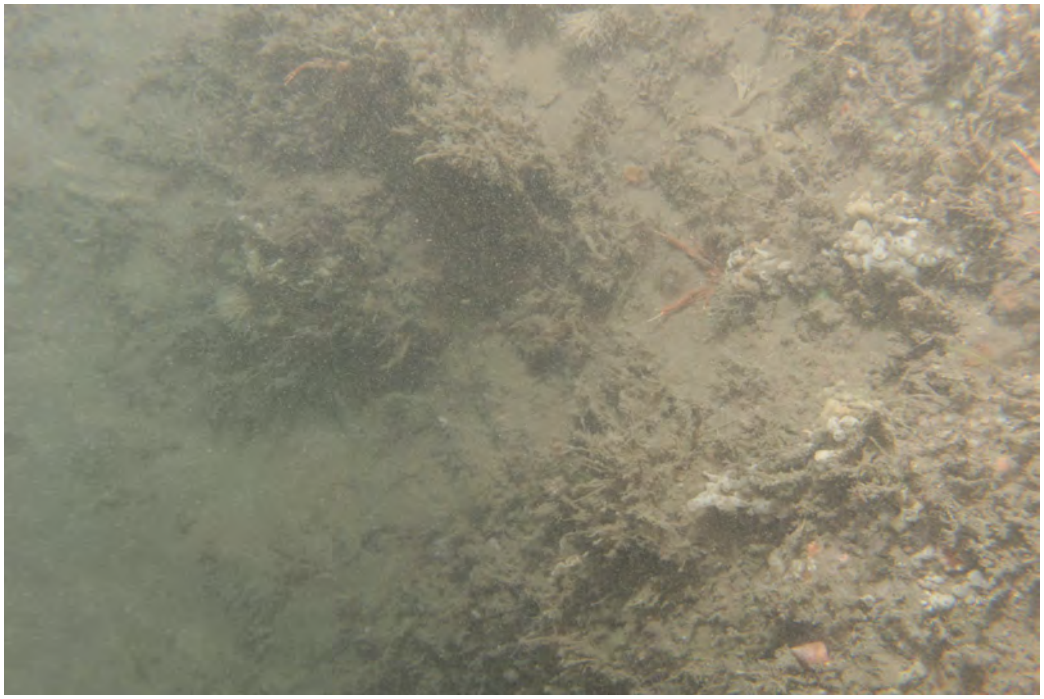
Figure 7-19 Annex I (1170) – Low Grade Biogenic reef with the habitat A5.611 – Sabellaria spinulosa on stable circalittoral mixed sediment (Image S20_005).



Several patchy areas of medium grade biogenic reef were located within the Proposed Development to the north of the indicative Greenlink centreline between KP42.0 and KP 42.60. The cable can be routed to avoid these areas.

S.spinulosa was identified on the bedrock during video transect T05 at KP42.055. The transect was planned to ground-truth bedrock identified in the geophysical data. It was difficult to assess to what extent the outcropping bedrock under the S.spinulosa aggregations added to the extent as no bedrock was visible through the dense aggregations of *S.spinulosa*. As the bedrock was not the prevailing reef forming substrate in the area, the S.spinulosa was considered to represent a reef. Due to the elevation (tube building height) being up to 10cm, the 10,000m^2 extent and the % cover ranging between 20%-30% the area was classified as a Medium grade reef (using Gubbay 2007). Figure 7-20 provides a representative photograph of the habitat.

Figure 7-20 Annex I (1170) – Medium Graded Biogenic Reef on the habitat A4.2212 – Sabellaria spinulosa didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock (image T05_013)



7.3.4.4 Environment (Wales) Act 2016 – Section 7 Priority species and habitats

The following habitats found within the Proposed Development are listed on the interim Priority Habitats lists issued by the Welsh Government (Welsh Government 2016a):

- Fragile sponge & anthozoan communities on subtidal rocky habitats
- Subtidal sands and gravels
- Subtidal mixed muddy sediments
- Mud habitats in deep water

None of the macrofauna species listed in the Environment (Wales) Act interim Priority Species list (Welsh Government 2016b) were identified by the cable route survey within the Project Development.

7.3.1 Natural evolution of the baseline

The natural evolution of the baseline has been compiled using information from the Offshore Energy Strategic Environmental Assessment 3 (OESEA 3) (DECC 2016). Over the last 11,000 years seabed habitats around the UK have been subject to change associated with post-glacial trends in sea level, climate and sedimentation. In the shorter term, seasonal, inter-annual and decadal natural changes in benthic habitats, community structure and individual species population dynamics may

result from physical environmental influences (e.g. episodic storm events; hydroclimatic variability i.e. hot summers and cold winters; and sustained trends) and/or ecological influences such as reproductive cycles, larval settlement, predation, parasitism and disease.

As a result of climate change certain habitats around the UK are predicted to decline e.g. it is predicted that blue mussel beds will decline significantly in number by 2050 and are set to be lost completely by 2100. In addition, it expected that climate change will:

- Increase the number of invasive non-native species;
- Shift the distribution of habitats and species;
- Increase the risk of disease to species from new pathogens as their distributions shift; and
- Result in an increase in storms which could damage areas of high biodiversity.

Taken this information into consideration, it is expected that over the lifetime of the Proposed Development (40 years) habitats could be effected by shorter term seasonal events (i.e. storm events) but longer term effects as a result of climate change may also be observed.

7.4 Potential Pressure Identification and Zone of Influence

A scoping exercise undertaken to inform the content of the EIA has excluded the following pressures from further consideration in this topic Chapter. Explanation for the exclusion is provided in Chapter 5, Table 5-2:

- Hydrocarbon and PAH contamination; and
- Temperature changes – local.

The pressures listed in Table 7-5 will be assessed further. For each pressure the assessment considered the different aspects of the project during installation, operation (including repair & maintenance) and decommissioning. In order to evaluate the most significant effects, the largest zone of influence from these aspects was selected. The zones of influence are presented in Table 7-5.

Table 7-5 Pressure identification and zone of influence – benthic and intertidal ecology

Project Phase	Project Activity	Aspect	Potential Impact	Receptor	Zone of Influence
Installation	Cable burial	Pre-sweeping	Penetration and/or disturbance of the substrate below the surface of the seabed,	Sand habitats	20m x approximately 5.6km

Project Phase	Project Activity	Aspect	Potential Impact	Receptor	Zone of Influence
			including abrasion		
Installation	Cable burial	Seabed preparation. Cable trenching (ploughing and jet trenching) External cable protection	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Subtidal habitats	15m
Operation	Cable repair and maintenance				
Decommissioning	Cable removal				
Installation	Cable burial	Pre-sweeping Seabed preparation. Cable trenching (ploughing and jet trenching) External cable protection	Siltation rate changes, including smothering (depth of vertical sediment overburden)	Subtidal habitats	100m*
Operation	Repair and maintenance operations				
Decommissioning	Cable removal				
Installation	Cable burial	External cable protection	Physical change (to another seabed type)	Subtidal habitats	10m x approximately 16.46km
Operation	Repair and maintenance operations				10m x 1km
Installation	Cable burial	Presence of project vessels Cable burial External cable protection	Introduction or spread of non-indigenous species	Subtidal habitats	15m
Operation	Repair and maintenance operations				
Decommissioning	Cable removal				

Project Phase	Project Activity	Aspect	Potential Impact	Receptor	Zone of Influence
		Cable removal			
Operation	Operation of cables	Emission of EMF	Electromagnetic Field effects	Subtidal species	2m (distance at which EMF attenuates to background levels)
* Chapter 6 concluded that whilst individual silt particles will remain in suspension for extended periods (up to 14 hours), sand particles suspended by installation activities will settle out of the water column quickly. Changes in sediment properties will not be detectable beyond 100m of the trench.					

7.5 Embedded Mitigation

The project description, Chapter 4, provides the current 'base case'. This includes mitigation measures which form part of the design and are therefore an inherent part of the Proposed Development and comprise embedded or primary mitigation. The embedded mitigation relevant to benthic and intertidal ecology is provided in Table 7-6 below. When undertaking the EIA it is assumed that these measures will be complied with; either as a matter of best practice or to ensure compliance with statute.

Table 7-6 Embedded mitigation

ID	Embedded mitigation measure
EM6	Ballast water discharges from Project vessels will be managed under the International Convention for the Control and Management of Ships' Ballast Water and Sediments standard.
EM8	The latest guidance from the GB non-native species secretariat (2015) will be followed and a Biosecurity Plan produced pre-installation.
EM13	HDD will be used for the cable landfalls to avoid disturbance of sensitive habitats (e.g. dune system) and disruption on beaches.
EM14	Route engineering was undertaken during the marine survey to avoid sensitive habitats where possible or to reduce the distance the submarine cable corridor crosses a sensitive feature.
EM15	Submarine cables will be bundled together, which reduces the seabed footprint of installation activities and the electromagnetic field generated during operation, thus minimising any potential compass deviation effects
EM18	Deployment of anchors/anchor chains on the seabed will be kept to a minimum in order to reduce disturbance to seabed.

ID	Embedded mitigation measure
EM26	Post-installation inspection surveys will be conducted along the length of the cables on a regular basis.
EM29	Rock and mattresses will only be deployed where adequate burial cannot be achieved. The footprint of the deposits will be the minimum required to ensure cable safety and rock berm stability.

7.6 Significance Assessment

7.6.1 Summary of Assessment

Table 7-7 presents the summary of the impact assessment conducted on the Proposed Development. Sections 7.6.2 to 7.6.6 provide the justification for the conclusions. Where the assessment concluded the effects are significant, Project Specific Mitigation has been proposed and is described in Section 7.7. Where there is still potential for residual effects this is discussed further in Section 7.8.

Table 7-7 Impact assessment summary – benthic and intertidal ecology

Determination of potential effect						Impact Assessment			Consideration of mitigation	Residual effect assessment		
Section	Project Phase	Aspect	Embedded mitigation (Table 7-6)	Pressure	Receptor	Magnitude	Sensitivity	Significance	Project Specific Mitigation (Table 7-11)	Magnitude	Sensitivity	Significance of Residual Effect
7.6.2	Installation	Cable burial	EM13, EM14, EM15, EM18, EM29	Penetration and/or disturbance including abrasion	Intertidal habitats	-	-	No effect	PS1	-	-	-
		Pre-sweeping Cable burial Cable removal			Sandy habitats (A5.142, A5.251. A5.272)	Low	Low	Negligible	-	-	-	-
	Installation Operation (Repair & Maintenance) Decommissioning	Pre-lay grapnel run Seabed preparation Cable burial Cable removal			Annex I Bedrock reef habitat	Low	Medium	Minor	PS2	Low	Medium	Minor
					Annex I Stony reef habitat	Low	Medium	Minor	PS6	Low	Medium	Minor
					Annex I Biogenic reef habitat	Low	Medium	Minor	-	Low	Medium	Minor
					Other subtidal habitats	Low	Medium	Minor	-	Low	Medium	Minor
7.6.3	Installation Operation (including repair & maintenance) Decommissioning	Pre-sweeping, Cable burial Cable removal	EM14, EM15	Changes in siltation rate, including smothering	Subtidal habitats	Negligible	Medium	Negligible	-	-	-	-
7.6.4	Installation Operation (including repair & maintenance)	Cable protection	EM14, EM15 EM29,	Physical change (to another seabed type	Bedrock & Stony Reef habitat	Low	Medium	Minor	PS2, PS6, PS7	Low	Medium	Minor
					Other subtidal habitats	Low	Medium	Minor	-	Low	Medium	Minor
7.6.5	Installation	Presence of project vessels Cable burial	EM6, EM8	Introduction or spread of non-indigenous	Subtidal habitats (A5.251, A5.252, A5.261 and A5.451)	Negligible	High	Negligible	PS7, PS8	-	-	-

Determination of potential effect						Impact Assessment			Consideration of mitigation	Residual effect assessment		
Section	Project Phase	Aspect	Embedded mitigation (Table 7-6)	Pressure	Receptor	Magnitude	Sensitivity	Significance	Project Specific Mitigation (Table 7-11)	Magnitude	Sensitivity	Significance of Residual Effect
	Operation (including repair & maintenance) Decommissioning	External cable protection Cable removal		species	Other subtidal habitats	Negligible	Low	Negligible	PS7, PS8	-	-	-
7.6.6	Operation	Operating cables	EM15	Electromagnetic changes	Benthic species	Low	Low	Negligible	-	-	-	-

7.6.2 Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion (change to seabed feature)

7.6.2.1 Installation

Intertidal habitats and species

The 'base case' being assessed is that horizontal directional drilling (HDD) will be used at Freshwater West; embedded mitigation EM13. Chapter 6 identified there is the potential for a significant effect if trenching across the intertidal area is required, and therefore Project Specific Mitigation (PS1) has been proposed. This commits GIL, to ensuring that the HDD exits below the low water mark. Compliance with PS1 will mean that there will be **No Effect** on intertidal habitats or species.

Subtidal habitats

This pressure is associated with activities that disturb the seabed but where there is limited or no loss of substrate from the system. Activities considered by the assessment that cause this pressure include cable route preparation e.g. boulder clearance, pre lay grapnel run, pre-sweeping; and cable burial e.g. jetting and plough trenching.

As the Proposed Development from KP0 to KP49.7 is within the Pembrokeshire Marine / Sir Benfro Forol SAC, the pressure has also been assessed within the Greenlink Marine HRA – Technical Appendix C. As the Proposed Development crosses areas of Annex I habitat, it concluded that there is the potential for likely significant effects and that an Appropriate Assessment is required.

The seabed within the direct zone of influence of the installation will be temporarily disturbed. The actual cable installation is a one-off event, but the seabed along the cable centreline could be disturbed on two to three discrete occasions within approximately a three month period. The first occasion will be for any seabed preparation works e.g. boulder clearance, pre-sweeping; the second occasion will be the pre-lay grapnel run; and the third occasion will be the cable lay and burial. These activities will be within the same zone of influence. When assessing the significance of the effect the assessment has considered the culmination of these activities.

It is likely that a high proportion of the benthic invertebrates within the width of the plough/trench footprint, will be susceptible to mortality, injury or displacement as a result of coming into contact with the route clearance grapnel, boulder clearance plough, dredging and/or cable installation machinery. This is more likely to affect sessile species such as *Sabellaria spinulosa*, bryozoans and hydroids and less mobile species such as echinoderms and polychaetes. Activities causing displacement and injury to infaunal species could also result in increased predation resulting from exposure of individuals.

The magnitude of the effect has been assessed as low for the following reasons:

- Disturbance will be brief and is equivalent to a one-off event which will not be repeated.
- The zone of influence is narrow in comparison to the wider extent of habitats in the Proposed Development and surrounds.
- Sediment will not be removed or altered leaving the underlying character of the habitat similar to that pre-development.

To determine the sensitivity of habitats within the Proposed Development an assessment has been carried out using information provided on the Marine Life Information Network (MarLIN). A wide range of habitats were identified in the Proposed Development of which Circalittoral fine sand (A5.25), polychaete-rich deep Venus community in offshore mixed sediments (A5.451), P*omatoceros triquieter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (A5.141), Deep circalittoral sand (A5.27), *Sabellaria spinulosa* on stable circalittoral mixed sediment (A5.611) and *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand (A5.251) represent the dominant habitats. Table 7-8 presents an assessment of the sensitivity of habitats to the pressures penetration and/or disturbance of the substratum below the surface and abrasion / disturbance of the substratum on the surface of the seabed.

Table 7-8 Sensitivity of habitats within the Proposed Development to the pressures penetration and abrasion

EUNIS habitat	Penetration and/or disturbance of the substratum below the surface				Abrasion/disturbance of the substratum on the surface of the seabed			
	Resistance	Resilience	Sensitivity	Confidence*	Resistance	Resilience	Sensitivity	Confidence*
A4.111 - *Balanus crenatus* and *Tubularia indivis*a on extremely tide-swept circalittoral rock	Not relevant				Medium	High	Low	High
A4.13 - Mixed faunal turf communities on circalittoral rock	Not relevant				Low	Medium	Medium	Medium-Low
A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock	Not relevant				Medium	High	Low	High
A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	Not relevant				Low	Medium	Low	Medium
A4.2212 - *Sabellaria spinulosa*, didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock	None	Medium	Medium	Medium	Low	Medium	Medium	Low
A5.13 - Infralittoral coarse sediment	*Medium*	*High*	*Low*	*High*	*Medium*	*High*	*Low*	*Medium*
A5.14 - Circalittoral coarse sediment	*Medium*	*High*	*Low*	*Low*	*Low*	*High*	*Low*	*High*
A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	Low	High	Low	High	Low	High	Low	High
A5.142 - *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	Medium	High	Low	High-Medium	Medium	High	Low	High-Low
A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand	Medium	High	Low	High	Medium	High	Low	Low
A5.15 - Deep circalittoral coarse sediment	*Medium*	*High*	*Low*	*High*	*Medium*	*High*	*Low*	*Medium*
A5.24 - Infralittoral muddy sand	*Medium*	*High*	*Low*	*Medium*	*Low*	*Medium*	*Medium*	*High*
A5.25 - Circalittoral fine sand	*Medium*	*High*	*Low*	*High-medium*	*Medium*	*High*	*Low*	*Low*
A5.251 - *Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Medium	High	Low	High - medium	Medium	High	Low	Low
A5.252 - *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	Medium	High	Low	High - medium	Medium	High	Low	Low
A5.261 - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Medium	High	Low	High - medium	Medium	High	Low	Low

EUNIS habitat	Penetration and/or disturbance of the substratum below the surface				Abrasion/disturbance of the substratum on the surface of the seabed			
	Resistance	Resilience	Sensitivity	Confidence*	Resistance	Resilience	Sensitivity	Confidence*
A5.27 - Deep circalittoral sand	*Low*	*Medium*	*Medium*	*Low*	*Medium*	*Medium*	*Medium*	*Low*
A5.272 - *Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand	Low	Medium	Medium	Medium - high	Low	Medium	Medium	Medium-High
A5.44 - Circalittoral mixed sediments	*Low*	*Low*	*High*	*High - medium*	*Low*	*Low*	*High*	*High-Medium*
A5.45 - Deep circalittoral mixed sediments	Medium	None	Medium	Medium	Medium	Low	Medium	High
A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments	Medium	High	Low	High-medium	Medium	High	Low	Medium
A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment	None	Medium	Medium	Medium-High	Low	Medium	Medium	Low

Italics and grey = Assessment has been based on sublevel habitat assessments

* Confidence is specific to sensitivity. It is based on the quality of evidence, applicability of evidence and degree of concordance (agreement between studies).

The discussion below has been split into five categories as follows:

- Sand habitats within the zone of influence of pre-sweeping
- Annex I Bedrock Reef habitat
- Annex I Stony Reef habitat
- Annex I Biogenic Reef habitat
- Other subtidal habitats

Sand habitats within the zone of influence of pre-sweeping

The widest zone of influence is associated with pre-sweeping of sandwaves. This will be a localised activity that will potentially be required at two locations. The combined length of cable route that may require pre-sweeping is 5.6km. The width of seabed disturbed is estimated to be up to 100m. The indicative pre-sweeping locations identified by the cable burial risk assessment are between KP25.8 and KP26.4 (a distance of 600m) and between KP64 and KP69 (approximately 5km). They are not located on the Annex I protected sandbank feature - Turbot Bank.

The habitats at the two locations are A5.142 - *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel; and A5.251 - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand and A5.272 - *Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand. Of the three habitats, A5.272 is the most sensitive to disturbance, with a medium sensitivity. The key species in the biotope are shallower burrowers, found close to the sediment surface. Sampled by grab station S18, the infaunal composition was characterised by the brittlestar, *Amphiura filiformis* and the polychaetes *Lumbrineris cingulate and Owenia fusiformis* and Nemertea. *Owenia fusiformis* can form tubes up to 30cm deep, whilst brittlestar are epifaunal fragile species. As fragile, effectively sessile species, animals in the zone of influence will be killed. Higher densities are expected to occur in summer when animals spawn. As cable installation is likely to take place between April and October it will overlap with this period of higher density. Although the habitat will have little resistance to the activity, resilience is medium as recovery from effects will occur through migration of adults from the surrounding unaffected area and through recruitment of juveniles from planktonic larvae. Recruitment rates will depend on favourable hydrodynamic conditions but as the habitat has been widely identified within the Proposed Development (and EMODNet [2019] shows the broadscale habitat A5.27 covers extensive areas of the Celtic Sea) recovery is expected to occur within 2 years.

As effects are short-term and the habitats identified are not Annex I listed the sensitivity of the effect has been assessed as low (using the criteria established in Chapter 5).

The overall sensitivity of the predominantly sandy subtidal habitats to pre-sweeping and cable installation has been assessed as **Negligible** and is **Not Significant**.

Annex I Bedrock Reef habitat

The extent of Annex I Bedrock Reef habitat within the Proposed Development has been calculated as 1.12km^2. This represents approximately 15.8% of the known bedrock reef habitat within the Pembrokeshire Marine / Sir Benfro Forol SAC; acknowledging that confidence in the extent within the SAC is very poor.

The Annex I Bedrock Reef habitat has been classified as A4.138 - *Molgula manhattensis with* a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock. Table 7-8 identifies that this habitat has low sensitivity to abrasion. The characterising species, *Molgula manhattenis* is a small solitary ascidian (sea squirt) which can form dense aggregations. It is short-lived with a life-span of less than 1 year and reproduces several times during this period. Recruitment is generally from existing individuals no more than a few kilometres away, but the fast growth rates means recolonization, and a dense cover can be established within about two months of disturbance (Stamp 2016).

Bedrock reef is a qualifying feature of the Pembrokeshire Marine / Sir Benfro Forol SAC and is of high environmental value as it supports a diverse range of algae, invertebrates and fish species. The EIA has therefore concluded that the sensitivity of the habitat should be increased from low to medium in recognition that the habitat is a key contributor to the overall biodiversity of the SAC.

The conservation objectives for the site state that to achieve favourable status:

- The overall distribution and extent of the habitat feature within the site and each of the main component parts is stable or increasing.
- The physical, biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded; and
- The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded.

The presence and location of the Annex I habitat offshore was taken into consideration during the design (routeing) of the Proposed Development. SECAMS bathymetry data and JNCC habitat maps were used to identify a suitable cable route through the SAC that avoids or minimises the crossing of the known and potential features (embedded mitigation EM14). Route engineering and additional survey was undertaken during the cable route survey to visualise a sand channel through the bedrock reef, to further avoid crossing Bedrock reef features. The 'base case' development being assessed is therefore an installation corridor that avoids crossing Annex I Bedrock reef habitat offshore.

However, a small area of outcropping Bedrock reef has been identified within the sand channel that it may not be feasible to avoid. The extent of disturbance would be approximately 30m long x 15m wide (450m^2; between KP2.38 and KP2.41). If jetting or plough trenching is used in this area (it may require external cable protection), the seabed will experience temporary disturbance but the underlying character and composition will not change. There is sufficient habitat in the

surrounding Proposed Development (within 100m) that will be undisturbed to allow recruitment and recolonisation.

The indicative Greenlink centreline crosses a second area classified as Bedrock Reef at KP5. However, analysis of video transect 06 photographs (Figure 7-16 Drawing P1975-SURV-008) shows that there is a small sand covered channel through the habitat and that habitat A4.138 is not present. Therefore, it is concluded that there will be no effect on Annex I Bedrock Reef in this area.

The EIA concluded that the effect will be temporary (habitat recovery will occur within a year), the area disturbed will be very small (450m^2, approximately 0.006% of the Bedrock Reef in the SAC) and the Proposed Development will not affect, other than temporarily the structure or function of the Annex I Bedrock Reef. The significance of the effect has been assessed as **Minor** and is **Not Significant**.

It is acknowledged that should the base case being assessed change, the significance of the effect could become more significant. Therefore, to ensure that the Annex I Bedrock Reef remains protected within the Proposed Development, Project Specific Mitigation (PS2) has been proposed, in the form of exclusion zones around the identified Annex I Bedrock Reef habitat.

Annex I Stony Reef habitat

Annex I Stony Reef classified as medium grade, was identified across the extent of the Proposed Development from KP15.0 to KP20.2, and then in wide patches from KP20.6 to KP22.1 (Figure 7-11, Drawing P1975-HAB-004 Sheet 2). It mainly consists of cobbles and boulders which harbour a rich epifaunal community. The habitat has been identified as A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (Figure 7-18).

Habitat A5.141 has a low sensitivity to penetration and abrasion. The fauna associated with this habitat are typically fast-growing epifauna, that are opportunistic as the habitat experiences seasonal and sporadic cycles of severe scour. The pebbles and cobbles are likely to be moved by the tidal streams in the region, which will be more severe during winter storms.

Studies off Chesil Beach, Dorset (cited in Tillin and Tyler-Walters 2016) showed that the epifaunal community coverage decreased in October, scoured away by winter storms, but was recolonised in May to June. As the Greenlink cable route survey was undertaken during winter months it is possible that the survey may therefore have under-represented the abundance of epifaunal communities that will be present during cable installation. However, Tillin and Tyler-Walters (2016) state that the habitat is characterised by short-lived species, that mature rapidly. There is a relatively extended reproductive season and pelagic larvae. As the habitat covers an extensive area within the Proposed Development, in comparison to the zone of influence, there will be a good larval supply to support colonisation of the disturbed area. Recolonization is expected to occur rapidly post-disturbance; within 1 year.

Stony Reef contributes to the Reef qualifying feature of the Pembrokeshire Marine / Sir Benfro Forol SAC. Overall the Reef habitat within the SAC has high environmental value as it supports a diverse range of algae, invertebrates and fish species. The EIA has therefore concluded that the sensitivity of the habitat should be increased from low to medium in recognition that the habitat is a key contributor to the overall biodiversity of the SAC.

If jetting or plough trenching is used in this area (it may require external cable protection), the seabed will experience temporary disturbance but the underlying character and composition will not change. The cobbles will not be removed from the Proposed Development, and will be used to cover the cable returning the seabed to a similar state as pre-installation. The area of habitat disturbed by cable installation will be approximately 7km x 15m (0.105km^2); approximately 3.5% of the habitat identified within the Proposed Development, and 0.15% of the wider extent of stony reef within the SAC. It should be noted that JNCC habitat maps show Stoney reef extends outside the boundary of the SAC as well.

The EIA concluded that as the effect will be temporary (recovery within 1 year) and the area disturbed small in the context of the wider habitat the Proposed Development will not affect, other than temporarily the structure or function of the Annex I medium grade Stony Reef. The significance of the effect has been assessed as **Minor** and is **Not Significant**.

Annex I Biogenic Reef habitat

Annex I Biogenic Reef classified as potential through to medium grade has been identified within the Proposed Development. There is sufficient room within the Proposed Development for the indicative Greenlink centreline to avoid areas classed as medium grade.

The areas of biogenic reef were mainly classified as habitat A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment, with the exception of one area of low-grade biogenic reef in habitat A5.15 – Deep circalittoral coarse sediment. A5.611 has a higher sensitivity to the pressure penetration than A5.15, and has been classed as medium.

Tillin et al. (2018) provides evidence from various studies (e.g. Gibb et al. 2014, Tillin et al. 2015, Vorberg 2000, Cunningham et al. 1984, and Holt et al. 1998) to assess the likely recovery rate of *S.spinulosa* reefs from effects. It reports data is limited with significant information gaps. Recovery rates are likely to be determined by a range of factors such as the degree of effect, the season of effect, larval supply and local environmental factors including hydrodynamics. There is evidence from studies on *S.alveolata* reefs which suggest that areas of limited damage on a reef (small impact) could be repaired rapidly (within weeks) through tube-building activities of adults, whereas following a medium effect recovery would be likely to occur within two years. Some thin crusts of *S.spinulosa* are relatively ephemeral and disappear following natural disturbance such as storms but

recover the following year, suggesting that recovery is high (within two years) even where reefs are removed.

Approximately 3.13km of the cable route will cross potential or low grade Biogenic reef. The area of habitat disturbed by cable installation will be approximately 0.05km^2; approximately 3.6% of the habitat identified within the Proposed Development. JNCC habitat maps do not show biogenic reef as occurring within the Pembrokeshire Marine / Sir Benfro Forol SAC.

Cable installation will temporarily disturb the seabed, but the underlying composition and character will not change. Given the wider area of habitat compared to the zone of influence of installation, recovery via recruitment from the surrounding area is likely to occur in the short-term (within two years). The significance of the effect has been assessed as **Minor** and is **Not Significant**.

Other subtidal habitats

Generally, the other subtidal habitats identified in the Proposed Development have low to medium sensitivity to the pressure. The exception is for A5.44 Circalittoral mixed sediments.

The assessment for A5.44 is based on the EUNIS sub-level habitat A5.442 - Sparse *Modiolus modiolus*, dense *Cerianthus lloydii* and burrowing holothurians on sheltered circalittoral stones and mixed sediment, as this is the only EUNIS sub-level habitat that has been assessed by MarLIN. The two featured species of the habitat are particularly sensitive to activities which cause abrasion and disturbance; *Cerianthus lloydii* is a tube-dwelling anemone, whilst *Modiolus modiolus* (blue mussel) are large, sessile and shallowly buried individuals unable to escape from activities which penetrate the seabed. The habitat A5.44 was identified on the Turbot Bank (Annex I sandbank feature), interpreted from sidescan sonar data. It was not sampled by any grabs.

The Turbot Bank is exposed to wave action, suggesting that epifauna and infauna present will be characteristic of moderately strong tidal currents, and given the dominance of sand and coarse sediments, can be viewed as adaptable to physical disturbance. Many infaunal species may live at depths where they will be protected from surface disturbance and in areas where direct loss occurs, it is likely that adjacent areas will act to replenish communities rapidly as most infaunal species are mobile and the zone of influence is narrow. The EIA therefore concluded that the sensitivity category of high presented in Table 7-8 is over conservative for the habitat and has reduced the sensitivity to medium.

The overall significance of the effect on the other subtidal habitats in the Proposed Development has been assessed as **Minor** and is **Not Significant**.

7.6.2.2 Operation (including maintenance and repair)

No disturbance or habitat loss will occur from the operating cables. Effects during any unforeseen repair and maintenance works will be of smaller magnitude when compared to cable installation. The assessment considered five discrete cable

repairs during operation and concluded that, given the sensitivity of habitats within the Proposed Development to penetration and abrasion, the significance of the effect remains **Minor** and is **Not Significant**.

7.6.2.3 Decommissioning

Two options will be considered at decommissioning; leaving the cables in-situ and removing them. If the cables are left in-situ there will be no effect on intertidal benthic and estuarine habitats and species during decommissioning. However, if the option to remove the cables (and any associated protection) is selected, this process would essentially be the same as installation activities but in reverse. Therefore, any effects that could arise due to the decommissioning phase of the Proposed Development will be of a comparable magnitude to those assessed above for cable installation and so the effect has been assessed **Minor** and is **Not Significant**.

7.6.3 Siltation rate changes, including smothering (depth of vertical sediment overburden)

7.6.3.1 Installation

The area surrounding the cable trench is likely to be affected by the suspension and subsequent deposition of sediments as a result of installation activities. Pre-sweeping and jet trenching will cause a greater level of sediment suspension compared to the use of ploughing equipment.

Although modern equipment and installation techniques have reduced the re-suspension of sediment during cable trenching activities, remaining suspended sediment dispersed into the water column has the potential to affect sessile filter feeders and, once settled out, could potentially smother organisms within the deposition area. Suspended sediments can obstruct the filtration mechanisms of some benthic and pelagic species. For example, some types of worm and brittlestars can be affected through the clogging of gills or damage to feeding structures. Suspended sediments can also attach to fish eggs causing abnormalities or death. It can also affect the growth of the macrobenthos and may have a lethal effect on some species.

Chapter 6 concluded that the change in suspended sediments (water clarity) as a consequence of cable installation is Negligible and is Not significant for the following reasons:

- Increases in SPM concentrations will be brief (restricted to the immediate period when cable burial is taking place)
- Sand and gravel disturbed during the cable burial operations will settle back to the seabed very rapidly (within 3 minutes) and the footprint is unlikely to extend any great distance from the cable route (median settling distance is 27m for sand).
- Silts, clay and chalk particles will remain in suspension for a greater period of time (up to 14 hours) and will be dispersed over a much greater distance,

depending upon the strength of the tidal currents. However, the depth of deposition over such a large area is likely to be unnoticeable.

- It is predicted that the change is suspended sediment concentrations will be within the normal environmental variation experienced after storm conditions in the region.

This has led to the magnitude of the effect of siltation rate changes on subtidal habitats being assessed as negligible. Some subtidal habitats within the Proposed Development will be exposed to more than one occasion of siltation changes e.g. from seabed preparation and subsequent cable lay. The activities will be separated temporally. No activities within the Proposed Development will accumulate in a manner that causes the magnitude of the effect to increase.

To determine the sensitivity of habitats within the Proposed Development an assessment has been carried out using information provided on the Marine Life Information Network (MarLIN). Table 7-9 identifies that the subtidal habitats identified within the Proposed Development generally have low to medium sensitivity to the pressure smothering and heavy siltation rate changes.

Table 7-9 Sensitivity of habitats within the Proposed Development to the pressure smothering and siltation rate changes (heavy)

EUNIS habitat	Resistance	Resilience	Sensitivity	Confidence*
A4.111 - *Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock	Medium	High	Low	Low
A4.13 - Mixed faunal turf communities on circalittoral rock	*Low*	*Medium*	*Medium*	*Low*
A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock	Medium	High	Low	Low
A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	Low	High	Low	Low
A4.2212 - *Sabellaria spinulosa,* didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock	None	Medium	Medium	Low
A5.13 - Infralittoral coarse sediment	*Low*	*Medium*	*Medium*	*Low*
A5.14 - Circalittoral coarse sediment	*Medium*	*Medium*	*Medium*	*Low-High*
A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	Medium	High	Low	Medium
A5.142 - *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	Medium	Medium	Medium	Low-High
A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand	No Evidence	No Evidence	No Evidence	Not Relevant
A5.15 - Deep circalittoral coarse sediment	*Medium*	*Medium*	*Medium*	*Low-High*
A5.24 - Infralittoral muddy sand	*Low*	*Medium*	*Medium*	*Low-High*
A5.25 - Circalittoral fine sand	*Medium*	*High*	*Low*	*Medium*
A5.251 - *Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Low	Medium	Medium	Low-High

EUNIS habitat	Resistance	Resilience	Sensitivity	Confidence*
A5.252 - *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	Low	Medium	Medium	Low-High
A5.261 - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Low	Medium	Medium	Low-High
A5.27 - Deep circalittoral sand	*Low*	*Medium*	*Medium*	*Medium-High*
A5.272 - *Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand	Low	Medium	Medium	Medium-High
A5.44 - Circalittoral mixed sediments	*Low*	*Low*	*High*	*Medium-High*
A5.45 - Deep circalittoral mixed sediments	*Medium*	*Medium*	*Medium*	*Low-High*
A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments	Medium	Medium	Medium	Low-High
A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment	None	Medium	Medium	Low
Italics and grey = Assessment has been based on sublevel habitat assessments * Confidence is specific to sensitivity. It is based on the quality of evidence, applicability of evidence and degree of concordance (agreement between studies).				

The sensitivity of subtidal habitats has been assessed as medium, recognising the differing sensitivities (identified in Table 7-8) within the Proposed Development. The overall significance of the effect has been assessed as **Negligible** and is **Not Significant.**

The potential effect of this pressure on the Pembrokeshire Marine / Sir Benfro Forol SAC has also been assessed within the Greenlink Marine HRA – Technical Appendix C. The HRA concluded no potential for significant effects and that an Appropriate Assessment is not required for this pressure.

7.6.3.2 Operation (including maintenance and repair)

No seabed disturbance or siltation rate changes will occur from the operating cables. Effects during any unforeseen repair and maintenance works will be of smaller magnitude when compared to cable installation. The assessment considered five discrete cable repairs during operation and concluded that as the sensitivity of habitats within the Proposed Development remains the same as for installation, the overall significance of the effect remains **Negligible** and is **Not Significant**.

7.6.3.3 Decommissioning

Two options will be considered at decommissioning; leaving the cables in-situ and removing them. If the cables are left in-situ there will be no effect on intertidal benthic and estuarine habitats and species during decommissioning. However, if the option to remove the cables (and any associated protection) is selected, this process would essentially be the same as installation activities but in reverse. Therefore, any effects that could arise due to the decommissioning phase of the Proposed Development will be of a comparable magnitude to those assessed above for cable installation and so the effect has been assessed **Negligible** and is **Not Significant**.

7.6.4 Physical change (to another seabed type)

7.6.4.1 Installation

External cable protection (i.e. concrete mattresses / rock berm) will be installed where the Proposed Development crosses a third-party telecommunications cable, and where ground conditions are unsuitable for cable burial. It is possible that up to 16.46km of the Proposed Development will require external cable protection. The footprint has been reduced by embedded mitigation EM15 and EM29. However, where it is used the seabed habitat within the footprint of the external cable protection will be lost and replaced with, in places, a harder substrate, changing the seabed type.

The crossing location lies outside of the Pembrokeshire Marine / Sir Benfro Forol SAC, but other indicative areas for external cable placement are within the site. Table 7-10 summarises the habitats within which external cable protection could be installed and the estimated length of protection required. The total loss of habitat within the SAC as a result of external cable protection has been calculated as 0.164km^2. Of this value 0.0017km^2 will be within Annex I Bedrock Reef habitat and 0.08km^2 will be within Annex I Stony Reef – medium grade habitat. These values represent less than 0.001% of the area of Bedrock Reef, and 0.11% of the Stony Reef in the Pembrokeshire Marine / Sir Benfro Forol SAC .

Table 7-10 Habitats within which external cable protection could be installed

EUNIS habitat	Distance crossed	Presence of Annex I habitat
A5.251- *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	120m	No
A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock.	30m (+140m*)	Yes - Bedrock Reef
A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand. A5.25 - Circalittoral fine sand	200m	No
A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	3000m	No
A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles A5.14 – Circalittoral coarse sediment	8000m	Medium grade stony reef
A5.27 – Deep circalittoral sand	3000m	No
A5.611 - Sabellaria spinulosa on stable circalittoral mixed sediment A5.45 – Deep circalittoral mixed sediments	2000m	Yes – potential biogenic reef
*Between KP2.7 and KP2.9 the cable route crosses Bedrock reef, but video transect shows narrow sand channel which is feasible for installation which is not classed as A4.138; Section 7.3.4.3		

It is likely that a high proportion of the benthic invertebrates within the width of the footprint, will be susceptible to mortality, injury or displacement as a result of the activities. The habitat beneath the external cable protection will be completely removed. Where external cable protection is installed, the underlying Reef habitat

will be lost, but it will be replaced by a suitable hard, stable habitat for colonising communities. The external cable protection might be a slightly less complex habitat than that which occurs naturally, which might result in a comparative reduction in the diversity of species. However, there is sufficient habitat in the surrounding area to allow recruitment and colonisation of the protection material.

MarLIN (2019) identifies that the habitats identified in Table 7-9 have a high sensitivity to the pressure, because a permanent change in substrate type would lead to the biotope being re-classified.

Material used for rock berms is typically coarse gravel, cobbles and boulders. Chapter 4 indicates that rock sizes will likely be in the range of 2-22cm. Langhamer (2012) comment that "in comparison to boulders, gravel protection will result in low diversity and abundance of organisms due to a more unstable environment".

In areas where there is stony or bedrock reef, the surrounding substrate is stable cobbles, boulders and bedrock and the dominant epifaunal species are rapid colonisers, capable of early reproduction and rapid growth. Therefore, it is expected that epifauna will be able to colonise the new substrate.

The external protection in sandy habitats will inevitably support the settlement of non-local hard bottom fauna that may not be representative of the surrounding benthos. Evidence (in discussion below) suggests that effects on the local fauna in soft sediment areas will in most cases be very localised but long-term.

The above conclusions are supported by evidence from post-construction monitoring of offshore windfarms. The examples provided below are from the introduction of a hard substrate into a predominantly sandy environment. This however can be used to infer that colonisation of external protection in areas, where there is already rock habitat, will likely be quicker i.e. as colonisation of external protection on sand habitats is dependent on the passive transport of adult organisms or the availability of larvae from the surrounding region.

Case Studies on the Offshore Windfarm Egmond aan Zee, Prinses Amalia Wind Farm and Horns Rev Wind Farm found that the density of species on scour protection material were high and the number of species observed increased with time. In addition, in many cases the number of rare species had also increased (Waardenburg et al 2017). Studies (Lindeboom et al 2011) at OWEZ identified 11-17 hard substratum benthos species on the rock material, noting the surrounding habitat was sandy. At the Horns Rev windfarm the scour protection has been colonised by sea anemones and the soft coral *Alcyonium digitatum* (Langhamer 2012). Monitoring of the Nord Stream pipeline in Swedish waters showed that over a period of four years a general increase in epifauna was seen on the introduced hard substrate (pipeline and rock berms) (Nord Stream 2014).

The external cable protection could be viewed as an artificial reef. The OSPAR Commission (2009) defines an artificial reef, as a 'submerged structure placed on the seabed deliberately, to mimic some characteristics of a natural reef. It could be partly exposed at some stages of the tide'. This places the external cable

protection material outside the formal definition on the basis of purpose. However, almost all man-made structures placed on the seabed are rapidly and quickly colonised by marine organisms (Linley et al 2007). The effects of artificial reefs are ambiguous with Linley et al (2007) citing studies such as Ambrose and Anderson (1990) which have shown that some species of infauna were enhanced whilst others were depressed. It is therefore acknowledged that whilst the external cable protection could enhance the productivity and biodiversity of the habitat, it will also represent a variation on the habitat that was previously there.

Although evidence above suggests that the introduction of external cable protection in sandy areas could increase the biodiversity of the area, it will result in a long-term change in habitat. Taking this into account and given that sand habitat is widespread and external cable protection on sandy sediments is not within a protected site, the sensitivity of the habitat has been assessed as medium. External cable protection will be very localised and will not change the character and composition of the habitat as a whole, therefore the magnitude has been assessed as low. The overall significance of the effect has been assessed as **Minor** and is **Not Significant for subtidal sand habitats**.

Where external cable protection is deposited in areas of Annex I Reef habitat, the seabed height will become elevated in comparison to the surrounds. Large boulders, up to 2m high, have been observed in the area and therefore structures of this height are not uncommon in the area. Camera drops on these boulders were undertaken during the cable route survey. Imagery indicates the presence of habitat A4.111 - *Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock. This biotope is characterised by a few species that are capable of maintaining a strong foothold in strong tides, either by forming a flat adherent crust, or by having strong attachment points. Species typically associated with the biotope include hydroids, sponges and anemones, as well as mobile species such as starfish, crab and whelk (Tillin 2016). The species associated with the biotope grow rapidly, are short-lived, and generally thought of as early colonisers of bare surfaces. Tillin (2016) cite evidence of *Balanus crenatus* colonising artificial reef structures and sublittoral rock surfaces within months. For example, the ship, HMS Scylla was colonised by *Balanus crenatus* four weeks after sinking in March; the timing of the sinking would have ensured a good larval supply. This suggests that the height of the external cable protection will not detrimentally effect the function of the reef habitat but will provide alternative areas for colonisation by species in the surrounds.

The potential effect of this pressure on the Pembrokeshire Marine / Sir Benfro Forol SAC has also been assessed within the Greenlink Marine HRA – Technical Appendix C. The HRA concluded potential for likely significant effects and that an Appropriate Assessment is required for this pressure. Further assessment, in Stage 2 (Information to Inform the AA), concluded that given species from the surrounds will colonise the cable protection, the distribution, extent, structure and function and the condition and diversity of the habitat will not be degraded in the long-term. The HRA therefore concluded that the integrity of the Pembrokeshire Marine / Sir

Benfro Forol SAC would not be adversely affected by the Proposed Development. In line with this conclusion, the sensitivity of the reef habitat has been assessed as medium, recognising that although the habitat is a designating feature of an SAC the distribution and extent, structure and function and quality and diversity of the habitat will not be altered in the long-term. The magnitude of the effect has been assessed as low given the small, localised footprint of the pressure, the potential for colonisation of the external cable protection, and the wider extent of the habitat within the region. The overall significance of the effect has been assessed as **Minor** and is **Not Significant**.

7.6.4.2 Operation (including maintenance and repair)

Effects during any unforeseen repair and maintenance works will be of a smaller magnitude when compared to cable installation. The assessment considered five discrete cable repairs during operation and concluded that as the sensitivity of habitats within the Proposed Development remains the same as for installation, the overall significance of the effect remains **Moderate** and is **Significant.**

7.6.5 Introduction or spread of non-indigenous species

7.6.5.1 Installation, Operation (including maintenance and repair) and decommissioning

MarLIN (2019) identifies that the majority of habitats within the Proposed Development are not sensitive (e.g. A4.111, A4.213, A4.2212 and A5.611) to the pressure. The exception is habitats A5.251, A5.252, A5.261 and A5.451 which have been assessed as having a high sensitivity. There is concern that the slipper limpet *Crepidula fornicata* may settle on stones in substrates and hard surfaces such as bivalve shells in these habitats. The species has a high dispersal potential with pelagic larvae. Temporary disturbance of the seabed i.e. through cable installation, could therefore allow juveniles to settle in a new area.

Slipper limpet are well established in the Milford Haven Waterway (and Pembrokeshire Marine / Sir Benfro Forol SAC) having first been recorded in 1953. However, Bohn (2014) indicates that it currently appears to be absent in subtidal habitats. Slipper limpet were not identified by the cable route survey (MMT 2019) within the Proposed Development.

The introduction of invasive non-native species (e.g. through discharge of ballast water from project vessels) will be managed under the International Convention for the Control and Management of Ship's Ballast Water and Sediments (embedded mitigation EM6). The latest guidance from the GB non-native species secretariat (2015) will be followed and a Biosecurity Plan produced pre-installation (embedded mitigation EM8). This would include factors such as origins of the vessels and ensuring that relevant equipment is cleaned before use. Taking the embedded mitigation into consideration, the magnitude of the effect has been assessed as negligible.

The overall significance of the effect has been assessed as **Negligible** and is **Not Significant**.

As Best Practice, Project Specific Mitigation (PS8) has been proposed.

7.6.6 Electromagnetic changes

7.6.6.1 Operation

The Greenlink cables will be installed in direct contact with each other (bundled configuration, embedded mitigation EM15), with currents flowing in opposite directions. Magnetic (B) fields will emanate into the surrounding environment; although they will attenuate with distance (both horizontally and vertically). Movement through the B fields i.e. water currents or organisms swimming through, creates an induced electric (iE) field. The effect will be present along the Proposed Development.

The background geomagnetic field for the Celtic Sea is approximately 48.7 µT (Natural Resources Canada 2019), with the background iE field calculated as between 34.09 µV/m and 48.7 µV/m in Irish waters.

It has been calculated that the Greenlink cables will generate B fields of 21µT directly over the cables reducing to natural background levels within 2m. The iE fields are estimated to be between 48.79 and 69.7 µV/m at 1m from the cables. No detectable change above background geomagnetic fields will be noticeable at 2m from the cables.

The effect of EMF on benthic species is largely unknown. There is little and contradicting evidence of interactions with anthropogenic sources of magnetic fields. As benthic communities are typified by sessile or low-mobility species, which are unlikely to navigate using magnetic fields and anomalies, these species, are less likely to be affected than more mobile species such as teleost fish or elasmobranchs, which are assessed in Chapter 8. The exception could be crustaceans, such as edible crabs (*Cancer pagurus*), lobster (*Homarus gammarus*) and prawns (e.g. *Nephrops norvegicus).* The brown shrimp (*Crangon crangon*) has been recorded as being attracted to AC magnetic fields of the magnitude expected from submarine power cabling (ICES 2003). However, Bochert and Zettler (2004) found no effects of exposure to static B fields upon the same species, nor upon the round crab (*Rhithropanopeus harrisii*), an isopod (*Saduria entomon*) or the mussel (*Mytilus edulis*). Demonstrations of B fields ranging between 1-100µT delaying embryonic development in sea urchins (Zimmerman et al. 1990), and of high frequency AC EMF causing cell damage to barnacle larvae and interfering with their settlement (Leya et al. 1999), contrasts with anecdotal evidence of benthic invertebrates living directly upon DC electrodes (Nielson 1986) with no apparent effects (Swedpower 2003). The sensitivity of the receptor to EMF has been assessed as low.

A number of marine invertebrate species that inhabit the Proposed Development are magnetically sensitive, including important commercially targeted taxa such as lobster, crabs, shrimps, and molluscs. As discussed above, B and iE fields generated

by the Proposed Development will attenuate to below background geomagnetic field levels within 2m of the cables.

Potential effects will largely be negated by cable burial; burial to a depth of at least 0.6m will prevent most invertebrates (except deep borrowing species such as certain Crustacea and bivalve molluscs) encountering the strongest fields present on the cable surfaces. In addition, embedded mitigation EM15, bundling of the cables, also significantly reduces the magnitude of the effect. The magnitude of the effect has been assessed as low, as although it will be a long-term change, the alteration will be extremely localised, and the underlying character of the baseline will be similar to the pre-development situation.

The overall significance of the effect has been assessed as **Negligible** and is **Not Significant.**

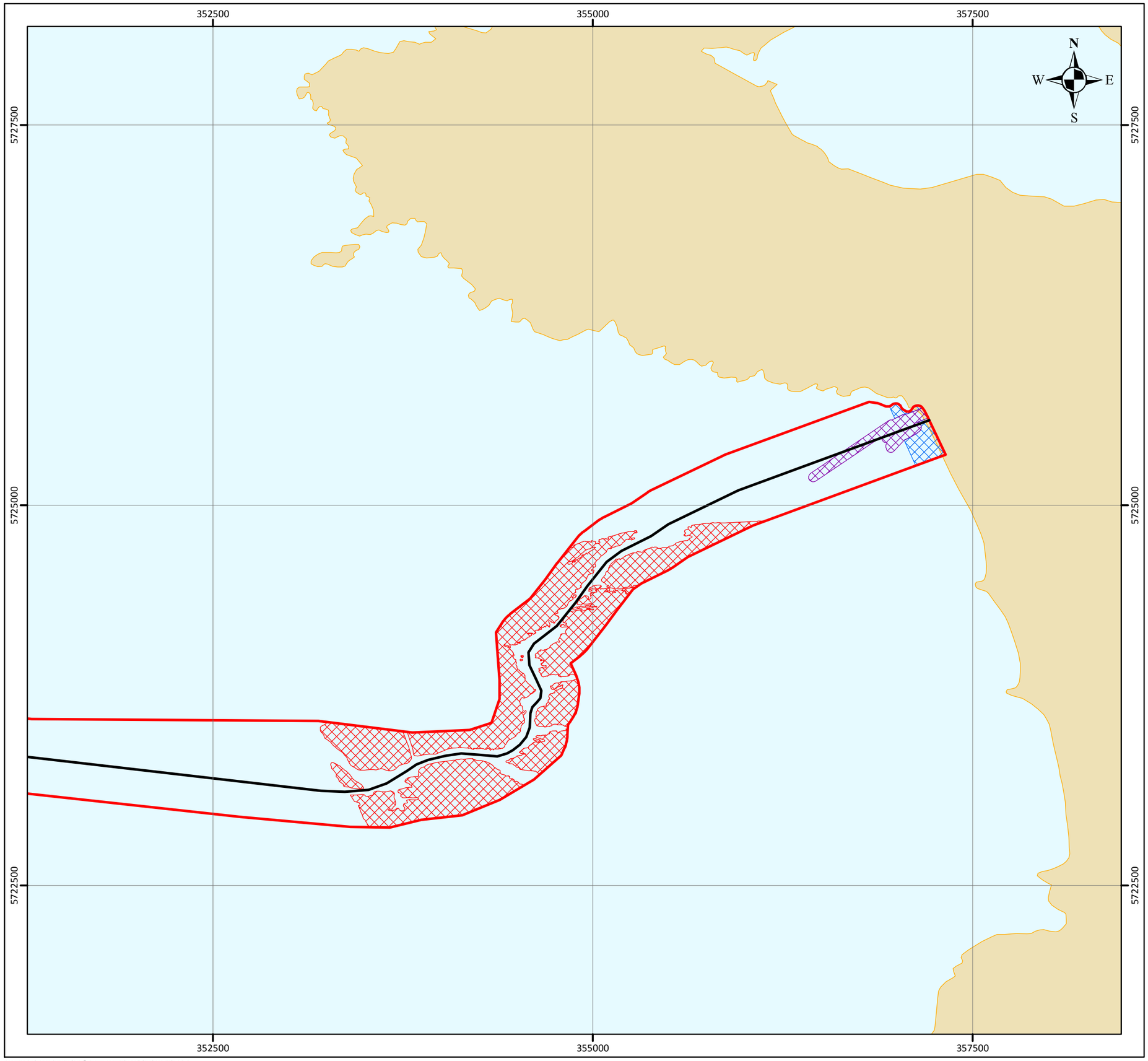
7.7 Project Specific Mitigation

In addition to the embedded mitigation outlined in Table 7-6, Table 7-11 presents measures that GIL is committed to adopting.

Table 7-11 Project specific mitigation – benthic and intertidal Ecology

ID	Project Specific Mitigation
PS1	No intrusive works will be undertaken at Freshwater West between mean high water springs and mean low water springs.
PS2	Exclusion zones have been established around Annex I bedrock reef features; shown on Figure 7-21, Drawing P1976-INST-009. No intrusive works (e.g. cable installation, deposit of external cable protection material) will be undertaken within these exclusion zones.
PS4	The preference is to bury the HDD duct exit and all cables in sediment to the required depth of lowering. No external cable protection should be deposited at the HDD exit point.
PS6	A burial assessment study will be carried out by the Installation Contractor that defines the feasibility of achieving the required depth of burial. When determining the installation technique for the cable route between KP15 and KP23 the preference shall be to bury the cable in sediment. If ground conditions do not allow this then cutting should be investigate as the next alternative. External cable protection shall only be consider as the final option, and if necessary, the Installation Contractor shall seek to minimise the footprint (length and width) of external cable protection required between KP15 and KP23 (Annex I stony reef).
PS7	Where external cable protection is used between KP15 and KP23 (Annex I Stony Reef) an environmental monitoring plan will be established to monitor colonisation of the external cable protection to demonstrate that the structure and function of the Reef feature has not been adversely affected in the long-term. The monitoring programme will be developed in consultation with NRW. It is proposed that one or more of transects MMT (2019) RR_T02, RR_T03 and RR_T04 are re-surveyed as a control, with additional video transects taken along the external cable protection to

ID	Project Specific Mitigation
	record epifauna. Monitoring would be planned to coincide with the first two routine cable inspection surveys. It is expected that the first inspection survey will be undertaken within the first three years of installation, with a second survey undertaken within three years of the first survey. All footage will also be reviewed for the presence of non-indigenous species. The objectives of monitoring colonisation of the external cable protection will be to establish an evidence base to inform future development within the Pembrokeshire Marine / Sir Benfro Forol SAC e.g. renewable energy generation. It will also confirm (or otherwise) the conclusion that the deposition of the external protection material adds to the Reef habitat within the SAC; albeit artificially.
PS8	A tool box talk will be given ahead of all works. It will provide key identifying features for slipper limpet. Any slipper limpet found during installation will be kept & destroyed.



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GREENLINK INTERCONNECTOR

INSTALLATION

Annex I Habitat Exclusion Zones - UK Route

Drawing No: P1975-INST-009	A

Legend

- Indicative Greenlink Route Centreline
- Proposed Development
- Annex I Habitat Exclusion Zone
- Decommissioned MOD Cable Avoidance Zone
- Trenching Exclusion Zone



NOTE: Not to be used for Navigation

Date	Monday, April 29, 2019 08:37:30
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OS; MMT; ESRI; Greenlink
File Reference	J:\P1975\Mxd\15_INST\ P1975-INST-009.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

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7.8 Residual Effect

The assessment presented in Section 7.6 identified two potential pressures could have significant effects on the receptor. The significance of these pressures was re-assessed taking into consideration the Project Specific Mitigation outlined in Section 7.7 to determine if a significant residual effect remains.

7.8.1 Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion

The assessment identified that subtidal habitats within the Proposed Development have a medium sensitivity to the pressure penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion. Extensive route development was undertaken during design (routeing) to identify an alternative route through the Pembrokeshire Marine / Sir Benfro Forol SAC that avoided Annex I habitat features. The Proposed Development represents the best alternative and has been optimised to avoid crossing Annex I habitat where possible, embedded mitigation EM14. The cables will also be bundled into the same trench to reduce the footprint of the Proposed Development (embedded mitigation EM15). In addition, Project Specific Mitigation in the form of exclusion zones (PS2, Figure 7-21, Drawing P1975-INST-009) have been established around the Annex I reef habitat within the Proposed Development. GIL will ensure that the Installation Contractor adheres to these exclusions. No further Project Specific Mitigation can be proposed that reduces the footprint, magnitude or sensitivity of the effect and therefore the significance of the residual effect remains **Minor** and is **Not Significant**.

7.8.2 Physical change (to another seabed type)

The assessment identified that the Proposed Development will have an effect of Minor significance on subtidal habitats. The preference is to bury the cables in sediment as this is the most cost-effective method of protection. External cable protection will only be deployed where adequate burial cannot be achieved. The footprint of the deposits will be the minimum required to ensure cable safety and rock berm stability (embedded mitigation EM29).

The alternative routes identified through the Pembrokeshire Marine / Sir Benfro Forol SAC also crossed extensive areas of Annex I reef habitat; and longer sections of external cable protection would have been required on these route options. The route developed, through consultation with NRW, is seen to be the best alternative. External cable protection in the area of Stony Reef is expected to be colonised by the surrounding epifauna rapidly.

The EIA concluded that burial in sediment and external cable protection, if required across the Stony Reef would have an effect of Minor significance. Project Specific Mitigation (PS6) has been proposed which outlines the environmental recommendations for cable protection between KP15 and KP23. A burial assessment study will be carried out by the Installation Contractor that defines the feasibility

of achieving the required depth of burial. When determining the installation technique for the cable route between KP15 and KP23, GIL will indicate that the preference shall be to bury the cable in sediment. If ground conditions do not allow this then cutting should be investigate as the next alternative. External cable protection shall only be considered as the final option, if necessary. The Installation Contractor shall seek to minimise the footprint (length and width) of external cable protection required between KP15 and KP23 (Annex I stony reef).

Project Specific Mitigation in the form of exclusion zones (PS2, Figure 7-21, Drawing P1975-INST-009 overleaf) have also been established around the majority of Annex I Bedrock Reef habitat within the Proposed Development. Micro-routeing will also be used to avoid Annex I habitat where possible. However, in certain areas the features cover the entire width of the Proposed Development and cannot be avoided. GIL will ensure that the Installation Contractor adheres to these exclusions.

No further Project Specific Mitigation can be proposed that reduces the footprint, magnitude or sensitivity of the effect. Where external cable protection is used monitoring has been recommended (PS7). Although monitoring will not reduce the effect, the objective is to validate the conclusion of short-term effects. It is thought monitoring would be beneficial for the management of the Pembrokeshire Marine SAC given that a number of renewable energy projects are proposed for testing and development within the SAC. Validating the conclusions of the Greenlink Marine HRA will support the decision making for future applications.

Taking the Project Specific Mitigation into consideration, the significance of the residual effect remains **Minor** and **Not Significant** in areas of Annex Bedrock and Stony reef and **Minor** and is **Not Significant** in all other subtidal habitats.

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Appendix D

Habitat Compensation Plan – Revision 0

GREENLINK INTERCONNECTOR LIMITED

Marine Licence CML1929: Greenlink Interconnector - Marine Wales

Pembrokeshire Marine Special Area of Conservation Habitat Compensation Plan

Greenlink - an interconnector between
GB and the Republic of Ireland

P1975_R5029_Rev0.1 | May 2020

DOCUMENT RELEASE FORM

Greenlink Interconnector Limited

P1975_R5029_Rev0.1

Marine Licence CML1929: Greenlink Interconnector - Marine Wales

Pembrokeshire Marine Special Area of Conservation Habitat Compensation Plan

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Rev No	Date	Reason	Author	Checker	Authoriser
Rev 0	23/04/2020	Draft for NRW TE review	EST, CC, ALF	EH	BM
Rev 0.1	07/05/2020	Draft for submission to NRW Marine Licensing	ALF	-	BM

EXECUTIVE SUMMARY

Without prejudice to Natural Resources Wales' (NRW) determination of the Greenlink Interconnector Marine Licence Application and decision with respect to adverse effect on site integrity, this Habitat Compensation Plan has been produced to describe the compensatory measures that could be implemented by Greenlink Interconnector Limited (GIL) to ensure the coherence of the European Site Network and specifically Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC).

Greenlink is a proposed electricity interconnector linking the existing electricity grids in Great Britain (GB) and Ireland. The subsea cables will cross the Pembrokeshire Marine / Sir Benfro Forol SAC for approximately 49.6km, starting at the landfall at Freshwater West, Pembrokeshire. The preference is to bury the cables in sediment – a process that will not affect the integrity or coherence of the European Site Network. However, soil conditions may not be suitable for burial in all locations, and the deposit of external cable protection may be required. If external cable protection is deposited on the SAC's Primary Feature Reef, NRW Technical Experts have advised that this would be considered a significant loss of Annex I habitat and that compensatory measures will be required.

The compensatory measures described in the Habitat Compensation Plan follow the precautionary principle and assume the worst-case i.e. the largest area of compensation will be required. In reality, the level of compensatory measures required will depend on the location and quantity of external cable protection and consequently the area of habitat loss. It is feasible that not all locations indicated in Revision 0 of the Plan will require compensatory measures. The refinement of the locations and quantities for the deposit of external cable protection will be an iterative process following the below sequence, which will not be concluded until the cables have been installed:

1. Selected Installation Contractor undertakes Burial Assessment Study (BAS) and determines potential external cable protection locations.
2. Installation Contractor undertakes planned trenching.
3. Locations of external cable protection confirmed.

The intention of Revision 0 of the Plan is to outline the principles of the compensation and monitoring for agreement with NRW. It is proposed that the Final Plan and the quantity of compensatory habitat required will be agreed with NRW post-installation.

Analysis of soil conditions ascertained through geotechnical investigations has indicated that external cable protection may be required at four locations. The compensatory measures proposed by GIL for the habitat loss of Primary Feature Reef habitat at these locations are:

Reef sub-type	Method of compensation (should burial not be feasible)	Expected results
Bedrock Reef	Deposit of up to 1700m^2 of rock revetment across two locations (surface area of approximately 1768m^2) and deposit of 15 reef blocks (surface area of approximately 320.52m^2).	Colonisation of novel bare surface within 3.5 years.

Reef sub-type	Method of compensation (should burial not be feasible)	Expected results
Stony Reef	Up to 80,000m^2 of rock revetment	Colonisation of novel bare surface within 1 year.
Biogenic Reef	Up to 1,100m^2 of rock revetment	Colonisation of novel bare surface within 5 years.

A Monitoring Plan has been proposed; the objective of which is to establish that the compensatory habitat has become colonised by benthic community similar to that of the baseline Reef habitat. Thus, restoring the habitat to a level that is determined to be, at least equal to, if not enhanced compared to baseline conditions and allows the continued ecological functioning of the area.

The Monitoring Plan proposes that seabed imagery will be acquired and analysed at up to 11 stations. The proposed method follows the below principles:

- At each station, three ~200m long replicate transects will be positioned approximately 50m apart to intersect the cable route at the mid-point.
- Each transect will be split into three sections for analysis; the rock revetment, a north/west control and a south/east control.
- One station each will be selected in the Bedrock Reef and Biogenic Reef sub-types.
- A maximum of eight stations will be selected within the Stony Reef sub-type; corresponding to one every 1km. If the full estimated 8km deposit of external cable protection is not required a maximum of two stations every 1km will be investigated.

Monitoring will be undertaken in the same season, at intervals of 2, 4 and 6-years post-installation. The monitoring surveys will be aligned with the Inspection Surveys necessary to ensure external cable protection is appropriately maintained. Data will be compared against established success indicators (assemblage composition, top 5 taxa, total taxa and abundance) to determine if the monitoring objective has been met. If after six years, monitoring has shown that:

- the objectives for the compensatory habitat have not been met;
- it is clear from analysis of trends in the data the objectives will not be met in the next two years; and
- that there is no downward trend in the condition of the control data which indicates that other environmental factors have contributed to the objectives not being achieved;

Then a course of action will be agreed with NRW to provide additional compensatory habitat. If monitoring has indicated that the Reef Blocks have been successful, consideration will be given as to whether it is appropriate to deposit more structures within the SAC. The number of Reef Blocks to be deposited would depend on the final area of habitat lost to external cable protection. As this cannot be determined until installation is complete it is proposed that a condition of the Marine Licence should be to agree post-installation the quantity of compensatory habitat required should the objectives of the monitoring plan not be met.

Estimate costs for providing the compensation measures outlined in the Plan (including monitoring) are approximately £750,000. GIL is bringing private capital to the project and will assume the majority of the project risks; this includes all costs associated with the compensation plan.

All areas of seabed where compensatory measures are planned are within Welsh territorial waters. The seabed is owned by The Crown and managed on its behalf by The Crown Estate.

GIL is responsible for ensuring that this Plan is implemented.

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1. Introduction

1.1 Overview

Greenlink is a proposed electricity interconnector linking the existing electricity grids in Great Britain (GB) and Ireland. The Greenlink project will consist of two converter stations, one close to the existing substation at Great Island in County Wexford (Ireland) and one close to the existing substation at Pembroke in Pembrokeshire (Wales). The converter stations will be connected by underground cables (onshore) and subsea cables (offshore). The subsea cables will run from Freshwater West, Pembrokeshire (Wales) to Baginbun Beach, County Wexford (Ireland) (Figure 1-1, Drawing P1975-LOC-001).

A Marine Licence Application (MLA, reference CML1929) for Greenlink was submitted by Greenlink Interconnector Limited (GIL) on 24 June 2019 and its examination by Natural Resources Wales (NRW) is currently in progress. On 24 February 2020, NRW issued a Request for Clarification/Further Information relating to the MLA.

With respect to the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC), and in relation to the Primary Feature Reef, NRW advised that

"the potential for colonisation of external cable protection should be considered a compensatory measure not as mitigation and therefore should not downgrade the overall significance of the impact within the appropriate assessment. NRW TE [Technical Experts] consider there is significant loss of Annex I habitat and therefore it must be considered whether the project can proceed under the derogation allowed by Article 6(4) of the Habitats Directive."

NRW invited GIL to provide further evidence on the matters set out in regulations 64 and 68 of the Conservation of Habitats and Species Regulations 2017, namely:

- whether there are any feasible alternative solutions to the project which are less damaging to the affected European site;
- whether there are any imperative reasons of overriding public interest (IROPI) for the project to proceed;
- what compensatory measures are proposed to ensure that the overall coherence of the network of European sites is protected.

Without prejudice to NRW's determination of the MLA and decision with respect to adverse effect on site integrity, this Habitat Compensation Plan (the 'Plan') has been produced to describe the compensatory measures that could be implemented to ensure the coherence of the National Site Network.

Information on the assessment of alternative solutions and IROPI is provided in the Greenlink Marine Habitats Regulations Assessment (document reference P1975_R4710_RevF2).

The information provided in this Plan is based on a 'worst-case' assessment. The preference is to bury the cables in sediment – a process that will not affect the

integrity or coherence of the National Site Network. For areas where burial in sediment is achieved, no compensatory measures will be required. However, soil conditions may not be suitable for burial in all locations, and the deposit of external cable protection may be required. Where the deposit of external cable protection leads to the loss in extent of a Primary Feature of the Pembrokeshire Marine / Sir Benfro Forol SAC, compensatory habitat will be required. The quantity of compensatory habitat required will therefore depend directly on the quantity of external cable protection deposited.

1.2 Principles of Compensatory Measures

Defra (2012) state that compensatory measures can include creation of a comparable habitat, but that the competent authority must have confidence that the compensatory measures will be sufficient to offset the negative effects caused by the project. Compensatory measures should be flexible enough to ensure adequate compensation without going further than necessary.

Successful compensation therefore relies on the project demonstrating, through monitoring, the success or failure of the proposed compensatory measures; recognising that it may take time to establish the compensatory measures to the required quality.

NRW TE have advised that rock revetment can provide compensatory habitat for this specific project, but have requested additional information with respect to evidence gaps relating to the success of colonisation of cable protective measures; a more detailed monitoring strategy; and a further management strategy - should monitoring demonstrate failure or limited success and compensation is deemed not to be successful. This Plan seeks to provide this information.

The Plan is based on the principle that compensatory habitat will have the same surface area as the area of Reef sub-type habitat lost. For the Reef sub-type Bedrock Reef, additional vertical surfaces will be provided (as an enhancement), if the area currently has vertical relief. The surface area of additional vertical surfaces will be equivalent to the surface area of Reef habitat lost.

1.3 Purpose of this Habitat Compensation Plan

This document describes the Habitat Compensation Plan (the 'Plan') proposed for use during the construction and operation of Greenlink.

It outlines how GIL plan to compensate for Reef habitat loss within the Pembrokeshire Marine / Sir Benfro Forol SAC and the monitoring requirements to be implemented to ensure compensation measures are effective.

The intention of Revision 0 of the Plan is to outline the principles of the compensation and monitoring for agreement with NRW. The level of compensatory measures required will depend on the location and quantity of external cable protection deposited and consequently the area of habitat loss. Deposit locations will be refined through an iterative process which will not conclude until the cables

have been installed. Feasibly not all locations indicated in Revision 0 of the Plan will require compensatory measures. Therefore, it is proposed that the final quantity of compensatory habitat required will be agreed with NRW post-installation; but will follow the principles outlined in this Plan.

Revision 0 of the Plan explicitly addresses three requests for clarification from NRW Technical Experts (TE), namely:

- Additional information with respect to evidence gaps relating to the success of colonisation of cable protective measures is presented by the applicant;
- A more detailed monitoring strategy is proposed by the applicant; and
- A further management strategy is proposed should monitoring demonstrate failure or limited success and compensation is deemed not to be successful.

The Plan has been developed following consultation undertaken with NRW TE and follows guidance issued by the Department for Environment, Food and Rural Affairs (Defra 2012).

The Plan:

1. Sets out the areas where compensatory habitat is required; subdividing it by type of Reef habitat affected; and identifying the conservation objectives, target features and ecological processes/functions to be compensated.
2. Details what compensatory measures will be implemented (including location maps, extent and surface area of habitat to be created).
3. Details the current status and conditions of the habitats within the compensatory area.
4. Outlines the expected results (including timeline) and how the proposed measures will compensate the predicted adverse effect on the integrity of the European site.
5. Identifies how the compensatory measures' effectiveness will be measured.
6. Sets out a monitoring plan for the compensatory measures.
7. Estimates the total cost of implementing the measures and how they will be financed.

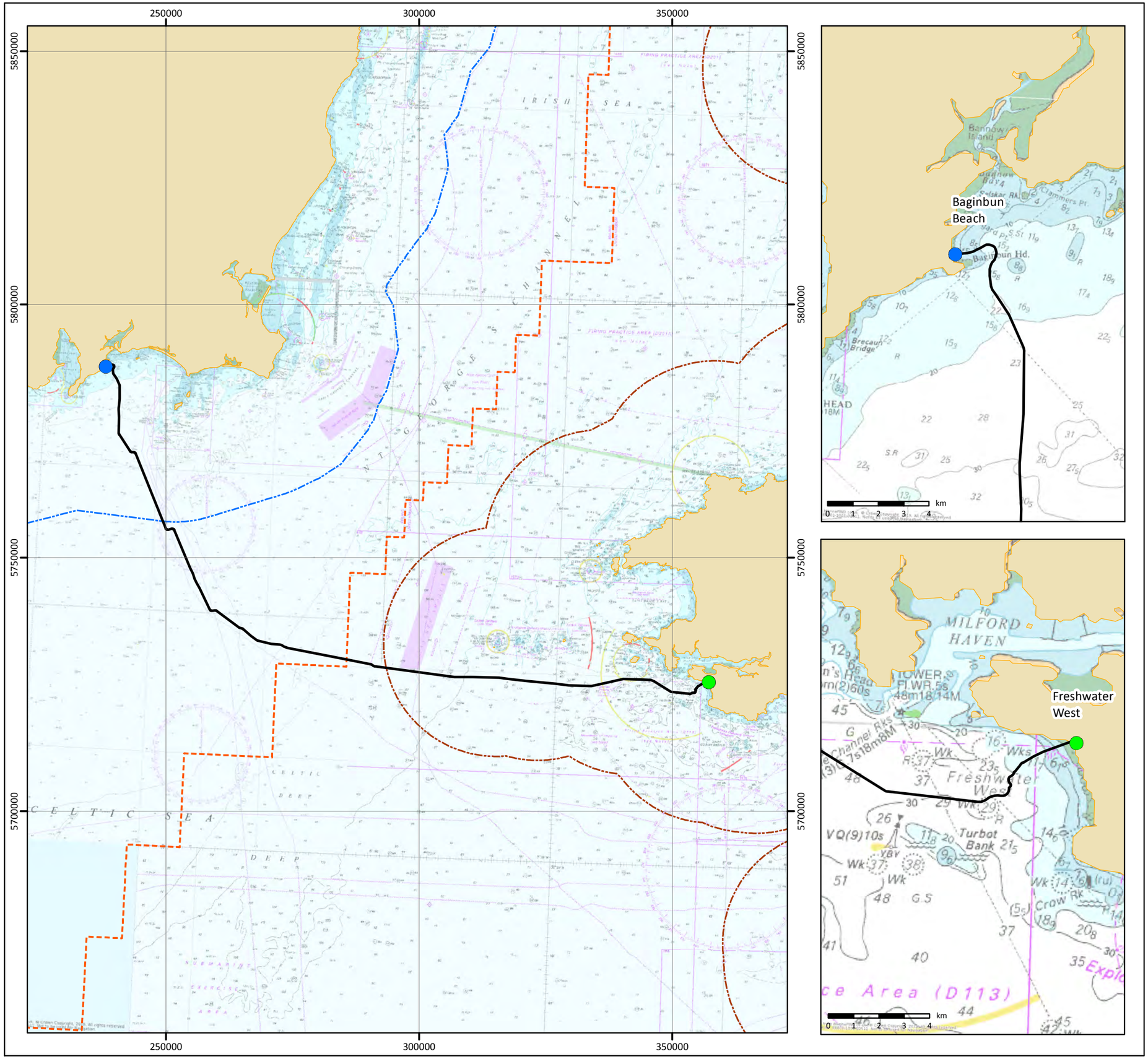
GIL is responsible for ensuring that this Plan is implemented.

All areas of seabed where compensatory measures are planned are within Welsh territorial waters. The seabed is owned by The Crown and managed on its behalf by The Crown Estate.

GREENLINK INTERCONNECTOR

ROUTE OVERVIEW

Drawing No: P1975-LOC-001 | **A**



Legend

Landfall

- Baginbun Beach
- Freshwater West
- Greenlink Route Centreline (Indicative)

Administrative Boundaries

- ROI 12nm Territorial Sea Limit
- UK 12nm Territorial Sea Limit
- Median Line

N
W E
S



NOTE: Not to be used for Navigation

Date	Monday, April 8, 2019 08:45:37
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	DCCAE; UKHO; CDA; GEBCO; MarineFind; Greenlink
File Reference	J:\P1975\Mxd\01_LOC\ P1975-LOC-001.mxd
Created By	Chris Goode
Reviewed By	Emma Langley
Approved By	Anna Farley

Greenlink

Co-financed by the European Union Connecting Europe Facility

intertek

0 10 20 30 40 km

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1.4 Pembrokeshire Marine / Sir Benfro Forol SAC

Pembrokeshire Marine / Sir Benfro Forol SAC is located off the Pembrokeshire coastline, extending from near Abereiddy in north Pembrokeshire to Manorbier in South Pembrokeshire. The site measures 138,038.5 hectares in extent (JNCC 2015). The Annex I habitats and Annex II species which are a Primary reason for the selection of the site are:

- Estuaries
- Large shallow inlets and bays
- Reefs
- Grey seal (*Halichoerus grypus*)
- Shore dock (*Rumex rupestris*)

The Natura 2000 – Standard Data Form (JNCC 2015; dated 22/12/2015) states the Reef habitat within the site covers 40997.43 hectares, accounting for 30% of the site's area.

1.5 External Cable Protection

The Proposed Development crosses the Pembrokeshire Marine / Sir Benfro Forol SAC within Welsh territorial waters for approximately 49.592 km, from Kilometre Point (KP) 0 at the landfall at Freshwater West to KP 49.592. Two high-voltage direct current cables (and a fibre-optic cable) will be bundled together in a single trench.

The cables must be protected from external threats e.g. fishing activity and anchor strikes. The preference is always to bury the cables in the sediment as this offers the best protection, is typically the most economical option and is recognised by the industry and Regulators as the best environmental practice. The target depth of lowering (TDOL)[1] has been calculated as 1.0m to 1.5m by a detailed Cable Burial Risk Assessment for Greenlink (Intertek 2019).

However, soil conditions may not be suitable for burial in all locations. Where underlying bedrock is close to the surface, or sediments have a very high shear strength (e.g. stiff clays), it is possible that trenching or jetting systems would not be capable of achieving cable burial. In these instances, external cable protection is considered.

The locations where potentially external cable protection may be required have been defined based on initial interpretation of the Greenlink cable route survey geophysical and geotechnical data. The assessment took into consideration soil conditions, depth of bedrock, the target depth of lowering (TDOL) and the capabilities of burial equipment to identify locations where burial may not be

[1] This is the depth that will be specified as the target depth to the cable installation contractor. TDOL is a depth which makes best use of what is achievable by industry standard burial tools to gain additional depth beyond the minimum depth of lowering recommended for protection from external threats without incurring a step change in costs. TDOL is also a practical application of depth which considers the effect burial depth has on tool stability.

achieved. A precautionary approach was taken to ensure the Habitats Regulations Assessment (HRA) presented the worst-case.

Four locations have been identified that cross areas of the Primary Feature Reef; other areas within the SAC are not located on sensitive habitat. It is possible that at the four locations, burial can be achieved and Project Specific Mitigation (included in the Greenlink Marine ES) will be implemented to ensure that the Installation Contractor considers burial first and justifies if and where external cable protection is used.

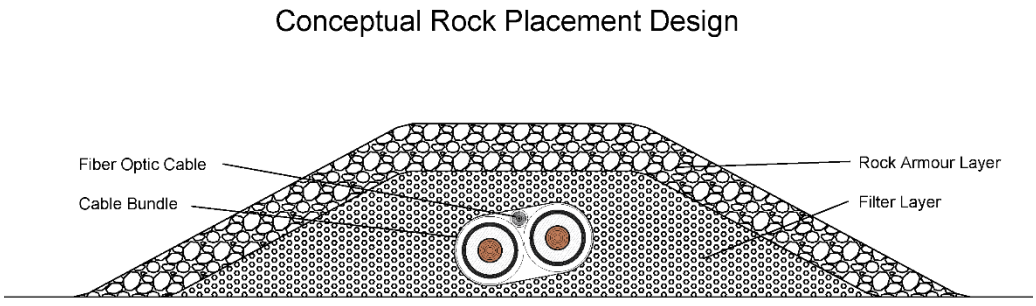
At these four locations, if required, external cable protection will take the form of rock revetment / berms. Justification for the use of this method in comparison to alternatives is provided in the Greenlink Marine HRA (document reference P1975_R4710_RevF2).

The maximum height and width of any rock berms placed will be 1.5m and 10m respectively, with the side slopes of the rock berm being 1 vertical in 2.5 horizontal, which is the natural angle of repose of placed rock. It is likely that the berm will have a flat top, potentially up to 1m wide. A typical rock berm is illustrated in Figure 1-2.

The grade of rocks used will depend on the current and wave loading conditions of the area they will be placed in, with rocks likely to range in size from 2 – 22cm. The larger grades are likely to form the armour on the outside with smaller grades being contained within the berm itself. This is necessary to ensure long-term berm stability.

The Installation Contractor will undertake the final design of the rock berm with the primary objective being to ensure that the rock sizes chosen provide the right level of protection to the cables whilst maintaining berm stability. For example. smaller grades if used in the armour layer may get washed away, compromising berm integrity. Conversely, the use of too large a boulder within the revetment could damage the cables; and would also pose a snagging hazard to other seabed users.

Figure 1-2 Conceptual Rock Placement Design



2. Bedrock Reef

This section describes where and why compensatory habitat is required in the Reef sub-type 'Bedrock Reef'; and how compensatory measures will be implemented for the sub-type.

2.1 Requirement for Compensation

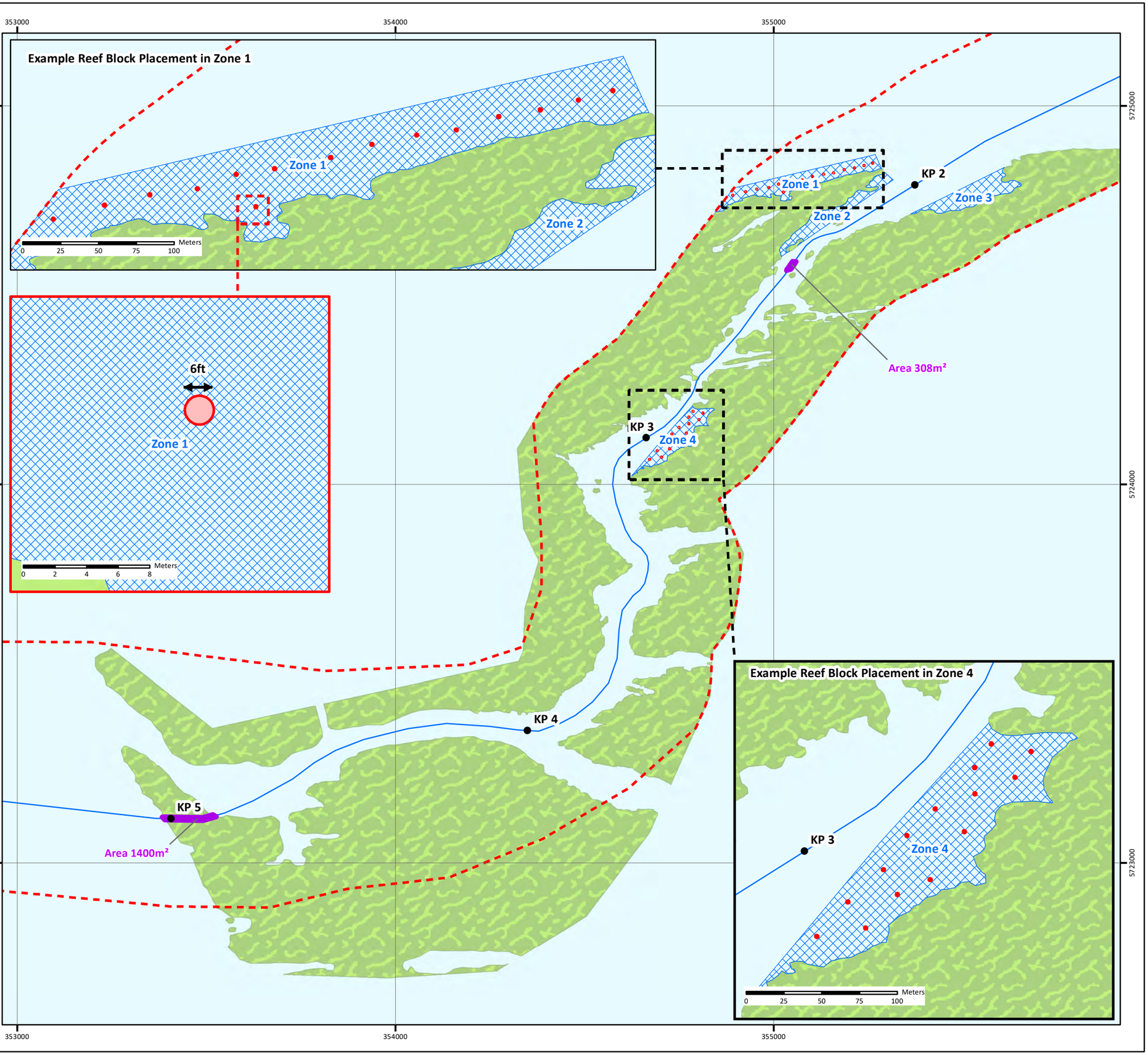
Target Features to be Compensated	**Bedrock Reef** A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock (see Figure 2-2 for representative photograph of habitat)
Conservation Objective	To achieve favourable status, all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status. • Range - The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing. • Structure and function - The physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include; geology, sedimentology, geomorphology, hydrography and meteorology, water and sediment chemistry and biological interactions. • Typical Species - The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include: species richness; population structure and dynamics; physiological health; reproductive capacity; recruitment; mobility; and range.
Ecological processes / functions to be compensated	Range The objective of the compensation is to replace the range of the habitat lost if external cable protection is deposited.
Extent of habitat to be compensated	170m x 10m = 1700m^2
Location of habitat to be compensated (should external cable protection be required)	Two small sections of the Greenlink cable route cross areas of Bedrock Reef. If burial in sediment is not possible due to the ground conditions, external cable protection may be required. The two locations are illustrated in Figure 2-1 (Drawing P1975-INST-017-A) and the exact coordinates provided below: **Area between KP 2.38 and KP 2.41 - approximately 30m long.** Area is a small outcrop with an elevation compared to surrounding seabed of 2m. Grid coordinates (DMS, latitude and longitude respectively): KP 2.38 - 51° 39' 13.017" N, 5° 5' 43.054" W KP 2.41 - 51° 39' 12.208" N, 5° 5' 43.917" W

	Area between KP 4.86 and KP 5.00 – approximately 140m long Grid coordinates (DMS, latitude and longitude respectively): KP 4.86 - 51° 38' 24.326" N - 5° 6' 59.532" W KP 5.00 - 51° 38' 23.749" N - 5° 7' 6.685" W Area is a small sand channel through Bedrock. Sand channel is approximately 1m deeper than surrounding Bedrock. As of the submission of the Greenlink Marine Environmental Statement (Document reference: P1975_R4484_RevF1), this area is considered to lack the characteristic species typical of the EUNIS habitat A4.138 *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock. However, as the sand channel is a thin veneer overlying the Bedrock Reef burial might not be possible and the deposit of external cable protection may be required. As a precaution it has been assumed that a Bedrock Reef habitat could become established within the sand channel between the baseline survey and installation and therefore this area would require compensatory measures.

GREENLINK INTERCONNECTOR

INSTALLATION
Potential Areas for Compensatory Habitat

Drawing No: P1975-INST-017 | **A**



Legend

- KP
- Indicative Greenlink Centreline
- Marine Licence Application Area (Proposed Development)
- Indicative External Cable Protection Area
- Reef Block (6ft diameter)
- Potential Area for Compensatory Habitat

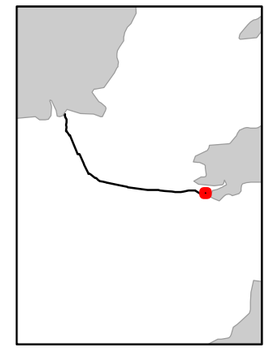
Annex I Habitat Classification

- Bedrock Reef

N W E S

Potential Areas for Compensatory Reef

Zone	Area_m²
1	17116
3	11282
4	10087
2	9617



NOTE: Not to be used for Navigation

Date	03 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	ESRI; MMT
File Reference	J:\P1975\Mxd\15_INST\ P1975-INST-017.mxd
Created By	Chris Dawe
Reviewed By	Chris Carroll
Approved By	Anna Farley

Greenlink

Co-financed by the European Union Connecting Europe Facility

intertek

0 0.1 0.2 0.3 0.4 km

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2.2 Proposed Compensation

Justification for compensation method	If burial in sediment cannot be achieved at the two locations being considered, the use of external cable protection will be required. NRW has agreed that the rock revetment can provide compensatory habitat in this instance. *M. manhattensis* tends to rapidly colonise novel bare surfaces, when such surfaces are found within a few kilometres of existing populations (Stamp 2016). Therefore, the introduction of novel habitat in the form of the rock revetment will provide sufficient surface area for the species to colonise. The rock revetment will have a shallower vertical profile than the existing outcrop at KP2.38; meaning that the surface area could be smaller than that lost and less topographically varied. Therefore, the deposit of Reef Blocks is also proposed (if external cable protection is used). These will increase the vertical surface area available for colonisation and provide a textured surface and 3D complexity that may be lacking in the rock revetment. Previous studies of the colonisation of vertical rock walls by epifauna found that Ascidian species like *M. manhattensis* achieved significant cover across the habitat in less than a year (Stamp 2016). The addition of Reef Blocks will also increase the area of compensatory habitat ensuring that the Range of the Primary Feature is increasing in-line with the Conservation Objective. Further information on the colonisation of artificial substrate by epifauna is detailed in Appendix A of this document.
Method of compensation (Should burial not be possible)	**Deposit of up to 1700m^2 of rock revetment (surface area of approximately 1768m^2) and deposit of 15 reef blocks (surface area of approximately 320.52m^2).** 1. **Rock revetment** Rock berms will be placed over the cable between KP 2.38 – KP 2.41 and KP 4.86 – KP 5.00. The maximum height and width of the berm will be 1.5m and 10m respectively, with the side slopes of the rock berm being 1 vertical in 2.5 horizontal. As such, the rock revetment will cover a maximum area of 1700m^2 and will have a surface area of approximately 1768m^2 (discounting the slope at either end). Figure 1-2 above shows an indicative cross section of a typical rock berm, with smaller grade rock material underlying larger grade material. The rock size will range from 2 – 22cm in size. At KP2.38 the rock outcrop currently protrudes approximately 2m from the surrounding seabed. It is likely that the cables will be laid to one side of the outcrop (rather than going over the top); but there is still the possibility that the rock revetment will cover all or part of the outcrop. The rock revetment will provide similar topographic relief to the existing outcrop. At KP4.86 the sand channel is currently 1m below the surrounding Reef habitat. A rock revetment at this location is likely to partly fill the bathymetric low providing an undulating but more continuous seabed topography.

	2. Reef blocks Up to 15 Goliath Reef Ball modules with full admixtures will be placed within a zone(s) near the existing reef habitat at KP 2.38 – KP 2.41. These are an additional compensatory measure to the rock revetment and will not form part of the revetment; instead they will be in close proximity, next to the reef walls (see Figure 2-1, Drawing P1975-INST-017-A). The purpose of the deposit of the Reef Balls is to provide vertical surfaces for settlement, and larger holes and crevices to provide habitat complexity similar to that currently associated with the rock outcrop. Each module is approximately 1.25m in height, 1.82m in diameter at the base and 0.9m at the top, weighs 2,268kg and contain an average of 35 interconnected holes. The surface texture of the modules is rough to increase the surface area available for colonisation. See Figure 2-3 below for an example of a module. Four zones have been proposed in Figure 2-1, Drawing P1975-INST-017-A. The Reef Balls would be able to fit comfortably into any one these zones. Indicative spacings have been provided for Zones 1 and 4 as an example. The zones have been selected to extend the existing extent of the reef feature, whilst maintaining the morphological feature through the Bedrock Reef.
Current status & condition of habitat in compensatory area	**Areas of Rock Revetment** The extent of Reef habitat within the SAC is reported as 40997.43 hectares (JNCC 2015). Maps showing the extent of 'Reef' habitat are available from the JNCC, which classifies the area according to confidence in the presence of the habitat. The JNCC maps indicate a slightly higher estimate of Reef in the SAC although confidence in some areas is given as low. The habitat maps indicate Bedrock Reef covers an area of 37,700 hectares; approximately 27% of the site. The feature level condition assessment for Reef in the SAC (NRW 2018) gives an overall indicative assessment of 'Unfavourable' (with a confidence level of medium). NRW (2018) states *"The main issue contributing to the unfavourable assessment is high levels of nutrients in the water column (in the Milford Haven waterway but not on the open coast)"*. Within the area where rock revetment compensation will be located, the habitat was classified by the Greenlink environmental baseline survey (MMT 2019) as A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock. The characteristic species of this habitat is *Molgula manhattenis*, a small solitary ascidian (sea squirt) which can form dense aggregations. Analysis of the number and type of species recorded along transects within the potential areas for external cable protection deposit found that, as expected, an Ascidiacea assemblage was the most commonly recorded species, with an average of 5.73 individuals per m^2 being found across each assessed transect. Other commonly observed species included Balanidae (3.23 per m^2), *Dendrodoa grossularia* (1.125 per m^2), *Polycorpa* sp. (2.5% coverage per m^2) and Porifera (1.12% coverage per m^2). In total 22 different species were recorded within the potentially affected areas. Table 2-1 provides full details on the type and abundance of all recorded species.

	Areas for Reef Blocks Within the areas where it is proposed Reef Blocks could be located the habitats were classified by the Greenlink environmental baseline survey (MMT 2019) as follows: **Zone 1 and Zone 3:** A5.261 - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment. **Zone 2:** A5.261 - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment and A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand. **Zone 4:** A5.25 Circalittoral fine sand and A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand. These habitats are typically impoverished sandy communities with bivalves and burrowing polychaetes as the characterising species. The habitats are not a Primary or Qualifying feature of the SAC and do not contribute towards the structure and functioning of the Primary Feature Reef habitat.
Expected results	It is expected that after a period of approximately 3.5 years the benthic community present on the introduced structures will be similar to the surrounding habitat. This statement is based on studies into the colonisation of previously installed infrastructure and reef-building measures. A literature review documenting the evidence to support this conclusion is provided in Appendix A. It is therefore concluded that through the introduction of the rock revetment and reef blocks, which provide the addition of new vertical surfaces for species to colonise, the extent of the existing bedrock reef habitat will be extended as a result of implementation of the compensation measures.
Monitoring of compensatory measures	The monitoring plan to determine the effectiveness of the compensatory measures is outlined in detail in Section 5.

Table 2-1 Baseline data – list of all species recorded within the Bedrock Reef habitat to be compensated

Taxa	Average species density / m²		
	T06	T07	Average across all transects
Annelida			
Sabellaria spinulosa	0.667%	1.40%	1.034%
Arthropoda			
Balanidae	0	6.46	3.23
Inachus sp.	1.35	0	0.675
Paguridae	0.45	0	0.225
Pandalidae	1.8	0	0.9
Bryozoa			
Cellaria sp.	0.1667%	0	0.08%
Celleporidae	0.33	0	0.165
Bryozoa/Cnidaria			
Bryzoa/Hydrozoa turf	0.83%	0.00%	0.42%
Chordata			
Ascidiacea	6.3	5.16	5.73
Dendrodoa grossularia	2.25	0	1.125
Polycarpa sp.	0.00%	5%	2.50%
Cnidaria			
Actiniaria	0	1.3	0.65
Alcyonium digitatum	0.50%	0.40%	0.45%
Caryophyllia smithii	0	1.3	0.65
Hydrozoa	0.1667%	0.2%	0.1834%
Tubularia sp.	0.1667%	0.2%	0.1834%
Porifera			
Axinella sp.	0.667%	0.00%	0.334%
Cliona sp.	0.000%	1.80%	0.900%
Ciocalypta sp	1.33%	0.00%	0.665%
Porifera	1.83%	0.4%	1.115%
Raspalia sp.	0.1667%	0.2%	0.183%
Stelligera sp.	0.00%	0.2%	0.100%

Figure 2-2A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock

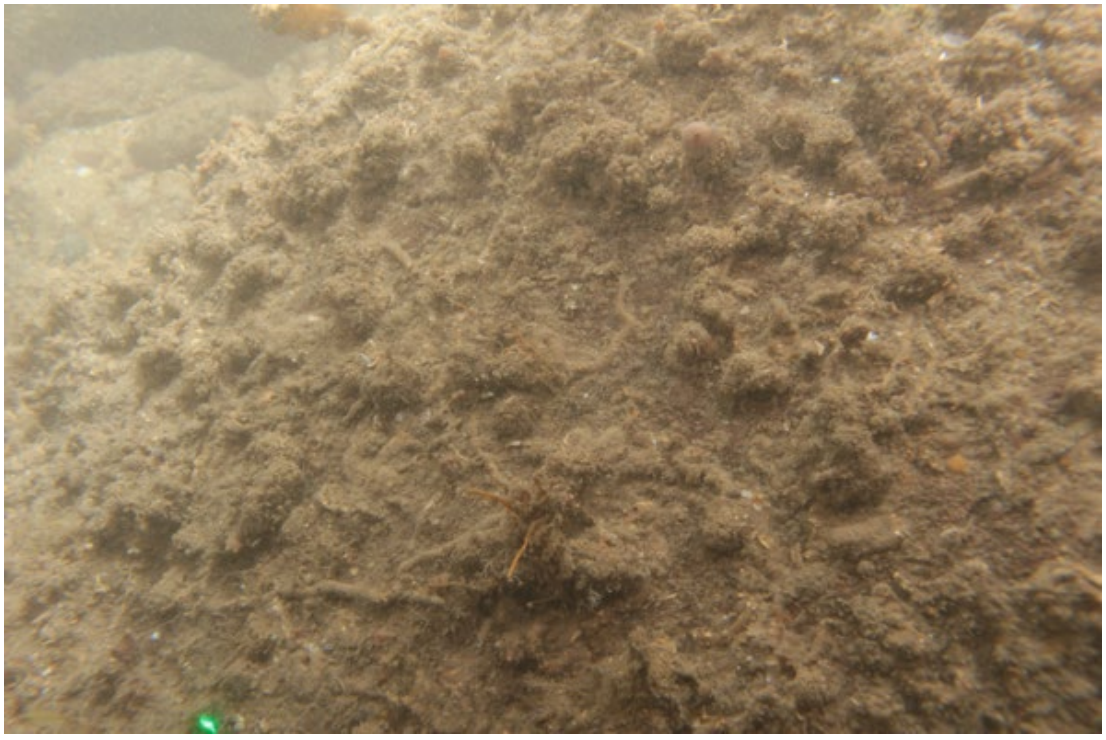
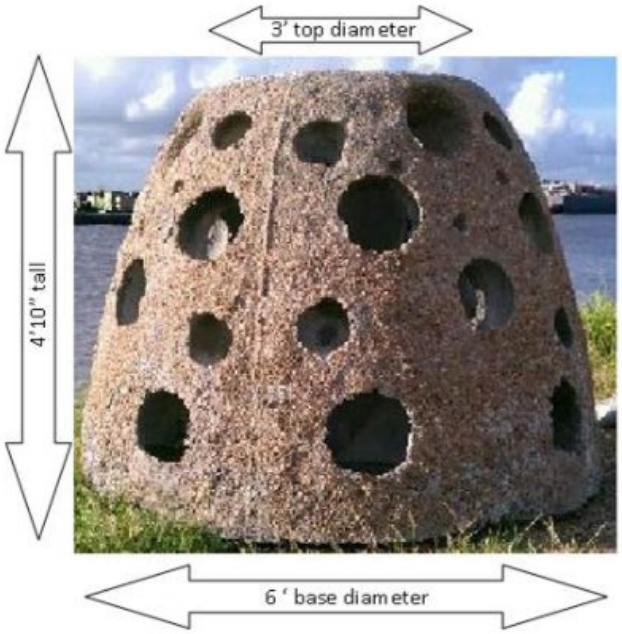


Figure 2-3 Example of a Goliath Reef Ball Module



3. Stony Reef

This section describes where and why compensatory habitat is required in the Reef sub-type 'Stony Reef'; and how compensatory measures will be implemented for the sub-type.

3.1 Requirement for Compensation

Target Features	Medium Grade Stony Reef A5.141 *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
Conservation Objective	To achieve favourable status, all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status. • Range - The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing. • Structure and function - The physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include; geology, sedimentology, geomorphology, hydrography and meteorology, water and sediment chemistry and biological interactions. • Typical Species - The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include: species richness; population structure and dynamics; physiological health; reproductive capacity; recruitment; mobility; and range.
Ecological processes / functions to be compensated	Range The objective of the compensation is to replace the range of the habitat lost by the deposit of external cable protection.
Extent of habitat to be compensated	8000m x 10m = 80,000m² (Worst-case scenario in the event cable burial is not possible along this section of the route)
Location of habitat to be compensated **(should external cable protection be required)**	If burial in sediment is not possible due to ground conditions, external cable protection may be required for all or some of the cable route between KP15 and KP23. This section is illustrated in Figure 3-2, Drawing P1975-INST-020 and the grid coordinates are provided below. Grid coordinates (DMS, latitude and longitude respectively): **KP15:** 51° 39' 46.096" N, 5° 15' 15.799" W **KP23:** 51° 39' 11.917" N, 5° 22' 5.315" W

3.2 Proposed Compensation

Justification for compensation method	If burial in sediment cannot be achieved between the KPs discussed, the use of external cable protection will be required. NRW has agreed that the rock revetment can provide compensatory habitat in this instance. While the typical cobble size within the area of Stony Reef potentially requiring compensation was 6.4cm, the overall makeup of the seabed varied from gravel to boulders, representing a wide diversity in the shape and sizes of rock in the existing habitat. As the grading of rock to be used for the rock revetment will range primarily from 2 – 22cm (with some outliers of increased size due to the production method of the rocks to be used), the introduced rock will comprise a similar range of sizes as that of the naturally occurring habitat. It should however be noted that the larger grades are likely to form the armour on the outside with smaller grades being contained within the berm itself. This is necessary to ensure long-term berm stability. However, the nature of the rock placement means that there will be small nooks and crevices between rocks (i.e. it will not form a continuous casing), introducing a degree of 3D complexity that increases with rock size. The rock revetment will provide a similar diversity in substrata to adhere to and colonise, as the current ground conditions. Previous studies on the colonisation of introduced rock revetment and subsea cables have found that such structures are typically recolonised to a similar degree to that of the surrounding habitat after a period of approximately 3.5 years. Evidence for this conclusion is provided in Appendix A. The inclusion of a mixture of rock sizes was considered as a potential means of increasing the amount of interstitial spaces required for microhabitats; as was the inclusion of larger boulders to increase the amount of vertical surfaces available for settlement. It may still be possible to consider a mixture of rock sizes and this will be discussed with the Installation Contractor post contract award. However, the stability of the berm is the primary objective. The Installation Contractor will need to ensure that the rock sizes chosen provide the right level of protection to the cables whilst maintaining berm stability i.e. smaller grades if used in the armour layer may get washed away, compromising berm integrity. Similarly, the use of large boulders within the revetment could damage the cables. They would also pose a snagging hazard to other seabed users and therefore have been discounted at this location.
Method of compensation (should burial not be possible)	**80,000m² of rock revetment.** In an absolute worst-case scenario where cable burial is not achievable, rock revetment will be placed over an 8km stretch of the route. The maximum height and width of the berm will be 1.5m and 10m respectively, with the side slopes of the rock berm being 1 vertical in 2.5 horizontal. The individual rocks will range in size from 2cm – 22cm. The rock revetment will form an area of compensatory habitat of 80,000m².
Current status & condition of habitat	Annex I Stony Reef habitat is estimated to cover an area of 70km² within the SAC, approximately 0.05% of the site. Within this area, the Proposed Development crosses an area of the EUNIS habitat A5.141, *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. This habitat is characterised by a few

in compensatory area	abundant robust and or fast-growing short-lived species which are able to colonise pebbles and unstable cobbles which are regularly moved by wave and tidal action. Typically, the most abundant species found in this habitat is *Pomatoceros triqueter*, a calcareous tube worm. Analysis of the transect recorded during the environmental survey for the Proposed Development, however, shows that the species was not recorded as present at any point within this section of the cable route. The most commonly recorded species was instead Balanidae, another species typical of this habitat, with an average of 7.4025 individuals per m^2 being recorded across all transects. Other species that were commonly recorded include Ascidiacea (7.0294 per m^2), Anomiidae (7.0014 per m^2), *Gibbula* sp. (3.467 per m^2), Buccinidae (2.3974 per m^2) and *Urticina* sp. (1.8608 per m^2). In total 30 different species were recorded as present within the area potentially requiring external cable protection. Table 3-1 provides full details on the species recorded and their abundance. Analysis of transect surveys conducted for the Proposed Development concluded that the seabed was covered by cobbles greater than 0.064m in diameter for 50% to 80% of the area, with a maximum elevation of 0.2m. These factors, combined with the habitat covering an extent greater than $25m^2$ across each transect, indicated that the area meets the criteria for Medium Grade Stony Reef. A representative image of the habitat is displayed in Figure 3-1 below.
Expected results	An assessment of the habitat A5.141 was conducted in the Habitats Regulations Assessment (Appendix C) for the Proposed Development. The assessment indicates that the characteristic epifauna for the site are of a fast-growing nature, and due to the large extent of the habitat in the Pembrokeshire Marine / Sir Benfro Forol SAC, there will be a good larval supply to support colonisation of the disturbed area. This should result in the rock revetment being colonised to a level similar to that of the surrounding reef habitat within one-year of disturbance. A literature review documenting the evidence to support this conclusion is provided in Appendix A.
Monitoring of compensatory measures	The monitoring plan to determine the effectiveness of the compensatory measures is outlined in detail in Section 5.

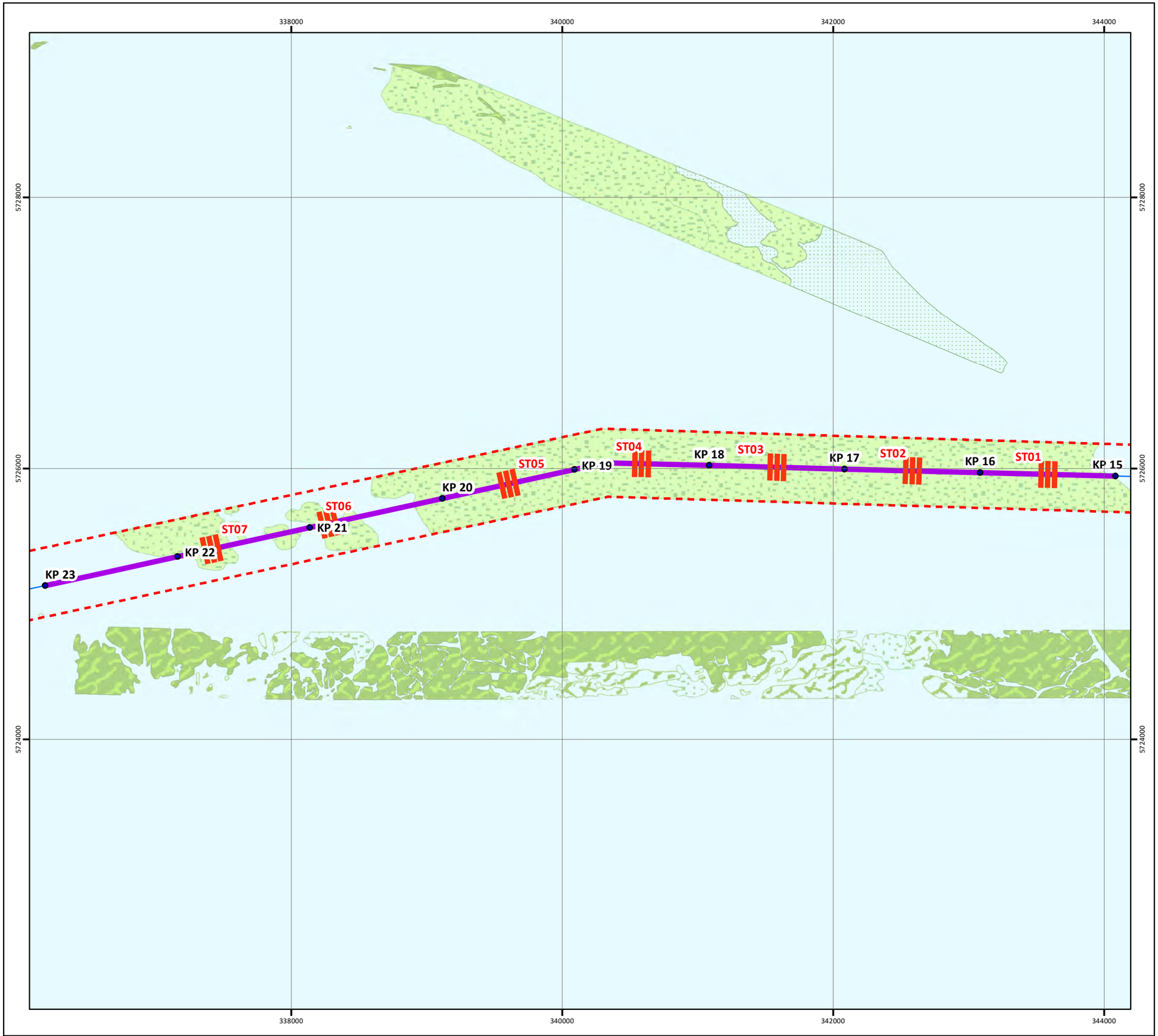
Figure 3-1 A5.141 *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles



Table 3-1 Baseline data – list of all species recorded within the Stony Reef habitat to be compensated

Taxa	Average species density / m²					
	T01	T02	T03	T04	T05	Average across all transects
Annelida						
Sabellaria spinulosa	2.63%	0%	0%	0.57%	0.38%	0.71%
Arthropoda						
Balanidae	0	0.51	2.875	6.59	27.0375	7.4025
Brachyura	0	0	0	0.66	0	0.132
Ebalia sp.	0.575	0	0	0.66	0.675	0.382
Eurynome sp.	0	0	0.575	0.66	0	0.247
Inachus sp.	0	0	0	0	0.675	0.135
Paguridae	1.15	1.53	1.725	1.31	3.375	1.818
Pandalidae	1.725	0	1.15	1.31	2.7	1.377
Xantho sp.	0	0.51	0	0	0	0.102
Bryozoa						
Bryozoa	0.50%	0.55%	0.50%	0.29%	0%	0.37%
Chordata						
Ascidiacea	1.15	1.022	0.575	0	32.4	7.0294
Dendrodoa grossularia	0	0	0.575	0	0	0.115
Didemnidae	0%	0%	0.25%	0%	0%	0.05%
Cnidaria						
Actiniaria	0	1.022	0	0	1.35	0.4744
Hydrozoa	0%	0%	0.25%	0%	0%	0.05%
Sagartiidae	0	0.511	0.575	0	1.35	0.4872
Urticina sp.	1.15	2.044	3.45	1.31	1.35	1.8608
Echinodermata						

Taxa	Average species density / m²					
	T01	T02	T03	T04	T05	Average across all transects
Asterias rubens	0	0	0	0.66	0	0.132
Asteroidea	0	0	0.575	0	0	0.115
Ophiurida	0	0.511	0	0	0	0.1022
Mollusca						
Anomiidae	1.15	7.677	19.575	5.93	0.675	7.0014
Buccinidae	2.3	1.022	4.025	3.29	1.35	2.3974
Gastropoda	2.3	0	1.15	0.66	1.35	1.092
Gibbula sp.	2.3	4.6	9.775	0.66	0	3.467
Nudibranchia	0	0	0.575	0	0	0.115
Patelloidea	0	0	0.575	0	0	0.115
Pectinidae	1.15	0	0	0	0.675	0.365
Polyplacophora	0	0.511	0	0	0	0.1022
Trochidae	1.15	0.511	1.725	0.66	0.675	0.9442
Porifera						
Porifera	0%	0.33%	0.125%	0.43%	0%	0.177%



GREENLINK INTERCONNECTOR

INSTALLATION
Rock Protection and Monitoring
KP 15 - KP 23

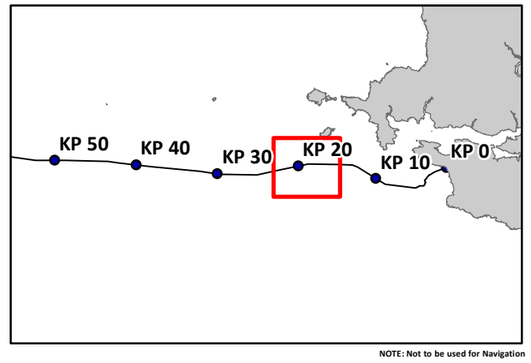
Drawing No: P1975-INST-020 | **A**

Legend

- KP
- Greenlink Route Centreline
- Marine Licence Application Area (Proposed Development)
- Monitoring Transect
- External Cable Protection Area

Annex I Habitat Classification

- Bedrock Reef
- Low/Medium Grade Stony Reef
- Potential Bedrock Reef
- Potential Biogenic Reef
- Potential Stony Reef



NOTE: Not to be used for Navigation

Date	08 April 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	MMT; Greenlink; OSOD
File Reference	J:\P1975\Mxd\15_INST\ P1975-INST-020.mxd
Created By	Chris Dawe
Reviewed By	Chris Carroll
Approved By	Emma Storey

Co-financed by the European Union Connecting Europe Facility

0 0.25 0.5 0.75 1 Kilometers

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4. Biogenic Reef

This section describes where and why compensatory habitat is required in the Reef sub-type 'Biogenic Reef'; and how compensatory measures will be implemented for the sub-type.

4.1 Requirement for Compensation

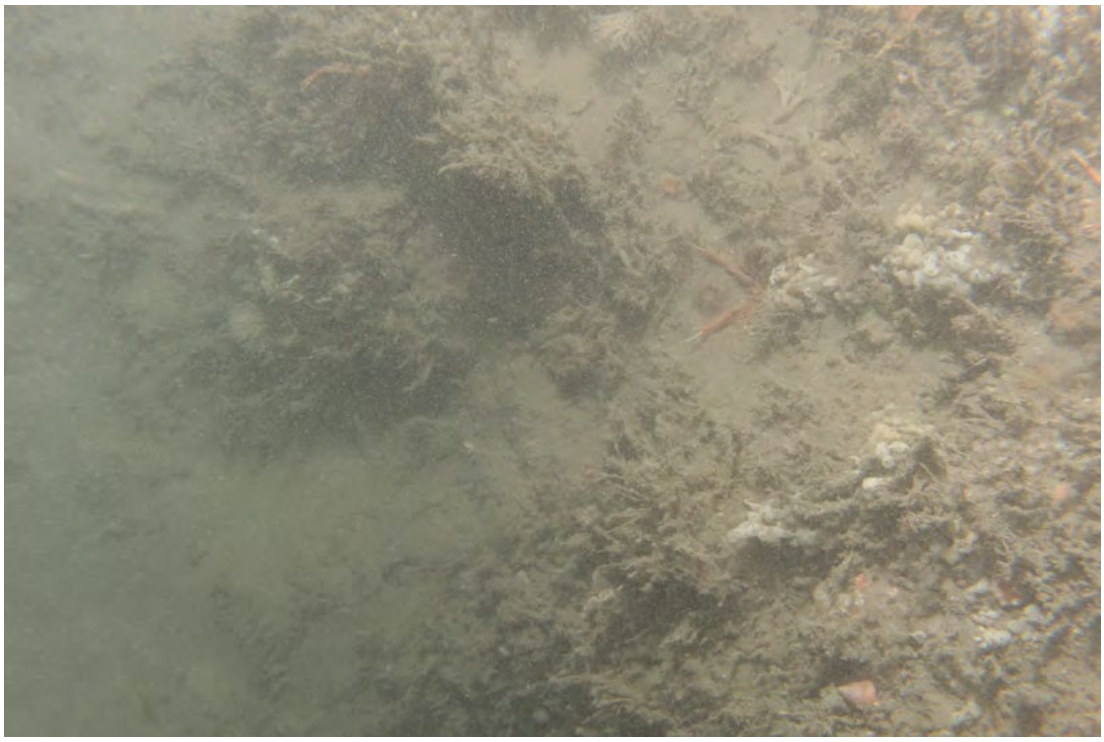
Target Features	Biogenic Reef A5.611 *Sabellaria spinulosa* on stable circalittoral mixed sediment
Conservation Objective	To achieve favourable status, all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status. • Range - The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing. • Structure and function - The physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include; geology, sedimentology, geomorphology, hydrography and meteorology, water and sediment chemistry and biological interactions. • Typical Species - The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include: species richness; population structure and dynamics; physiological health; reproductive capacity; recruitment; mobility; and range.
Ecological processes / functions to be compensated	Range The objective of the compensation is to replace the range of the habitat lost by the deposit of external cable protection.
Extent of habitat to be compensated	The section of route that may require external cable protection stretches approximately 2km. However, it only crosses Biogenic Reef for 110m. 110m x 10m = 1100m^2
Location of habitat to be compensated (should external cable protection be required)	If burial in sediment is not possible due to ground conditions, external cable protection may be required for all or some of the cable route between KP42 and KP44. This section is illustrated in Figure 4-2, Drawing P1975-INST-021. The section of this area within Biogenic Reef lies between KP43.89 and KP44.0; the grid coordinates for which are provided below. Grid coordinates (DMS, latitude and longitude respectively): **KP43.89:** 51° 39' 28.498" N, 5° 40' 06.107" W **KP44.00:** 51° 39' 48.433" N, 5° 40' 11.831" W

4.2 Proposed Compensation

Justification for compensation method	If burial in sediment cannot be achieved between the KPs discussed, the use of external cable protection will be required. NRW has agreed that the rock revetment can provide compensatory habitat in this instance. Studies of *S. spinulosa* colonisation on artificial hard substrates has found that the species has been recorded on a wide range of surfaces of differing material types (Orsted 2018). Examples of colonised structures include concrete Tecnoreef barriers in the northern Adriatic Sea, exposed subsea pipeline in the North Sea, and other natural substrata such as dead mussel and oyster shells and sandy gravel and rock (Orsted 2018). As such the rock revetment will not preclude the development of the existing potential biogenic reef habitat. Further details on *S. spinulosa* colonisation are provided in Appendix A of this document. The use of rock revetment as a compensatory habitat will also introduce a stable habitat for the inclusion of slower growing organisms, provide 3D complexity with the introduction of nooks and crevices to provide shelter for multiple species and will provide a topographic high in area of relatively flat but gently sloping seabed.
Method of compensation (should burial not be possible)	**1100m² rock revetment.** In a worst-case scenario where cable burial is not achievable, rock revetment will be placed over a 110m stretch of the route which has currently been identified as containing Biogenic Reef habitat. The maximum height and width of the berm will be 1.5m and 10m respectively, with the side slopes of the rock berm being 1 vertical in 2.5 horizontal. The individual rocks will range in size from 2cm – 22cm. As such, the rock revetment will form compensatory habitat with an area of 1100m².
Current status & condition of habitat in compensatory area	Potential Biogenic Reef habitat was found to be present between KP43.89 and KP44. This conclusion was based on the analysis of geophysical data indicating a difference in texture between this area and the surrounding seabed, as well as the frequent occurrence of *S. spinulosa* at grab sample site S24, located at approximately KP46.981. Given the similarity in geophysical data and samples taken from the surrounding seabed, the area was classed as the EUNIS habitat A5.611 (*Sabellaria spinulosa* on stable circalittoral mixed sediment). While no samples or transects were undertaken between KP43.86 and KP44 directly, data from grab sample site S24, given its' proximity to the area, can give a likely approximation of the species makeup of the area. The seabed at this grab sample was comprised of gravelly sand, occasional cobbles and boulders and remnants of *S. spinulosa*. The infauna was characterised by an abundance of *S. spinulosa*, with other characterizing species including *Ampharete lindstroemi, Lumbrineris cingulate, Ampelisca spinipes* and *Kellia suborbicularis*. A representative image of the habitat is presented in Figure 4-2 below.
Expected results	Based on previous studies of *S. spinulosa* colonisation (See Appendix A), it is expected that the novel hard substrate introduced to the seabed in the form of the rock revetment will provide habitat for *S. spinulosa* larvae to adhere to and colonise. Recovery of the habitat to a similar level of coverage or species abundance as identified pre-installation is expected to occur over a short timeframe (up to 5 years). Evidence supporting this expected result is provided in Appendix A.

Monitoring of compensatory measures	The monitoring plan to determine the effectiveness of the compensatory measures is outlined in detail in Section 5.

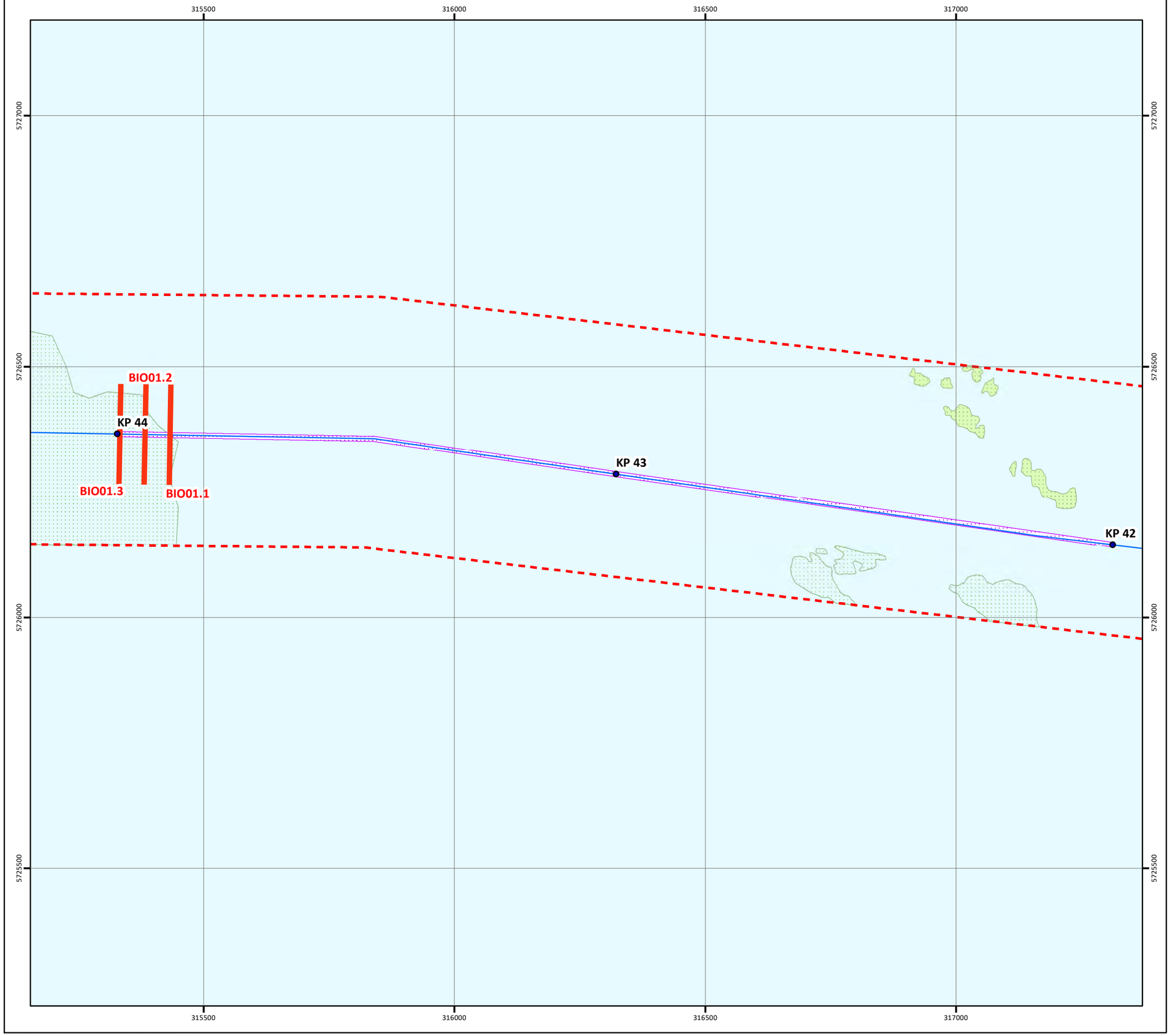
Figure 4-1 A5.611, *Sabellaria spinulosa* on stable circalittoral mixed sediment



GREENLINK INTERCONNECTOR

INSTALLATION
Rock Protection and Monitoring
KP 43.89 - KP 44

Drawing No: P1975-INST-021 | **A**



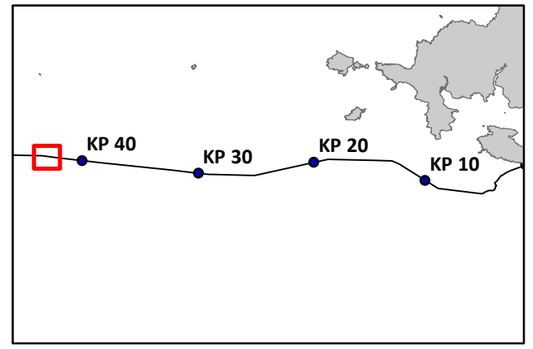
Legend

- KP
- Greenlink Route Centreline
- Marine Licence Application Area (Proposed Development)
- Monitoring Transect
- External Cable Protection Area

Annex I Habitat Classification

- Low/Medium Grade Biogenic Reef
- Potential Biogenic Reef

N
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5. Monitoring Plan

5.1 Overview

Revision 0 (April 2020) of this monitoring plan is based on indicative external cable protection locations identified from analysis of the Greenlink cable route survey data; as presented in the Greenlink Marine ES. The preference is to bury the cables in sediment and as such the areas indicated as requiring external cable protection are areas where ground conditions may preclude burial. This is based on a 'worst-case' assessment i.e. the largest area has been considered.

The refinement of the locations and quantities for the deposit of external cable protection will be an iterative process following the below sequence:

1. Selected Installation Contractor undertakes Burial Assessment Study (BAS) and determines potential external cable protection locations.

   BAS is informed by the Greenlink cable route survey data, and individual installation equipment specifications. It will outline the degree of confidence the Installation Contractor has at achieving the required burial depth at any given location. The preference will always be to bury in sediment, as external cable protection is comparatively more expensive.

2. Installation Contractor undertakes planned trenching.

   During installation the Installation Contractor will monitor equipment performance to determine if the required burial depth is achieved. If the required burial depth is not achieved a decision will be taken as to whether to take remedial measures (i.e. another pass with the equipment, a switch to a different tool) or to use external cable protection.

3. Locations of external cable protection confirmed

   Based on the results of Step 2 the final positions for external cable protection will be identified.

Therefore, not all locations indicated in Revision 0 may require monitoring. The intention of Revision 0 is to outline the principles of the monitoring for agreement with NRW. The Monitoring Plan will be updated once the exact details of the locations of external cable protection is confirmed.

5.2 Monitoring Objective

The objective of the monitoring is to establish that the compensatory habitat (rock revetment and artificial reef blocks) has become colonised by benthic community similar to that of the baseline Reef habitat at the specific location and surrounds. Thus, restoring the habitat to a level that is determined to be, at least equal to, if not enhanced compared to baseline conditions and allows the continued ecological functioning of the area.

5.3 Principles

The Monitoring Plan proposes that seabed imagery will be acquired and analysed at up to 11 stations. The proposed method is similar to that reported in Sheehan et al (2018) used for post-installation monitoring of rock revetment on Wave Hub, Cornwall, UK. It follows the below principles:

- At each station, three ~200m long replicate transects will be positioned approximately 50m apart to intersect the cable route at the mid-point.
- Each transect will be split into three sections for analysis; the rock revetment, a north/west control and a south/east control.
- One station each will be selected in the Bedrock Reef and Biogenic Reef sub-types.
- A maximum of eight stations will be selected within the Stony Reef sub-type; corresponding to one every 1km. If the full estimated 8km deposit of external cable protection is not required a maximum of two stations every 1km will be investigated.

Monitoring will be undertaken in the same season, 2, 4 and 6-years post-installation. The monitoring surveys will be aligned with the Inspection Surveys necessary to ensure external cable protection is appropriately maintained. Data will be compared against established success indicators to determine if the objective set out in Section 5.2 have been achieved. Monitoring will cease once the success indicators have been met, else compensation will be reviewed with NRW 6-years post-installation.

5.4 Method

To assess the development of epibenthic assemblages on the rock revetment, relative to the surrounding environment, seabed imagery will be acquired at up to 11 stations at pre-defined locations. To ensure statistical comparisons can be attributed to the effects being monitored i.e. the rock revetment deposit, rather than being an artefact of an environmental gradient, controls and affected sites will be spatially interspersed.

At each site, three replicate ~200m video transects will be conducted perpendicular to the cable route. Replicate transects will be placed ~50m apart, and each one will intersect the cable route at the transect mid-point.

Each transect will be split into three sections for analysis; cable footage and north/west and south/east control footage. Control footage will be a minimum of 20m distance from the rock revetment. In the area of Bedrock reef sub-type the control footage should include adjacent Bedrock Reef i.e. it should not focus on the sediment channel and transects may be extended to accommodate this if necessary.

Monitoring surveys will follow NE Atlantic Marine Biological Analytical Quality Control (NMBAQC) guidelines of current best practice for the interpretation of video and stills imaging data of benthic substrata and epibenthic species (Turner *et al.* 2016).

High resolution digital photography (stills and video footage) will be acquired by 'drop-down technique' (or suitable alternative e.g. remotely operated vehicle) to identify biotope, abundance of species and species coverage.

A live feed will be displayed on a monitor and photographs will be taken continually along the selected transects. Whenever a photograph is taken this information will be relayed to the on-line surveyor and a positional fix taken of the USBL (Ultra Short Baseline) beacon attached to the camera frame (NB recommended, although if USBL beacon is not available, alternative positioning equipment will be considered). Accuracy of positioning will be <10m if possible. Photographs will be time stamped to allow cross-checking with fixes in the event of a discrepancy between the numbers of fixes and photographs.

Seabed footage from the video camera will be recorded simultaneously onto two DVD discs (as a backup of the data) or Hard disk with backup. A video overlay will be used to display a navigation string from the ship's navigation system onto the video feed. The coordinates given on the string will be the actual coordinates of the USBL (Ultra Short Baseline) beacon attached to the camera frame. The navigation string will include the following:

- coordinated universal time (UTC)
- date, easting and northing
- depth of station
- survey location
- station number.

Along the transects photographs should be taken at 5 second intervals, with accompanying video recording.

The video / stills camera system will have the following specification as a minimum:

- High resolution (minimum 3 megapixels) digital video and stills camera system
- Dedicated flash gun and lamps to provide accurate exposure control
- Optical zoom
- Automatic and manual focus
- Onboard memory (standard 256Mb)
- Functions to be operated remotely via an umbilical with associated software.
- Video Overlay unit - overlay client details, station number, date, time, depth, and camera position
- DVD recorders - or dedicated hard disk with back-up.

The camera housing will be tested to the water depth appropriate to the monitoring area. Additional lights will also be required such as 300W halogen floodlights.

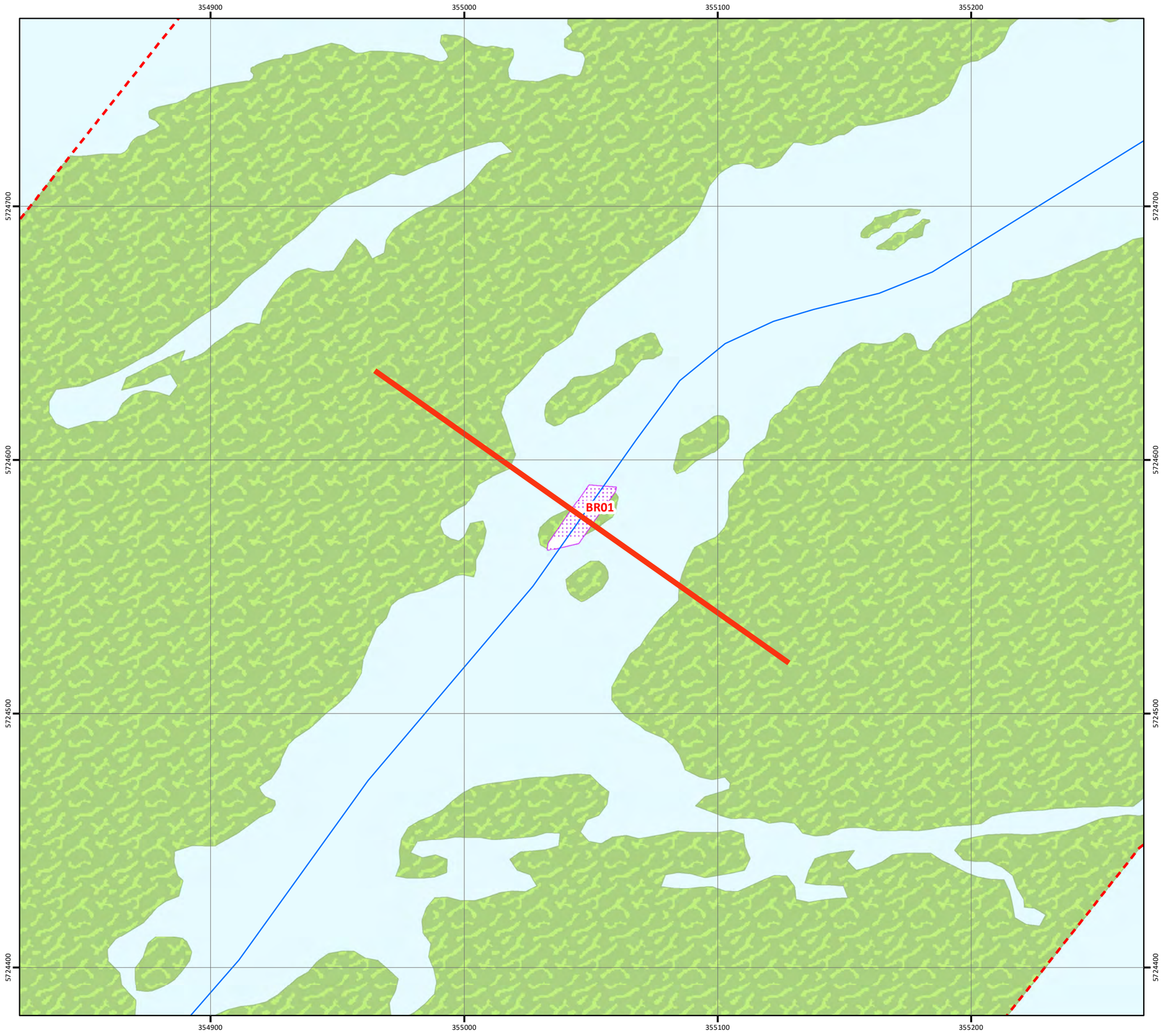
Final locations of stations to be selected following cable installation and confirmation of as-laid positions of external cable protection. However, the maximum number of stations likely to be required is indicated in Table 5-1. Current proposed station positions are shown in Figures 5-1 to 5-4 (Drawings P1975-INST-018, P1975-INST-019, P1975-INST-020, P1975-INST-021).

Table 5-1 presents the worst-case external cable protection requirements within the Medium Grade Stony Reef habitat i.e. an 8km long revetment. It is possible that this entire length will not be required and could instead be replaced by short sections. In this situation the following parameters will be used to determine the spacing of the Stations.

- A maximum of seven Stations will be selected between KP15 and KP23.
- Stations will be spaced 1km apart or no more than two every one kilometre.

Table 5-1 Indicative Station Locations

Reef sub-type	Station	Transect ID	Length (m)	Start (Decimal Degrees)		End (Decimal Degrees)	
				Latitude	Longitude	Latitude	Longitude
Bedrock Reef	Station BR01	BR01.1	200	51.6530	-5.0942	51.6540	-5.0966
	Station BR02	BR02.1	200	51.6391	-5.1166	51.6409	-5.1175
		BR02.2	200	51.6390	-5.1177	51.6408	-5.1178
		BR02.3	200	51.6390	-5.1184	51.6408	-5.1185
	Compensation habitat BR03		200	TBC - dependant on area selected for compensation habitat			
Medium Grade Stony Reef	Station ST01	ST01.1	200	51.6619	-5.2609	51.6637	-5.2609
		ST01.2	200	51.6619	-5.2616	51.6637	-5.2616
		ST01.3	200	51.6619	-5.2623	51.6637	-5.2623
	Station ST02	ST02.1	200	51.6618	-5.2753	51.6636	-5.2754
		ST02.2	200	51.6618	-5.2761	51.6636	-5.2761
		ST02.3	200	51.6618	-5.2768	51.6636	-5.2768
	Station ST03	ST03.1	200	51.6618	-5.2898	51.6636	-5.2898
		ST03.2	200	51.6618	-5.2905	51.6636	-5.2905
		ST03.3	200	51.6618	-5.2912	51.6636	-5.2913
	Station ST04	ST04.1	200	51.6617	-5.3042	51.6635	-5.3043
		ST04.2	200	51.6618	-5.3050	51.6636	-5.3050
		ST04.3	200	51.6618	-5.3057	51.6635	-5.3057
	Station ST05	ST05.1	200	51.6602	-5.3188	51.6619	-5.3195
		ST05.2	200	51.6603	-5.3181	51.6620	-5.3188
		ST05.3	200	51.6600	-5.3195	51.6618	-5.3202
	Station ST06	ST06.1	200	51.6573	-5.3371	51.6590	-5.3378
		ST06.2	200	51.6572	-5.3378	51.6589	-5.3385
		ST06.3	200	51.6570	-5.3385	51.6588	-5.3392
	Station ST07	ST07.1	200	51.6553	-5.3495	51.6571	-5.3502
		ST07.2	200	51.6552	-5.3502	51.6569	-5.3509
		ST07.3	200	51.6551	-5.3509	51.6568	-5.3516
Potential Biogenic Reef	Station BIO01	BIO01.1	200	51.6570	-5.6684	51.6588	-5.6685
		BIO01.2	200	51.6570	-5.6691	51.6588	-5.6692
		BIO01.3	200	51.6570	-5.6699	51.6588	-5.6699



GREENLINK INTERCONNECTOR

INSTALLATION
Rock Protection and Monitoring
KP 2.38 - KP 2.41

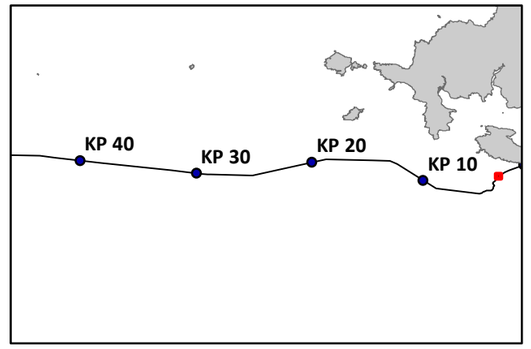
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Legend

- Greenlink Route Centreline
- Marine Licence Application Area (Proposed Development)
- Monitoring Transect
- External Cable Protection Area

Annex I Habitat Classification

- Bedrock Reef



NOTE: Not to be used for Navigation

Date	08 April 2020
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Projection	Transverse Mercator
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Data Source	MMT; Greenlink; OSOD
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GREENLINK INTERCONNECTOR

INSTALLATION
Rock Protection and Monitoring
KP 4.88 - KP 5.02

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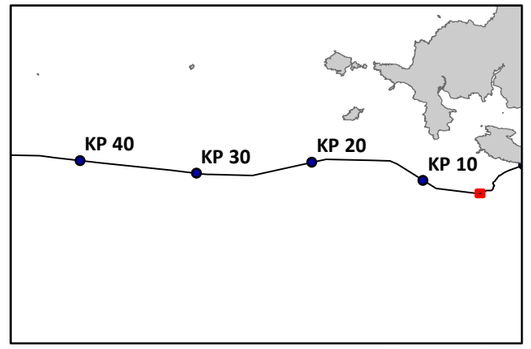
Legend

- KP
- Greenlink Route Centreline
- Marine Licence Application Area (Proposed Development)
- Monitoring Transect
- External Cable Protection Area

Annex I Habitat Classification

- Bedrock Reef

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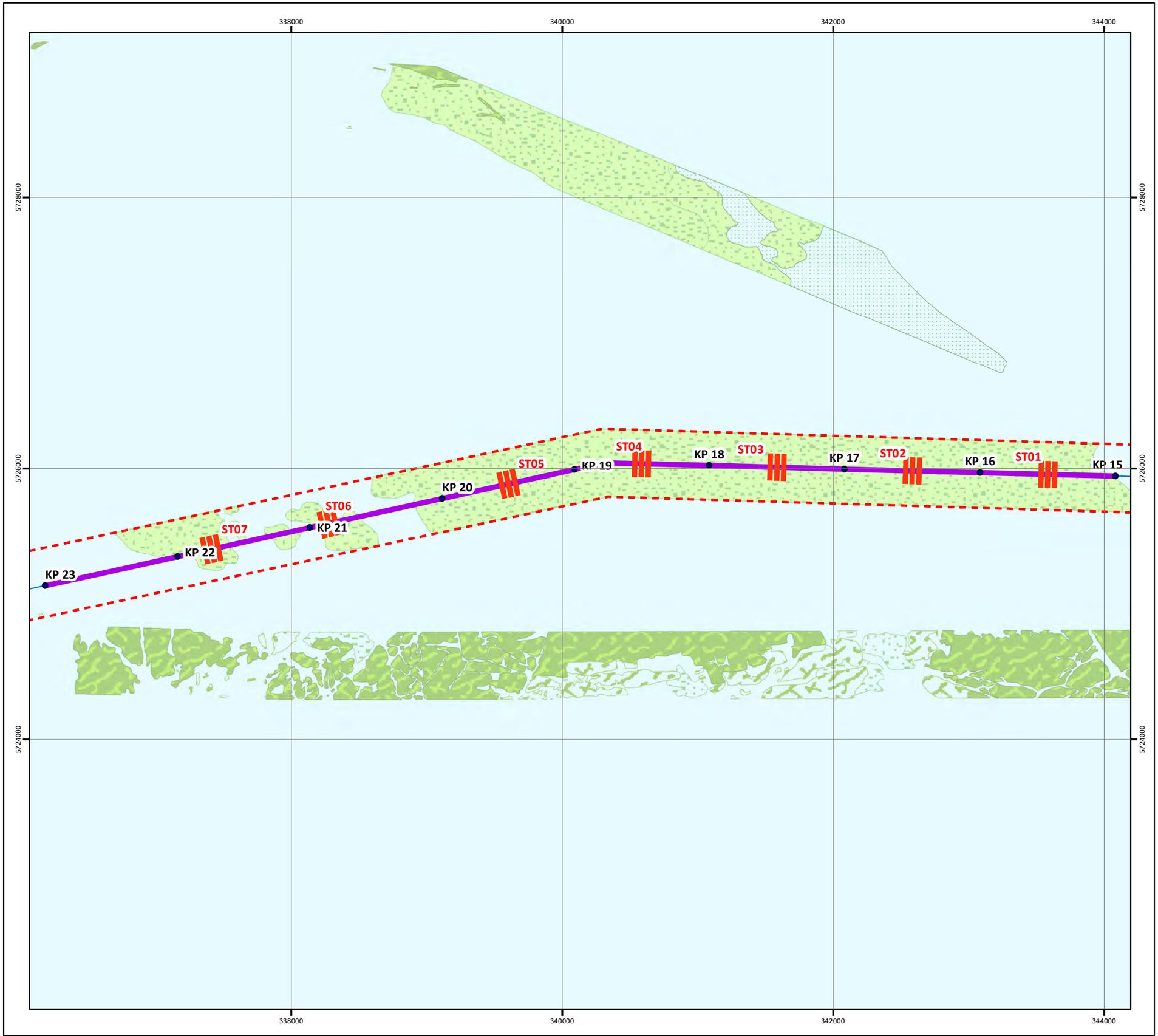
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GREENLINK INTERCONNECTOR

INSTALLATION
Rock Protection and Monitoring
KP 15 - KP 23

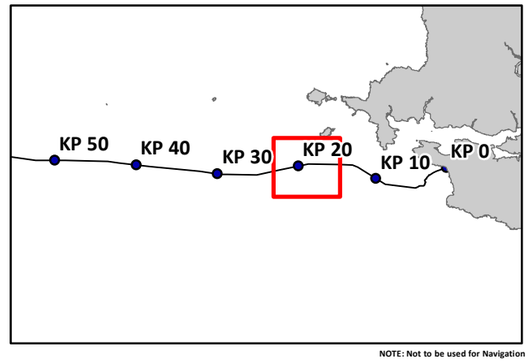
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Legend

- KP
- Greenlink Route Centreline
- Marine Licence Application Area (Proposed Development)
- Monitoring Transect
- External Cable Protection Area

Annex I Habitat Classification

- Bedrock Reef
- Low/Medium Grade Stony Reef
- Potential Bedrock Reef
- Potential Biogenic Reef
- Potential Stony Reef



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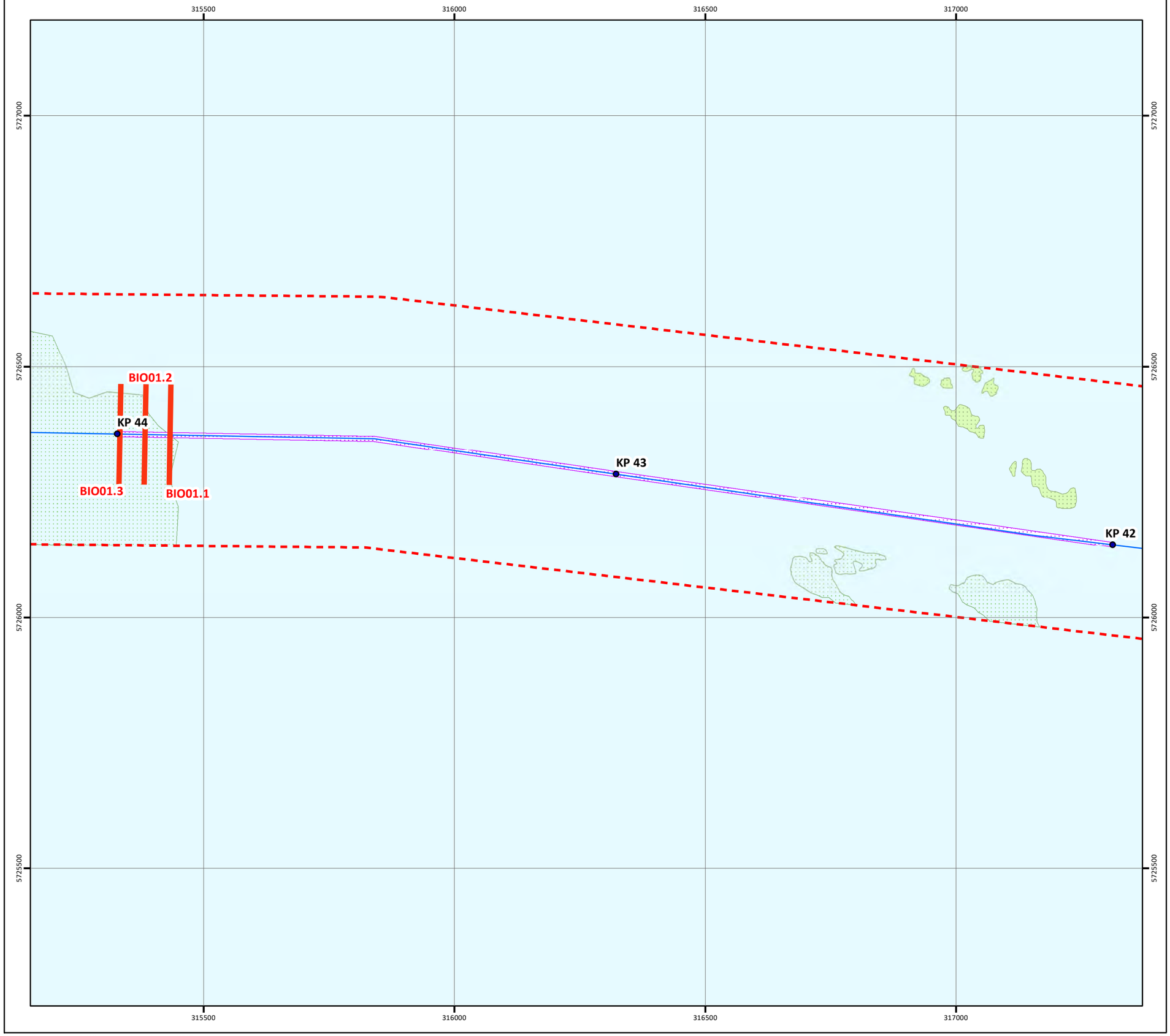
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KP 43.89 - KP 44

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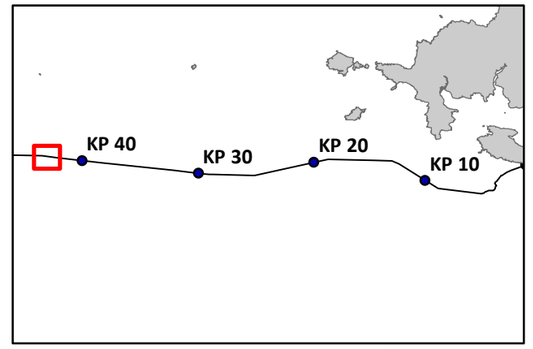
Legend

- KP
- Greenlink Route Centreline
- Marine Licence Application Area (Proposed Development)
- Monitoring Transect
- External Cable Protection Area

Annex I Habitat Classification

- Low/Medium Grade Biogenic Reef
- Potential Biogenic Reef

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NOTE: Not to be used for Navigation

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5.4.2 Timing

Once the Installation Contractor has undertaken their BAS and confirmed likely locations for external cable protection the transect locations will be confirmed.

A transect will be acquired at each agreed location prior to installation to establish the current baseline environment. Thereafter, monitoring surveys will be undertaken in the same season 2, 4 and 6-years post-installation. Monitoring will terminate once the objective has been achieved (as set out in Section 5.1), else compensation will be reviewed with NRW 6-years post-installation.

5.5 Success Indicators

Success indicators have been identified to determine whether the objective, defined in Section 5.2, has been achieved. The success indicators are as follows:

1. Assemblage composition – The epibenthic assemblage between the cable and the controls should be statistically similar as demonstrated by permutational multivariate analysis of variance, Bray Curtis similarity or similar.
2. Taxa - The top five most abundant species identified in the controls should be present on the compensatory habitat.
3. Number of taxa – the number of taxa on the cable should be statistically similar or increased in comparison to the controls.
4. Abundance - There should be an equal or increased level of biodiversity than that present in the controls, as determined by biodiversity measures (e.g. Simpson's index).

In addition, non-native species should be identified in order to manage risks of new reefs acting as ecological stepping-stones for these species. If non-native species are identified these must be discussed with NRW and a course of action agreed. This could be to monitor the situation; or take steps to discourage or remove the species.

If after six years, monitoring has shown that:

- the objectives for the compensatory habitat have not been met;
- it is clear from analysis of trends in the data the objectives will not be met in the next two years; and
- that there is no downward trend in the condition of the control data which indicates that other environmental factors have contributed to the objectives not being achieved;

Then a course of action will be agreed with NRW to provide additional compensatory habitat. If monitoring has indicated that the Reef Blocks have been successful consideration will be given as to whether it is appropriate to deposit more structures within the SAC. The number of Reef Blocks to be deposited would depend on the final area of habitat lost to external cable protection. As this cannot be determined until installation it is proposed that a condition of the Marine Licence should be to

agree post-installation the quantity of compensatory habitat required should the objectives of the monitoring plan not be met.

6. Costs & Financing

6.1 Estimated Cost

Table 6-1 provides an estimate of the cost of the compensatory measures and the assumptions costs are based on.

Table 6-1 Estimate costs for compensatory habitat and monitoring

Activity		Cost	Assumptions
Reef Blocks	Procurement	£9,900	15 Reef Blocks Cost per unit £600 Includes 10% contingency to allow for exchange rate fluctuations & inflation
	Installation	£260,000	Day rate = £26,000 (including vessel hire, diving, surveying & underwater positioning, tooling, consumables, slings etc) 10-day campaign (including mobilisation, demobilisation & weather contingency)
Rock revetment	Installation	-	If required, rock revetment will be a necessary part of the cable installation and not an additional cost. It is therefore included in the overall project cost.
Monitoring Plan	Baseline	£171,500	11 stations £1500 per station based on ROV (higher cost than DDV) Day rate for vessel = £45,000 3-day campaign (excludes mobilisation & demobilisation as part of planned inspection surveys). Includes £20,000 for charting & reporting by survey contractor 3% inflationary increase on costs per year. Values have been rounded up to nearest £1000.
	Year-2	£182,000	
	Year-4	£194,000	
	Year-6	£206,000	

6.2 Financing

Greenlink Interconnector Limited is bringing all necessary private equity to the project and will assume the majority of the project risks; this includes all capital costs associated with the compensation plan. The Greenlink project is being developed by Greenlink Interconnector Limited, which is owned jointly by two Shareholders (i) Element Power Holdings, part of Hudson Sustainable Investment,

and (ii) Partners Group. Hudson Sustainable Investment is an independent investment management firm with a strong track record and expertise in investing in and developing sustainable energy infrastructure projects in Ireland, the UK and internationally. Partners Group is a global private markets investment management firm with €73 billion in investment programs under management in private equity, private real estate, private infrastructure and private debt.

The operational costs arising from this compensation plan will be supported via the "Cap and Floor regime for Electricity Interconnectors" agreed with Ofgem. The budget necessary to implement the compensatory habitat and monitoring has been agreed with the Shareholders and submitted to Ofgem as part of their assessment of the project. This includes a realistic contingency to account for eventualities such as weather.

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Appendix A

Evidence for colonisation of external cable protection

A.1 INTRODUCTION

A.1.1 Objective

The purpose of this Technical Note is to present the findings of a literature review undertaken to investigate the colonisation of external cable protection in the marine environment. It seeks to provide evidence to support the following key assumptions made within the Greenlink Marine Habitat Compensation Plan:

- Where rock revetment is deposited, it will be colonised by epibenthic species from the surrounding Annex I Reef habitat;
- Colonisation will occur within a relatively short time scale, anticipated to be within 5 years post-installation; and
- There will be continued ecological functioning in these locations.

A.1.2 Data Sources

The data sources reviewed as part of this technical note include, but are not limited to the following:

- Kogan, I., Paull, C.K., Kuhnz, L.A., Burton, E.J., Von Thun, S., Greene, H.G. and Barry, J.P. (2006). ATOC/Pioneer Seamount cable after 8 years on the seafloor: Observations, environmental impact. Continental Shelf Research, 26(6), pp.771-787.
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- Other data sources as referenced in the text and listed at the end of the Technical Note.

A.2 EVIDENCE

A.2.1 Colonisation of cable protection

This section provides a summary of the available evidence found, that supports the key assumption that external cable protection and specifically rock revetment will be colonised by epibenthic species of the surrounding reef habitat, thus creating an artificial reef. As stated by Langhammer (2012): *"Artificial offshore constructions will inevitably be colonized by a number of organisms."* A number of studies have found evidence of this (Taormina *et al*. 2018; Love *et al*. 2017; Langhammer 2012; Kogan *et al*. 2006); including several that have observed the colonisation of cable rock protection (Sherwood *et al*. 2016; Lacey and Hayes 2019; Sheehan *et al*. 2018). For example, Sheehan *et al*. (2018) made observations of the colonisation of rock protection installed for the Wave Hub subsea cable off the north coast of Cornwall, United Kingdom (as shown in Figure A-1). The cable was installed predominantly over circalittoral rock and biogenic reef habitat. The study found the benthic fauna that colonised the rock protection was comparable to the surrounding rocky reef, and no significant difference in abundance was found in comparison to controls 5 years post-installation. This represents a similar habitat to areas that may require compensation in Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC). As such it would be reasonable to expect that any rock protection that may be required within these habitat types for the Greenlink cable may see similar results.

Figure A-1 Observational photographs of rock protection and adjacent control sites as published by Sheehan *et al*. (2018)

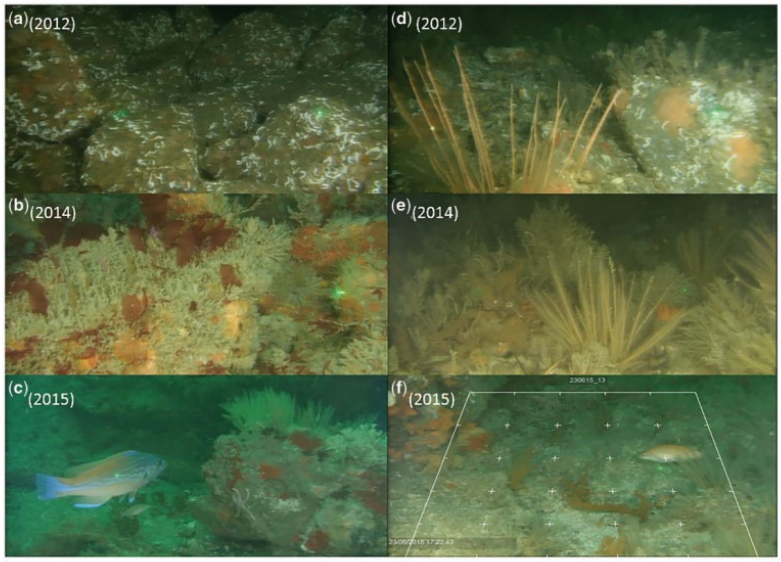


Figure 2. Example images from transect footage from cable rock armouring (a, b, c) and control sites adjacent to the cable route (d, e, f). Image f also depicts the digital quadrat overlay that was applied to each frame grab during the video analysis. Laser spacing (bright dots) = 0.3 m.

The studies demonstrate the colonisation of a range of cables, pipelines and protection measures of different characteristics (i.e. materials, shapes and sizes). A study by Lacey and Hayes (2019) investigated this; observing the colonisation of six types of pipeline and protective covering structures in the North Sea. The six structures include exposed pipeline; buried pipeline; concrete mattresses; Link-lok mattresses; rock berms; and a 3-layer polypropylene (3LPP) plastic sheath. Figure A-2 and A-3 show example photographs of these published as part of the study.

Figure A-2 Observational photographs of an exposed pipeline and neighbouring sediment (as published by Lacey and Hayes 2019)

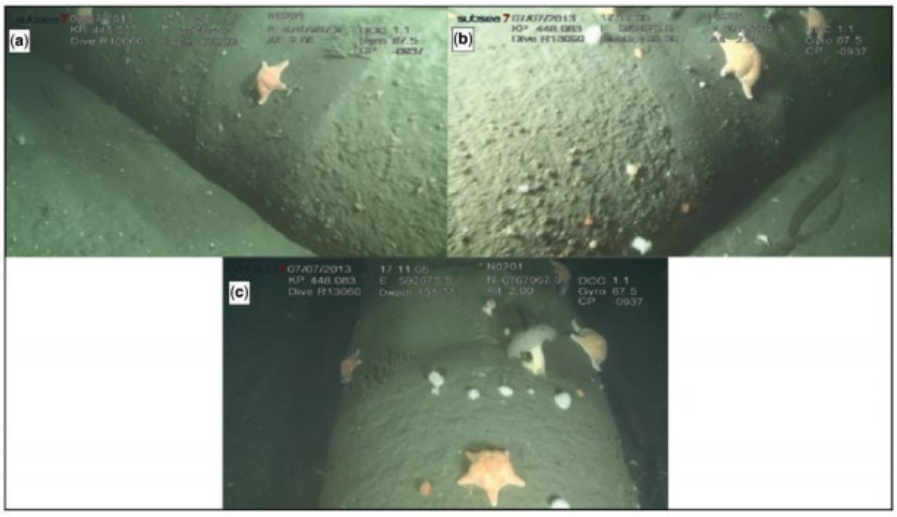


Figure 2. Example view of an exposed pipeline and neighbouring sediment showing (a) port, (b) starboard, and (c) central camera views.

Figure A-3 Observational photographs of colonised pipelines and associated infrastructure (as published by Lacey and Hayes 2019)

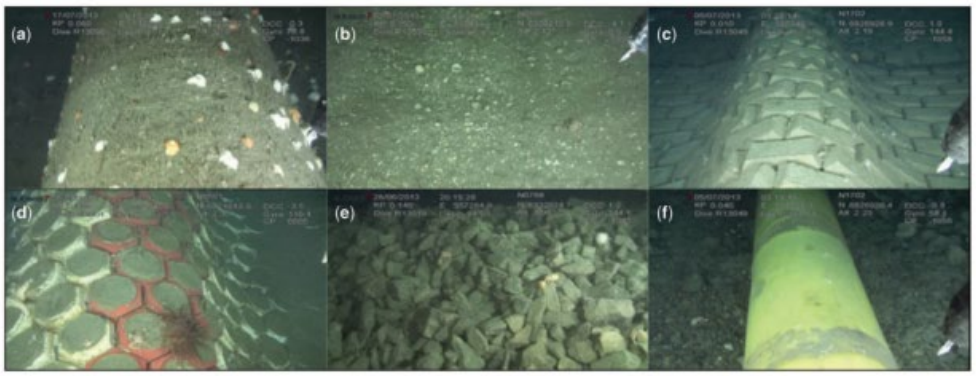


Figure 3. Central camera ROV views of the pipeline protective covering types investigated in this study. (a) Exposed concrete pipe, (b) buried, (c) concrete mattress, (d) Link-lok mattress, (e) rock-dump, (f) 3-layer polypropylene (3LPP). Refer to Supplementary Table S1 for frequencies.

Figure A-3 shows limited colonisation of pipelines and associated infrastructure in terms of species abundance and diversity. While the study did observe relatively low levels of these it did acknowledge the following limitations: blurred ROV

footage; difficulty observing organisms as a result of the complexity of structures; and the date of placement of rock revetment is unknown, which if recent would explain the low levels of colonisation observed. Therefore, this may not represent the true diversity and abundance of the communities that have colonised these artificial structures.

Furthermore, the colonisation of subsea infrastructure by epibenthic species characteristic of surrounding habitats has been demonstrated over a range of habitat types. For example, in addition to rocky reef habitat previously mentioned, a study by Sherwood *et al*. (2016) found that iron shell armoured cable along the Basslink HVDC cable in South East Australia provided a similar hard substrate to the surrounding bedrock reef. Magnetic and electric fields generated during the operation of the cable did not appear to affect this process; with the armoured surface quickly becoming colonised by reef species, comparable to the surrounding reef, as new habitat. Similar observations for other habitat types include sand habitats in California; and glass sponge reefs in the Strait of Georgia (Love *et al*. 2017; Kuhnz *et al*. 2011; Dunham *et al*. 2015).

Figure A-4 below shows observational photographs, as published in Taormina *et al*. 2018, of where different cables and cable rock protection has become colonised.

Figure A-4 Observational photographs of colonised cables and rock-protection (as published by Taormina *et al*. 2018)

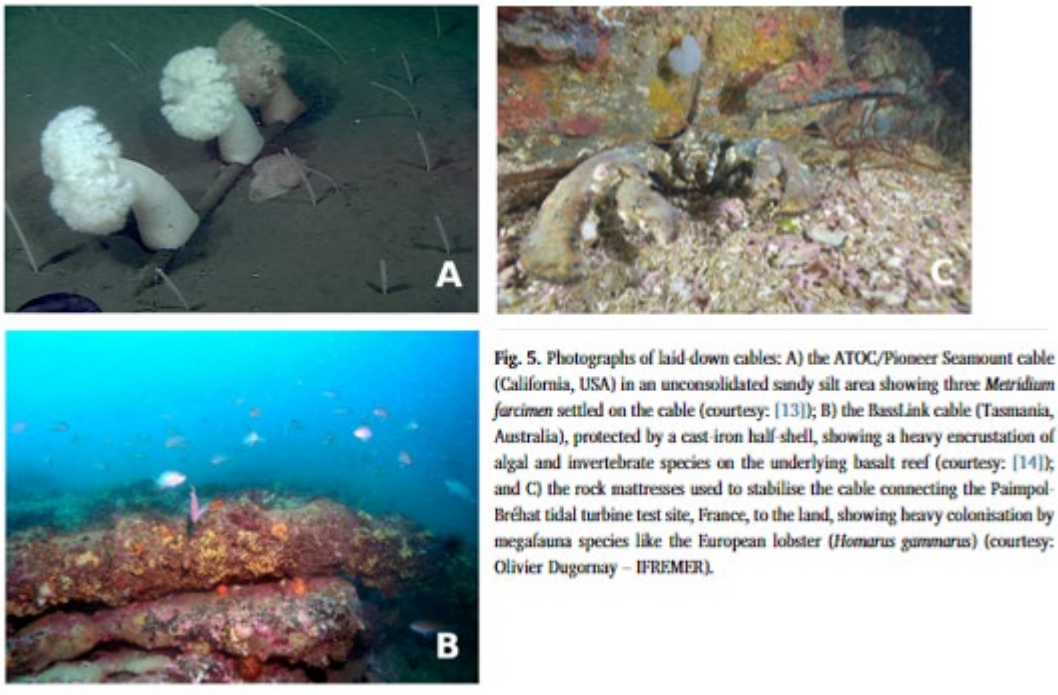


Fig. 5. Photographs of laid-down cables: A) the ATOC/Pioneer Seamount cable (California, USA) in an unconsolidated sandy silt area showing three *Metridium farcimen* settled on the cable (courtesy: [13]); B) the BassLink cable (Tasmania, Australia), protected by a cast-iron half-shell, showing a heavy encrustation of algal and invertebrate species on the underlying basalt reef (courtesy: [14]); and C) the rock mattresses used to stabilise the cable connecting the Paimpol-Bréhat tidal turbine test site, France, to the land, showing heavy colonisation by megafauna species like the European lobster (*Homarus gammarus*) (courtesy: Olivier Dugornay – IFREMER).

A.2.2 Timescales

The time taken for the colonisation of artificial substrata by existing epifauna varies by the ease at which the existing species can recolonise novel surfaces, the existing habitat the infrastructure is being placed on and the material type being utilised (e.g. concrete, rock, iron-cast pipe). For example, long-term analysis of the installation and operational effects of the BassLink HVDC cable found that after a period of 3.5 years from installation, the benthic sessile community present on the cast-iron half-shell cover was similar to the surrounding basalt bedrock reef area (Sherwood *et al*. 2016). Other studies conducted on the colonisation of subsea cables on hard-bottomed areas found similar timescales for the novel habitat to be recolonised to an extent similar to that of the pre-existing habitat (Taormina *et al*. 2018).

A study on the development of epibenthic assemblages on artificial habitat associated with marine renewable infrastructure in UK waters found that 5 years after cable installation, the assemblage found on the introduced cable rock armouring had recovered to a similar extent with a comparable benthic assemblage to that of the surrounding circalittoral rock and biogenic reef (Sheehan *et al*. 2018). This represents a similar habitat to that of the areas potentially requiring compensation in the Pembrokeshire Marine / Sir Benfro Forol SAC.

These timescales of recolonisation to states nearing the original habitats biodiversity lie in contrast to unburied cables laid in areas of soft-bottomed sediment, where the reef effect has been observed to be stronger than that of the surrounding seabed. Analysis of the Acoustic Thermometry of Ocean Climate (ATOC)/Pioneer Seamount cable found that after an 8-year period the community of Actiniarians had become well-established on the cable, creating an area of greater habitat complexity than the surrounding seabed which in turn led to an increased abundance in fish species (Kogan *et al*. 2006).

As such, the timescales for artificial substrata to be recolonised to a similar degree to that of the existing habitat will take a period of several years. However, particular characterising species of affected habitats, such as the ascidian *Molgula manhattensis* characteristic of bedrock reef, are known to rapidly recolonise novel surfaces when in proximity of existing populations of up to several kilometres away, achieving significant coverage within a year (Stamp 2016). Similarly, *Sabellaria spinulosa* is known to have the ability to colonise a range of substrate types including rock and mixed sediments (Gibb *et al*. 2014), with rapid colonisation of subsea pipelines being observed off the north east coast of Scotland (Braithwaite *et al*. 2006). As such, the characterising species of the biotopes potentially being affected by the Proposed Development should have the ability to quickly recover and utilise the newly introduced artificial substrata.

A.2.3 Comparison of natural and artificial reefs

Depending on the nature and location of an artificial reef, and characteristics of the native population, the 'reef' effect may generate an enhanced habitat (Langhammer 2012). For example, as previously mentioned, Kogan *et al*. (2006) found the ATOC/Pioneer Seamount cable created an area of greater habitat complexity than the surrounding seabed, leading to an increased abundance of actiniarians (sea anemones) and fish species. Artificial reefs like these are noted to have a stronger effect, being located on soft sediments, as it hosts a new community. The effect may be more limited when located within naturally hard substrate areas (Taormina *et al*. 2018).

Several studies have found that benthic assemblages that colonise artificial infrastructure are comparable to that of natural surrounding reef habitat (Lacey and Hayes 2019; Sheehan *et al*. 2018; Dunham *et al*. 2015; Sherwood *et al*. 2016). For example, as previously mentioned in Section A.2.1, Sheehan *et al*. (2018) found that the benthic fauna that colonised the rock protection installed for the Wave Hub subsea cable was comparable to the surrounding rocky reef 5-years post-installation. The rock protection was found to be colonised by many similar species characteristic of the rocky reef habitat, including Hydroids spp. and the bryzoan *Pentapora foliacea*, and no significant difference in abundance was found. While a significantly lower number of taxa was reported in comparison to controls, successive monitoring surveys (1, 4 and 5 years post-installation) showed evidence of ecological succession and indicate a trajectory of recovery for the habitat. Example photographs from the successive monitoring surveys of the rock protection and adjacent controls can be seen in Figure A-1. In a similar study, Sherwood *et al*. (2016) found the benthic community that colonised the BassLink cable was comparable to the surrounding bedrock reef habitat in terms of abundance and characteristic species.

The extent to which rock protection may attract species and promote a positive reef effect may be dictated by the design. For example, small-scale habitat heterogeneity such as surface roughness of the artificial substrate may increase habitat complexity and promote biodiversity and a positive reef effect. A study by Lengkeek *et al*. (2017) investigated the enhancement of ecological functioning of scour protection in the North Sea, and proposed design principles to do this, these include:

- Adding larger structures;
- Adding a variation in sizes of holes and crevices to function as shelter;
- A mix of materials to offer habitat complexity and different niches; and
- Ensuring the stability of hard substrates to allow for the establishment of slower growing species.

Lengkeek *et al*. (2017) concluded that the existing data indicates the number of species on conventional scour protection is relatively low in comparison to natural rocky reef habitats and other artificial reefs (i.e. wrecks) in the North Sea.

Therefore, following these design principles may enhance the reef effect of rock protection measures, promoting biodiversity, species richness and abundance.

A.3 CONCLUSION

This review provides evidence to support the key assumptions made within the Greenlink Marine Habitat Compensation Plan, as set out in Section A1.1 of this Appendix. As such the following conclusions have been drawn in respect of these:

- Evidence provided in Section A.2.1 indicates that where rock revetment may be required within Pembrokeshire Marine / Sir Benfro SAC, it will be colonised by species from surrounding Annex I Reef habitat to a similar extent as the existing habitat.
- The colonisation of any potential rock revetment would likely be within a relatively short time scale. Evidence provided in Section A.2.2 indicates a period of 3.5 – 5 years for the habitat to recover post-installation, likely with some individual characterising species recovering more rapidly.
- Given the evidence provided in Section A.2.3, it is reasonable to assume that artificial reef created over any rock revetment locations may be comparable in terms of ecological functioning to that of the surrounding natural reef; and therefore also any existing natural reef lost as a result of the installation of the Greenlink cable.

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Appendix E

Greenlink Wales Marine Mammal Mitigation Plan – Revision 1

GREENLINK INTERCONNECTOR LIMITED

Greenlink Marine Mammal Mitigation Plan

Wales

Greenlink - an interconnector between
GB and the Republic of Ireland

P1975_R5028_Rev1 | August 2020

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1. Introduction

1.1 Purpose of this Plan

This document describes the Marine Mammal Mitigation Plan (MMMP) for use in Welsh Waters during the Greenlink project. It is based on the statutory advice on minimising the impacts of underwater noise generating activities on marine mammals provided by the Joint Nature Conservation Committee (JNCC); and additional mitigation agreed with Natural Resources Wales (NRW).

The MMMP:

1. Outlines the mitigation measures that will be implemented to avoid or reduce injury and disturbance effects to marine mammals;
2. Provides the procedures to be followed to implement the mitigation measures effectively and in line with current guidelines and best practice;
3. Sets out the roles and responsibilities of key personnel who will implement the MMMP; and
4. Describes the reporting protocol in place to demonstrate that the MMMP has been successfully implemented.

Greenlink Interconnector Limited (GIL) and its contractors are responsible for ensuring this MMMP is implemented.

1.2 Project Background

Greenlink Interconnector Limited (GIL) is proposing to develop an electricity interconnector (Greenlink) linking the existing electricity grids in Ireland and Great Britain. The Greenlink project will consist of two converter stations, one close to the existing EirGrid substation at Great Island in County Wexford (Ireland) and one close to the existing National Grid substation at Pembroke in Pembrokeshire (Wales). The converter stations will be connected by underground cables (onshore) and subsea cables (offshore).

The landfall points for the submarine cables are Freshwater West, Pembrokeshire (Wales) and Baginbun Beach, County Wexford (Ireland); see Figure 1-1 Drawing P1975-INFR-004 for Proposed Development in Welsh Waters.

GREENLINK INTERCONNECTOR

INFRASTRUCTURE

Castlemartin Firing Range & SAC's

Drawing No: P1975-INFR-004	A

Legend

- Proposed Developoment
- Irish Offshore
- UK 12nm Territorial Sea Limit
- Median Line
- Castlemartin Firing Range
- SAC

N
W E
S



NOTE: Not to be used for Navigation

Date	24 March 2020
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	UKHO; CDA; JNCC; MarineFind; Oceanwise; ESRI; OSOD
File Reference	J:\P1975\Mxd\10_INFR\ P1975-INFR-004.mxd
Created By	Chris Dawe
Reviewed By	Emma Langley
Approved By	Stuart McLaren

Co-financed by the European Union
Connecting Europe Facility

0 2.5 5 7.5 10 km

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1.3 Activities covered by this Plan

1.3.1 Geophysical Survey

Although detailed engineering surveys have been completed for Greenlink (September to December 2018, and March 2019), there is the potential that the Installation Contractor will conduct further surveys prior to the commencement of cable installation. The objectives of these surveys are:

- To confirm that no new obstructions have appeared on the seabed since the detailed engineering surveys;
- To identify any unexploded ordnance that requires micro-routeing around.
- To confirm the seabed level pre- and post-installation to demonstrate that the required burial depth for the cable has been reached.
- To inform micro-routeing around mobile bedforms and sensitive habitats.

The survey will involve standard geophysical survey techniques as follows:

- Bathymetry: Swathe and multi-beam acoustic echo sounder systems are used to record water depth, prepare a 3D digital terrain model of the route and to describe the seabed topography along the Proposed Development. The 3D terrain model built from the bathymetrical data will be used to identify mobile seabed features and, where applicable, to assess the mobility of these mobile seabed features by comparing its location relative to the previous route survey.
- Side Scan Sonar (SSS): The sonar signal is emitted from a towfish towed behind the survey vessel along the Proposed Development. Reflections from sediments and other hard objects are received back at the towfish and processed on board the survey vessel to produce an image of the seabed. This technique enables mapping of the seabed surface and identification of sediment types but cannot determine the thickness of sediments. Obstacles lying on the seabed, such as wrecks, trawler debris and telecommunication cables that might impede cable installation can be identified from the SSS image.
- Sub-Bottom Profiler (SBP): It is unlikely that this survey is required. In the event that the Installation Contractor chooses to obtain additional data, this technique involves injecting a pulse of acoustic energy into the seabed and detecting the reflections from the sub-surface geological units. From the reflections the thickness of the sediment can be assessed, but the type of sediment can only be inferred until “ground-truthing” geotechnical data is obtained.
- Ultra Short Baseline (USBL) systems: It is possible that these systems will be required. USBL utilises high frequency sound which falls within the range of 21-31 kHz to communicate between a vessel-based transceiver and a seabed-based transponder to calculate the transponder’s position. They are

sometimes used to monitor the positions of remotely operated vehicles or towed equipment.

1.3.2 Unexploded Ordnance (UXO) Clearance

The primary objective will be to avoid encountered potential UXO by micro-routeing within the Proposed Development. Typically, a standoff distance of 15-25m relative to potential UXO and depending on the nature of the UXO and installation method, is considered safe for cable installation purposes.

If re-routeing around a particular potential UXO appears not to be possible, this potential UXO will be investigated. If visual inspection confirms a UXO, then if it is safe to do so the UXO will be removed, or as a last resort detonation measures (deflagration) will be undertaken, as outlined in this MMMP in accordance with UK Best Practice.

There is a higher risk of requiring a UXO deflagration ~~detonation~~ within the Proposed Development as it passes through the Castlemartin Firing Range, due to the historic and current activity in the area. However, an initial UXO survey has been undertaken within the Range and GIL are confident that the route is deliverable without deflagration ~~detonation~~. It is less likely that a UXO deflagration ~~detonation~~ would be required further offshore unless an ordnance is found during the survey process.

1.4 Relevant Legislation

All cetaceans, chelonians and otter are listed on Annex IV of EC Council Directive 92/43/EC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) as European Protected Species (EPS). The Conservation of Habitats and Species Regulations 2017 (CHSR) and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (COMHS) transpose the requirements into UK statute.

It is an offence to deliberately kill, injure or disturb animals classed as EPS. The mitigation measures outlined in the JNCC guidelines[1,2] are designed to reduce the risk of deliberate injury to marine mammals and relevant measures are incorporated as part of the consenting regimes for geophysical activities and UXO detonation within the United Kingdom Continental Shelf (UKCS).

The JNCC guidelines were originally written with the oil and gas industry (for geophysical survey) and offshore wind industry (for UXO detonation) in mind, however, since their conception the use of geophysical technologies and the requirement for UXO detonation by other marine industries has grown. Any activities that have the potential to result in injury to marine mammals should apply the mitigation measures outlined in these guidelines. Whilst the mitigation measures in these guidelines have some limitations and their effectiveness may not

[1] JNCC (2017) Guidelines for minimising the risk of injury to marine mammals from geophysical surveys: https://hub.jncc.gov.uk/assets/e2a46de5-43d4-43f0-b296-c62134397ce4
[2] JNCC (2010) Guidelines for minimising the risk of injury to marine mammals from using explosives https://hub.jncc.gov.uk/assets/24cc180d-4030-49dd-8977-a04ebe0d7aca

be able to be fully tested, they are based on reasonably conservative assumptions. It is considered that compliance with these guidelines constitutes best practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels.

GIL are aware that new guidance for the use of explosives is in draft format and is due to be issued in 2020. This MMMP will be reviewed prior to works commencing and updated as necessary in line with Best Practice.

1.5 Marine Mammal Baseline

Marine mammals present in the Proposed Development include cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). Most cetaceans and pinnipeds are wide-ranging and individuals encountered within UK waters form part of much larger biological populations; the ranges of which extend into the North Atlantic and North West European waters. As a result, management units (MUs) have been outlined for seven of the common regularly occurring species following advice from the Sea Mammals Research Unit and the International Council for the Exploration of the Sea (ICES)[3]. These provide an indication of the spatial scales at which effects of anthropogenic activities should be taken into consideration.

1.5.1 Cetaceans

Harbour porpoise is the most abundant and commonly sighted species in the area. Most sightings occur during the summer months with peak sightings in August; but animals are likely to be present year-round. The Proposed Development crosses the West Wales Marine / Gorllewin Cymru Forol Special Area of Conservation (SAC) which has been designated to conserve harbour porpoise. Harbour porpoise generally prefer coarser sediments which is the habitat of sandeel, a known prey species[4].

Four other species are relatively common, namely common bottlenose dolphin; short-beaked common dolphin; Risso's dolphin and minke whale. There are also some cetaceans that are seen occasionally, for example striped dolphin, Atlantic white-sided dolphin, white-beaked dolphin, long-finned pilot whale, killer whale, humpback whale and fin whale.

1.5.2 Pinnipeds

Grey seal are present in coastal waters around Wales throughout the year, with pup production highest in Pembrokeshire[5]. The Proposed Development lies within the South West England MU and Wales MU for grey seal. Grey seal are a designating feature of the Pembrokeshire Marine / Sir Benfro Forol SAC (which the Proposed Development crosses), but animals from the Pen Llyn a'r Sarnau / Lleyn Peninsula

[3] ICES (2016) Sea Mammals Research Unit and the International Council for the Exploration of the Sea
[4] Department of Energy and Climate Change (DECC) (2016). Offshore Energy Strategic Environmental Assessment. Department of Energy and Climate Change. March 2016
[5] Baines, M.E. and Evans, P.G.H. (2012). Atlas of the Marine Mammals of Wales. CCW Monitoring Report No. 68. 2nd edition. 139pp

and the Sarnau SAC and Bae Ceredigion / Cardigan Bay SAC may also be in the region. It is estimated[6] that the mean number of individuals in the waters along the cable route will vary from five to ten individuals per 5km^2.

1.5.3 Conservation sites

The cable route crosses both Pembrokeshire Marine/ Sir Benfro Forol SAC and West Wales Marine/ Gorllewin Cymru Forol SAC which have marine mammals as a Primary or Qualifying feature.

Pembrokeshire Marine/Sir Benfro Forol SAC is the most important breeding site for the grey seal in Wales. Seal pupping season is between August and January, meaning that there will be higher numbers of seals in the area at this time.

West Wales Marine / Gorllewin Cymru Forol SAC has been designated to conserved harbour porpoise. Harbour porpoise is likely to be present within the Proposed Development throughout the year, but densities will be highest during summer months. It is estimated that the European site supports over 5,000 individuals for at least part of the year (summer); representing approximately 5.4% of the population within the UK part of the Celtic and Irish Seas MU[7]. The site's selection assessment document[8] notes that harbour porpoise within the MU prefer water depths shallower than 40m, and that lower densities are observed in areas with high levels of shipping activity (based on a threshold of approximately 50 ships per day in summer).

[6] Russell, D.J.F., Jones, E.L. and Morris, C.D. (2017). Updated seal usage maps: The estimated at-sea distribution of grey and harbour seals. Scottish Marine And Freshwater Science Report Vol 8 No 25.
[7] Estimate based on July 2005 SCANS-II survey data and it is unlikely to be reflective of abundances in other months, especially winter. Therefore, the estimate is merely indicative and cannot be considered as a specific population number for the site.
[8] JNCC (2017) West Wales Marine Selection Assessment Document, January 2017 [Online] Available at: jncc.defra.gov.uk/pdf/WestWalesMarineSelectionAssessmentDocument.pdf (Accessed August 2018).

2. Marine Mammal Mitigation Plan

2.1 Monitoring Methods, Roles and Responsibilities

For Greenlink a Marine Mammal Observer (MMO) is required for any geophysical surveys undertaken along the complete route in Welsh waters and for any UXO deflagration ~~detonation~~ activities.

There are standard techniques available for monitoring marine mammals in the vicinity of geophysical survey and UXO deflagration ~~detonation~~ operations. These include visual monitoring using a MMO and acoustic methods such as using a Passive Acoustic Monitoring (PAM) system. The efficiency of visual and acoustic techniques comes down to several factors. Visual detection of marine mammals can be dependent on the size, surfacing behaviour, group size, weather conditions and visibility. This means that the techniques sometimes will have to be used in conjunction to get the best results.

Where practical, operations should be timed to commence during daylight hours to ensure that visual mitigation by MMOs can be undertaken. If visibility is impaired e.g. due to weather conditions or darkness, depending upon the guidance or (if appropriate) EPS licence conditions, operations may have to be delayed until conditions change or improve; unless an alternative method to visual surveys, such as PAM, is available and can be deployed.

PAM is used as a tool for monitoring marine mammals during the night and poor visibility operations. Where PAM is a condition of the EPS licence, it must be used when soft starts occur during hours of darkness and during periods when day-time conditions are not conducive to visual surveys (e.g. fog).

Where PAM is not a condition on the consent or licence a PAM operator may also be used alongside visual techniques to enhance the findings during daylight hours. The combined technique is especially effective in an area with dolphins and harbour porpoise.

Where day-time conditions are such that visual observations cannot be undertaken and no other form of monitoring is available, best practice would be to delay initiation of soft starts until conditions improve (see Section 2.2.2).

2.1.1 Marine Mammal Mitigation Team

The role of an MMO/PAM operative is to detect marine mammals as part of the mitigation procedures and to advise a delay in the commencement of activity should any marine mammals be detected within the mitigation zone (defined as a radius of 500m from the noise source during geophysical survey and 1000m for UXO deflagration ~~detonation~~). This is to reduce the potential for deliberate injury to occur and ensure that the activity complies with relevant best practice or EPS licence conditions. Ultimately, however it is GIL's and their appointed Contractors responsibility to ensure best practice and EPS licence conditions are adhered to, noting the advice provided by the MMO/PAM operatives.

MMO and PAM operatives should be equipped with an up-to-date copy of the appropriate JNCC guidelines, recording forms (see Appendix A) and if appropriate EPS licence. MMOs should be equipped with binoculars and a tool to estimate distance i.e. range finding stick or binoculars with reticles.

Both the MMO and PAM operative should ensure their efforts are concentrated on the mitigation periods, which for geophysical survey are the pre-survey search and soft-start time periods until the survey line has started and data acquisition has begun and for UXO deflagration ~~detonation~~ the pre-detonation and post-detonation search periods.

It is acceptable under the JNCC guidelines[9] for an individual to fulfil both the MMO and PAM role during the same activity, but not by the same individual simultaneously. It is essential in this case that personnel are trained and competent in both roles.

2.1.1.1 Marine Mammal Observer(s)

For a MMO to be classified as trained, the individual must have undertaken formal training on a JNCC recognised course[10] plus have some experience of visually spotting marine mammals. An experienced MMO should have a minimum of 20 weeks' experience of implementing JNCC guidelines in UK waters over the previous ten years, and preferably within the last five. They will be experienced at identifying UK marine mammal species (visually and/or acoustically depending on the role) and be familiar with their behaviour.

A dedicated MMO is employed for the sole purpose of undertaking visual observations to detect marine mammals and advising on and monitoring the implementation of JNCC guidelines. They are not normally a member of the vessel crew (i.e. they are sub-contracted professionals).

A non-dedicated MMO may undertake other roles on board the vessel when not conducting their mitigation role. They may be a member of the crew and are usually utilised on short surveys.

All MMOs must be trained by a JNCC accredited trainer and have experience in visually recording marine mammals during offshore survey work. MMO's must be equipped with the most up to date JNCC guidelines and recording forms which will be used to record sightings.

For the Greenlink project a non-dedicated MMO is required for geophysical surveys; unless a dedicated MMO is outlined as a condition on the marine licence.

Two dedicated MMOs will be required for the UXO deflagration ~~detonation~~ activity.

[9] https://hub.jncc.gov.uk/assets/e2a46de5-43d4-43f0-b296-c62134397ce4
[10] Further information on recognised course providers is available at: http://www.jnccc.gov.uk/page-4703

2.1.1.2 PAM Operator

PAM consists of hydrophones that are in the water to listen out for any noises that are then transferred to specialist software on board. Specialist trained PAM operatives are needed to set up and deploy the equipment and to interpret detected sounds. A PAM operator has to have attended a JNCC accredited MMO training course and be competent in the use of a PAMS software.

A PAM operator will be required for the UXO deflagration ~~detonation~~ activity and may be required for the geophysical survey, although the current assumption is that one will not be needed as survey activities will commence during daylight hours and will continue during night-time operations with no planned breaks in activity.

2.1.1.3 Explosive Ordnance Disposal (EOD) Supervisor

For UXO deflagration ~~detonation~~ activities an EOD Supervisor will be situated on the explosives vessel and will be the main point of contact with the MMMT. The EOD Supervisor is responsible for the safe disposal of ordnance. The MMO/PAM operator will advise the EOD supervisor of the possible presence of marine mammals and whether delay of deflagration is required in accordance with the provisions of the MMMP and JNCC guidelines.

2.1.1.4 Acoustic Deterrent Device (ADD) Operative

The ADD Operative is responsible for determining the best location for ADD deployment from the vessel (supported if necessary, by the operational manager, the explosives rigger and an electrical supervisor) and ensuring the control unit and power supply are temporarily installed ready for deployment.

The ADD Operative needs to be able to deploy the ADD over the side of the vessel to a depth lower than the draft of the vessel, testing the ADD to make sure it is operational prior to activation.

2.2 *Geophysical Survey*

The marine mammal mitigation protocol to be followed during geophysical survey operations is outlined below:

2.2.1 Procedural summary flow chart - geophysical survey



2.2.2 Monitoring Procedure

A non-dedicated MMO will undertake monitoring prior to any survey work to make sure the geophysical survey can commence. The MMO will monitor the mitigation zone for 30 minutes prior to soft-start commencing, during soft-start and throughout the survey operation. The recordings of any marine mammal sightings must be noted on a reporting form (see Appendix A).

2.2.2.1 Location of MMO & PAM Operator

All monitoring should be undertaken from the source vessel (where the noise source is deployed from).

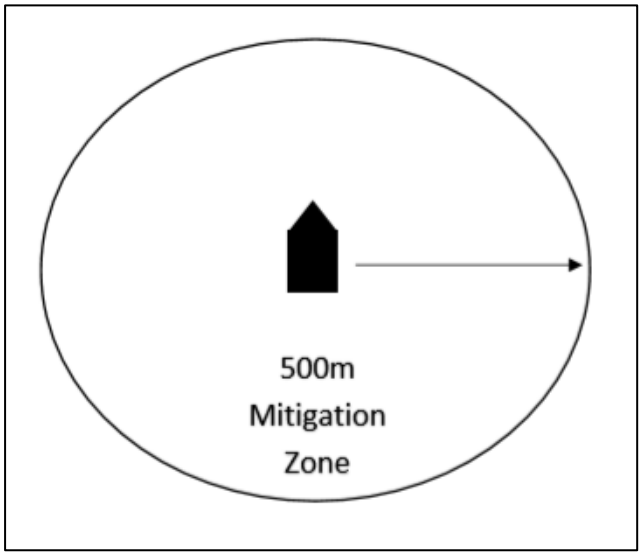
The MMO should be positioned on a high platform with a clear view of the horizon, mitigation zone and ahead of the vessel.

Note for Greenlink surveys an assumption has been made that PAM is not required as survey activities will commence during daylight hours and will continue during night-time operations with no planned breaks in activity. However, should NRW require PAM the PAM operator should be positioned in the most appropriate location to allow them to monitor the PAM equipment for acoustic detections and maintain contact with both the MMO and relevant crew, for both mitigation purposes and ensuring the PAM equipment is deployed correctly.

2.2.2.2 Mitigation zone

The MMO/PAM operative will monitor the mitigation zone (radius 500m, estimated from the centre of the survey noise source location – see Figure 2-1) and advise if any marine mammals are within it.

Figure 2-1 Geophysical Survey Mitigation Zone



2.2.2.3 Duration of search

The MMO must monitor the mitigation zone for the full duration of the pre-survey search and soft-start procedure. Where PAM is being used in conjunction with or in place of visual surveys, acoustic monitoring must also occur for the full duration of the pre-survey search and soft-start procedure. Once the soft start has ended and data acquisition begin, monitoring can cease.

The duration of the pre-survey search will be **30 minutes**[11] prior to survey soft-start commencing.

2.2.2.4 Detection of marine mammals in mitigation zone

If marine mammals are detected within the mitigation zone during the pre-survey search (visually or acoustically), the soft-start must be delayed until their passage, or the transit of the vessel, results in them being outside of the mitigation zone. There must be a minimum of a 20-minute delay from the time of the last detection within the mitigation zone and the commencement of the soft-start, to allow animals unavailable for detection (i.e. not re-surfacing in that time) to have moved outside the mitigation zone.

A full soft-start must be undertaken after any delay due to the presence of marine mammals in the mitigation zone.

If marine mammals are detected within the mitigation zone during soft-start or whilst the survey is underway, there is no requirement to stop.

2.2.2.5 Soft-start

Two criteria define the standard duration of a soft-start:

- From the start of the soft-start until full operational power: minimum 15-25 minutes; and
- From the start of the soft-start until the start of the survey line: maximum 40 minutes.

Power should be built up gradually, in uniform stages from a low energy start-up. However, it is acknowledged that this is not possible for some SBP equipment (i.e. it is either on or off). If such equipment is to be used, the Survey Contractor should highlight this to GIL and NRW will be notified.

2.2.2.6 Breaks in operations

- **Unplanned breaks of less than 10 minutes**: There is no requirement for a soft-start provided no marine mammal(s) have been detected in the mitigation zone during the breakdown period. If a marine mammal is detected in the mitigation zone during the breakdown period the MMO/PAM operative will advise to delay survey recommencement until their passage, or transit of the vessel, results in the marine mammals being outside of the mitigation zone. There must be a 20-minute delay from the time of the last

[11] Proposed Development is within water depths of less than 200m.

detection within the mitigation zone and a soft-start must then be undertaken.

- **Unplanned breaks of longer than 10 minutes**: If it takes longer than 10 minutes to recommence surveying, a full pre-survey search and soft-start should be carried out before the survey recommences. If an MMO/PAM has been monitoring during the breakdown period, this time can contribute to the pre-survey search time (30 minutes). If the breakdown occurs at night or during daylight conditions not conducive for a visual search, the mitigation zone should be monitored as described above using PAM. If PAM is not available, the survey must be delayed until conditions are suitable for visual observations.
- **Planned breaks**: The same procedures as above (for unplanned breaks) can be applied. However, if the planned break will be less than 10 minutes, the MMO/PAM operatives must begin monitoring 20 minutes prior to the planned break and continue for the duration of the break.

NOTE: Multi-beam surveys in shallow waters (<200m) i.e. complete route in Welsh Waters, are not subject to the monitoring requirements outlined above as it is thought the higher frequencies typically used fall outside the hearing frequencies of cetaceans and the sounds produced are likely to attenuate more quickly than the lower frequencies used in deeper waters. JNCC do not, therefore, advise that mitigation is required for multi-beam surveys in shallow waters.

2.2.3 Communication Protocol

There should be clear communication between the MMO/PAM and relevant crew members including contractors and company personnel. This must be outlined prior to any operations taking place. This will make it easier if the MMO requests the job to be stopped or suspended due to a sighting in the work area. The crew must inform the MMO/PAM operators (or nominated lead) sufficiently in advance of survey operations so that full pre-survey search can be completed prior to the soft start commencing.

A toolbox talk will be conducted between the MMO/PAM and relevant crew members to make sure they are aware of the requirements of the MMMP and associated JNCC guidelines. Copies of the Marine Licence and any other relevant documentation (electronic or paper) will be provided to the MMO/PAM by GIL at least 1 week prior to survey mobilisation.

2.2.4 Reporting

An MMO report must outline how JNCC guidelines were implemented during the works including any issues for example, crew non-compliance. The report must also include the completed marine mammal sightings forms (Appendix A). Any visual sightings and any difficulties must be reported to NRW and copied to the JNCC. The report should also be accompanied by any raw data that was gathered over the period of observation i.e. the data in the spreadsheets. The report should be

submitted to the JNCC (via e-mail to seismic@jncc.gov.uk) after the survey has been completed within six weeks. It is the responsibility of the consent holder to ensure that the MMO report is sent in a timely manner.

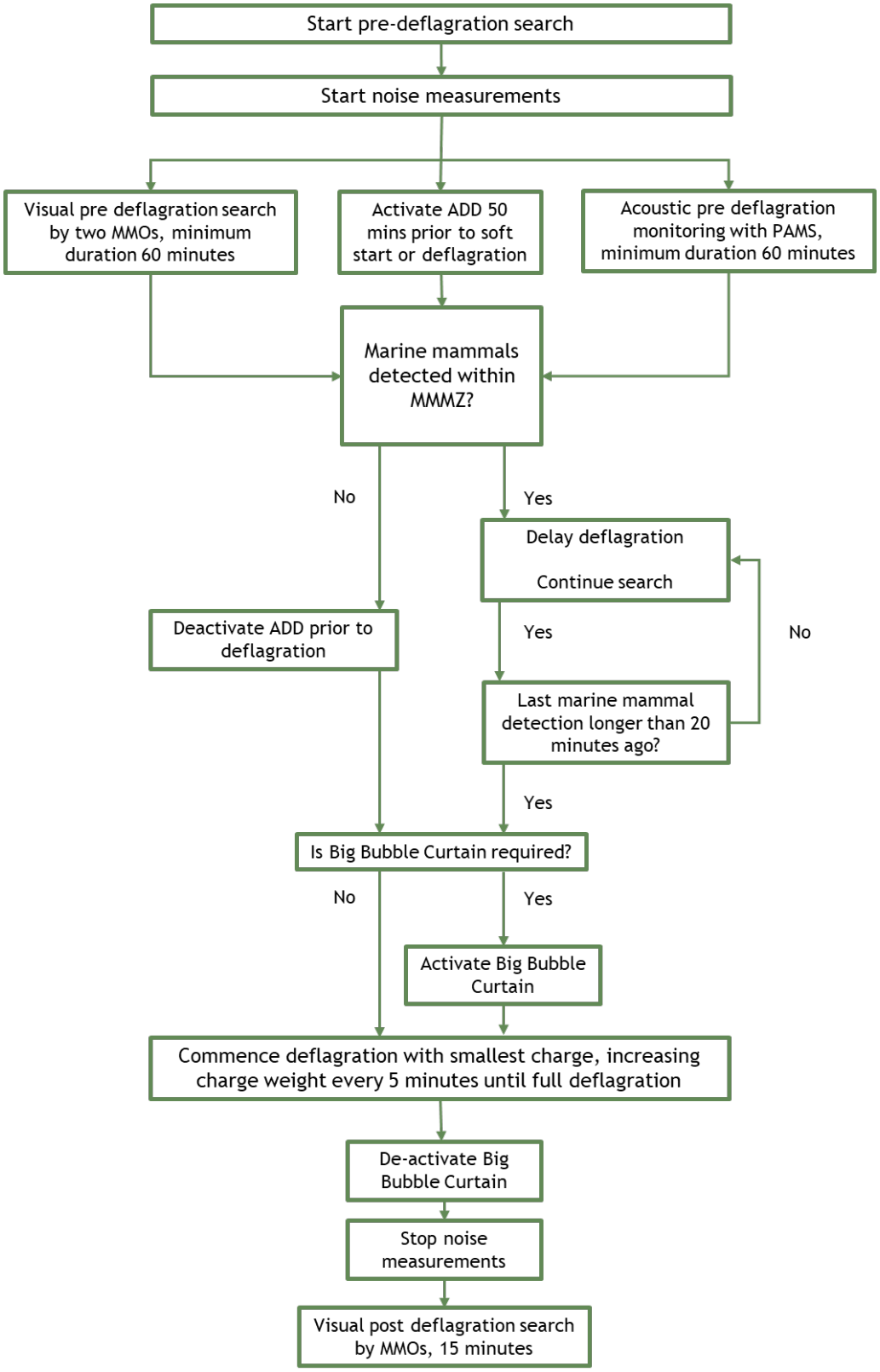
2.3 UXO Deflagration ~~detonation~~

2.3.1 Planning

The following requirements should be noted when planning UXO Deflagration activities:

- Deflagration will be undertaken on all charge sizes (see Section 2.3.3.9).
- UXO deflagration will only be carried out during the winter season i.e. between 01 October and 30 April.
- Underwater noise measurements shall be collected prior to, during and after all mitigation and deflagration events.
- The radius of the mitigation zone may be reduced, or increased, from the default 1km if evidence supporting this change is accepted by NRW.
- Explosive detonations should only be commenced during the hours of daylight and good visibility and should be scheduled to reduce the likelihood of encounters with marine mammals ~~e.g. outside seal pupping periods~~.
- Trained MMO/PAM should be used (see Section 2.1.1).
- The amount of explosive required for the deflagration ~~operation~~ should be accurately determined so that the amount is not excessive.
- The use of acoustic mitigation devices is required e.g. Acoustic Deterrent Devices (see Section 2.3.3.6).
- The use of noise abatement methods (e.g. big bubble curtains, BBC) to attenuate the emitted sound is required between KP0 and KP9.4 (see Section 2.3.3.7).
- If UXO is identified in water depths of 40-70m advice should be sought from a BBC supplier as to practicalities and cost of deploying a BBC in winter at the specific location. A BBC will be used if the contractor concludes it will be effective (see Section 2.3.3.7).
- The sequence of multiple explosive charges should be planned so that, wherever possible, the smaller charges are detonated first to maximise the 'soft-start' or 'ramp-up' effect (see Section 2.3.3.8).

2.3.2 Procedural summary flow-chart - deflagration



2.3.3 Monitoring Procedure

The marine mammal mitigation protocol to be followed during UXO detonation is outlined below:

2.3.3.1 Marine Mammal Mitigation Team (MMMT)

The MMMT will consist of two dedicated MMOs, a PAM Operative, an EOD Supervisor and an ADD Operative. Section 2.1.1.1 defines their roles and required levels of training.

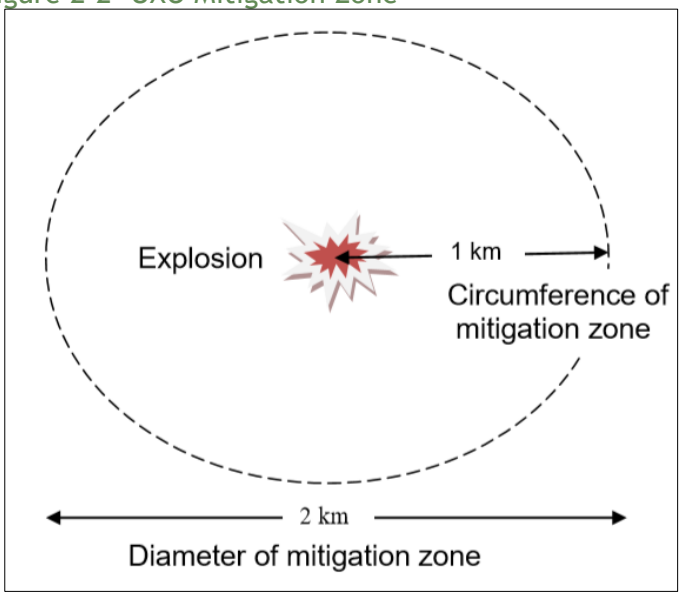
2.3.3.2 Mitigation Vessel

The MMMT will be located onboard the vessel, on which the explosive operation will take place. The vessel will move to a safe distance from the detonation zone once all of the preparation has been completed. MMO/PAM visual and acoustic monitoring will continue up until the point of detonation and then continue as part of a post detonation search for 15 minutes after deflagration ~~detonation~~. Visual monitoring should be carried out from a suitable platform such as the ships bridge that allows 360° coverage.

2.3.3.3 Marine Mammal Mitigation Zone

The Marine Mammal Mitigation Zone (MMMZ) refers to the radius around the outlined detonation area, where injury/PTS onset may occur. ~~the visual and acoustic monitoring will be concentrated~~. The JNCC requires a default 1km mitigation zone; which is based on previous charges when detonating World War II UXOs (see Figure 2-2). Greenlink underwater noise modelling suggests that the onset of injury/PTS may also occur outside of this mitigation zone, hence why temporal restrictions, noise abatement and acoustic deterrents are also proposed. The EOD Supervisor is responsible for providing the MMMT with the exact position of the UXO so they can assess the location for the MMMZ.

Figure 2-2 UXO Mitigation Zone



2.3.3.4 60-minute Pre-Detonation Search

The UXO deflagration ~~detonation~~ operations should only commence following a full pre explosion monitoring period in good sighting conditions.

Visual and acoustic monitoring will continue for a minimum of 60 minutes prior to the deflagration and consequent detonation of the explosive charges. When the 60-minute pre explosion monitoring period is complete in good sighting conditions, the lead MMO will communicate with the EOD Supervisor that deflagration ~~detonation~~ can take place. If a marine mammal is observed during the 60-minute pre-detonation search period, then the delay procedure outlined in Section 2.3.3.5 should be followed.

2.3.3.5 Delay procedure

Explosive deflagration ~~detonation~~ should be delayed if marine mammals are detected within the mitigation zone. If a marine mammal is detected, operations cannot continue until 20 minutes after the mammal has passed out of the mitigation zone. When a marine mammal is observed or acoustically detected within the mitigation zone it should be tracked until it has moved out of range. The MMO must notify the chain of command of the detection and advise that operations must be delayed. If the mammal has been detected acoustically, the PAM operator should use a range indication and their judgement to determine whether the marine mammal is within the mitigation zone. If an MMO or PAM operative is uncertain whether marine mammals are present within the mitigation zone, they should advise that operations be delayed as a precaution.

2.3.3.6 Use of Acoustic Deterrent Devices

Acoustic Deterrent Devices (ADDs) are designed to emit sound at frequencies that are uncomfortable to marine mammals, so they prevent them from entering a specific area. The aim of using an ADD in the deflagration ~~detonation~~ of a UXO is to reduce the risk of hearing damage and injury to harbour porpoise that may be in the vicinity.

The ADD likely to be used is the Lofitech AS seal scarer[12], although this will be confirmed prior to the deflagration ~~detonation~~ taking place.

ADDs should only be used in conjunction with visual and/or acoustic monitoring and for as short a period as necessary to minimise the introduction of additional noise. They should be positioned in the water in close proximity to the installed explosive source; the vessel with the MMOs and PAM operatives may not be a suitable mooring location for these devices. ADDs should be switched on for a pre-determined number of emissions during the pre-detonation search and turned off immediately once the detonations have commenced.

[12] http://www.lofitech.no/en/seal-scarer.html

Herschel *et al*. (2013)[13] recommend that the ADD should be activated for at least as long as it takes for a marine mammal to swim twice the distance of the mitigation zone at the onset of soft-start detonation. The duration of ADD deployment can be calculated using swimming speed assumptions to ensure that marine mammals are outwith the mitigation zone.

A swim speed of 1.5m/s[14,15] will be assumed for all marine mammals except for minke whale. For minke whale a swim speed of 3.25m/s will be assumed. There is data[16,17,18] to suggest that animals will flee at much higher speeds e.g. harbour porpoise at 1.9m/s[17], at least initially and that these figures are therefore precautionary.

Once the ADD is deployed and in position, they should be tested for operational efficiency. A low sensitivity hydrophone should be lowered over the side of the vessel near the ADD and the signals tested. The ADD Operative should also ensure that the communications are in place between themselves, the MMOs, the PAM Operative (if present) and the EOD Supervisor.

The ADD will be activated for 50 minutes[19] directly prior to the soft start procedure, during the pre-detonation search. The ADD cannot be used during transit to another deflagration ~~detonation~~ event and must be activated prior to the soft start procedure for any deflagration ~~detonation~~ event or sequence. Once the ADD has been activated for a period of 50 minutes, then the ADD Operative will recover the ADD and undertake routine checks to ensure it is still working correctly, ready for the next deployment and activation. If the MMO/PAM Operative and ADD Operative are the same person, then the ADD should be deployed and tested prior to the 1-hour pre-detonation search and activated at the appropriate time.

2.3.3.7 Use of Big Bubble Curtain (BBC)

Big Bubble Curtains (BBC) are noise abatement techniques designed to change the physical condition of the water and the outward propagation of the acoustic/shock waves. The aim of using a BBC is to reduce the sound energy emitted into the environment, thereby reducing the distance over which injury/PTS onset may occur.

A BBC will be used for deflagration in water depths equal to or less than 40m i.e. between KP0 and KP9.4.

[13] Herschel, A., Stephenson, S., Sparling, C., Sams, C. and Monnington, J. (2013) Use of Deterrent Devices and Improvements to Standard Mitigation during Piling. ORJIP Project 4, Phase 1. Xodus Group Ltd. Document L-300100-S00-REPT-002.
[14] Otani, S., Naito, Y., Kato, A. and Kawamura, A. (2000). Diving behavior and swimming speed of a freeranging harbor porpoise, *Phocoena phocoena*. Marine Mammal Science 16:811-814.
[15] Lepper, P. A., Robinson, S.P., Ainslie, M.A., Theobald, P.D. and de Jong, C. A. (2012). Assessment of cumulative sound exposure levels for marine piling events. Pages 453-457 The Effects of Noise on Aquatic Life. Springer.
[16] McGarry, T., Boisseau, O., Stephenson, S., Compton, R. (2017) Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (Balaenoptera acutorostrata), a Low Frequency Cetacean. ORJIP Project 4, Phase 2. RPS Report EOR0692. Prepared on behalf of The Carbon Trust. November 2017.
[17] Kastelein, R.A. Van de Voorde, S. and Jennings, N. (2018). Swimming Speed of a Harbor Porpoise (Phocoena phocoena) During Playbacks of Offshore Pile Driving Sounds. Aquatic Mammals. 44. 92-99. 10.1578/AM.44.1.2018.92.
[18] van Beest, F.M., Teilmann, J., Hermannsen, L., Galatius, A., Mikkelsen, L., Sveegaard, S., Balle, J.D., Dietz, R. and Nabe-Nielsen, J. (2018). Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun. Royal Society Open Science. Volume 5, Issue 1.
[19] Based on calculation that at a swimming speed of 1.5m/s it will take 50 minutes to swim 2km.

Verfuss et al (2019)[20] reports the limiting factors for BBC deployment are:

- Water depths greater than 40m
- Significant wave heights between 1.5m – 3m.
- Current speeds greater than 1m/s

If a UXO is identified in water depths of 40-70m advice should be sought from a BBC contractor as to practicalities and cost of deploying a BBC in winter at the specific location. A BBC shall be used if the contractor concludes it will be effective.

2.3.3.8 Use of 'soft-start'

If required, a sequence of small to large charge size in order will be implemented to allow additional time for marine mammals to leave the area of potential impact; this is known as a "soft-start" procedure. Typically, charges of 50g, 100g, 150g and 200g would be deployed 5 minutes after the deactivation of the ADD and would be sequenced to commence at 5-minute intervals, with a further 5-minute interval before the deflagration charge. ~~An additional 250g charge may be added to the sequence if the UXO requiring detonation is greater than 250kg.~~ This allows marine mammals to move further from the site, ensuring they are beyond the increased potential permanent injury onset range.

The introduction of additional small charges must ensure a balance between the deterrence of marine mammals beyond the potential range of injury, and minimizing the additional noise introduced into the environment.

Once the soft-start has commenced, and a marine mammal is detected within the 1 km mitigation zone by the MMO and/or PAM Operative, the soft-start sequence should be paused, the ADD reactivated until the marine mammal is clear of the mitigation zone for a period of 20 minutes. Once the MMO and/or PAM Operative has confirmed that the marine mammal has been clear for 20 minutes, then the soft-start procedure can recommence with the next charge.

Note: Where there is a requirement that groups of charges must be detonated together, consideration should be given to appropriate fusing to fractionally delay the detonation of the second and subsequent charges (only by milliseconds), thus reducing the cumulative effect of the charges and in order to lessen the impact of the shock wave.

2.3.3.9 Use of deflagration

Deflagration, whereby the explosive in the UXO is burnt out rather than blown up, should be utilised for all UXO's requiring in-situ disposal. This is due to the predicted injury ranges for a 1.54kg UXO being greater than the area that can be mitigated using ADD's and other measures.

[20] Verfuss, U.K., Sinclair, R.R. and Sparling, C.E. (2019). A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070.

2.3.3.10 Post-detonation search

A 15-minute post detonation search must be conducted in the mitigation zone by the MMO to look for any evidence of injury to marine life, including fish kills. Any observations should be noted in the MMOs report.

2.3.3.11 Underwater noise measurements

Noise measurements will be undertaken before, during and after the UXO deflagration following a separate Noise Measuring Procedure.

Measurements will be undertaken following the 'Good Practice Guide for Underwater Noise Measurement'[21] including following best practice for in-situ measurement of underwater sound, for processing the data, and for reporting the measurements using appropriate metrics.

The Noise Measuring Procedure will be agreed with NRW and JNCC and will be appended to this plan.

2.3.4 Communication Protocol

Clear communication channels must exist between MMOs/PAM operators and personnel detonating the explosives. As each explosive use is likely to be different, it is recommended that communication channels should be established and in place before the activity commences. Communication channels will be discussed at a pre-mobilisation meeting so every party knows what to do in case there is an observation in the mitigation zone prior to detonation.

2.3.5 Reporting

Reports detailing the marine mammal mitigation activities should be completed by the MMO and sent to the Greenlink Consents Manager to forward to JNCC by email to seismic@jncc.gov.uk and NRW **trwyddedrhywogaeth@cyfoethnaturiolcymru.gov.uk** within six weeks of the explosives operation being completed.

The information to record in the MMO report includes:

- The reference number for the activity provided by the regulatory authority.
- Date and location of the activity.
- A full account of the deflagration operation including all mitigation deployed e.g. ADD, BBC, and start and end times of deployment.
- The start and end times of watches by MMOs and any acoustic monitoring using PAM.
- Any marine mammal sightings, summarised in the completed 'marine mammal recording forms'

[21] National Measurement Office, Marine Scotland, The Crown Estate, Robinson, S.P., Lepper, P. A. and Hazelwood, R.A. (2014). NPL Good Practice Guide No. 133, ISSN: 1368- 6550, 2014. https://www.npl.co.uk/special-pages/guides/gpg133underwater

- Details of any acoustic deterrent devices used, and any relevant observations their efficiency.
- Details of any problems encountered during the operations including any non-compliance with JNCC regulations or agreed procedure.

Appendix A

Reporting Forms

MARINE MAMMAL RECORDING FORM - COVER PAGE

Regulatory reference number (e.g. DECC no., BOEM permit no., OCS lease no., etc.)	**Country**	**Location**	**Ship/ platform name**
Client	**Contractor**	**Survey type** □ site □ VSP □ 2D □ WAZ □ 3D □ piling □ 4D □ explosives □ OBC □ other □ 4C	
Start date	**End date**		

Number of source vessels	**Type of source** (e.g. airguns)	**Number of airguns** (only if airguns used)	**Source volume** (cu. in.)
Source depth (metres)	**Frequency** (range in which peak energy is emitted, in Hz)	**Intensity** (primary peak-to-peak amplitude in dB re. 1µPa or bar metres)	**Shot point interval** (metres)
Method of soft start □ increase number of guns □ increase frequency (where permitted) □ increase pressure (where permitted) □ increase number and frequency □ increase number and pressure □ other			

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.)	**Magnification of optical equipment** (e.g. binoculars)	**Height of eye above water surface** (metres)	**How was distance of animals estimated?** □ by eye □ with laser rangefinder □ with rangefinder stick/ callipers □ with reticle binoculars □ by relating to object at known distance □ other
Number of dedicated MMOs	**Training of MMOs** □ JNCC approved MMO training course for UK waters □ PSO training course for the Gulf of Mexico □ MMO training course for Irish waters □ MMO training course for New Zealand waters □ other □ none		

Was PAM used? □ yes □ no	**Number of PAM operators**	
Description of PAM equipment		
Range of PAM hydrophones from airguns (metres)	**Bearing of PAM hydrophones from airguns** (relative to direction of travel)	**Depth of PAM hydrophones** (metres)

MARINE MAMMAL RECORDING FORM - OPERATIONS

Regulatory reference number .....…….. **Ship/ platform name** .....
(e.g. DECC no., BOEM permit no., OCS lease no., etc.)

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any purpose.
Times should be in UTC, using the 24 hour clock.

Date	**Reason for firing** l = line t = test x = test followed immediately by line	**Time soft start/ ramp-up began**	**Time of full power**	**Time of start of line**	**Time of end of line**	**Time of reduced output** (if relevant)	**Time airguns/ source stopped**	**Time pre-shooting search began**	**Time search ended**	**Time PAM began**	**Time PAM ended**	**Depth range** (during pre-shooting search) s = <200m d = >200m b = both	**Was it day or night in period prior to firing?** d = day n = night w = dawn k = dusk	**Was any mitigating action required?** (yes/ no)

MARINE MAMMAL RECORDING FORM - EFFORT

Regulatory reference number .....…….. **Ship/ platform name** .....
(e.g. DECC no., BOEM permit no., OCS lease no., etc.)

Record the following for all watches, even if no marine mammals are seen.
START A NEW LINE IF SOURCE ACTIVITY OR WEATHER CHANGES. ENTER DATA AT LEAST EVERY HOUR.

Date	**Visual watch or PAM** (v/ p)	**Observer's/ operator's name(s)**	**Time of start of section of watch** (UTC, 24hr clock)	**Time of end of section of watch** (UTC, 24hr clock)	**Source activity** (f/ s/ r/ n/ v)	**Start position** (latitude and longitude)	**Depth at start** (m)	**End position** (latitude and longitude)	**Depth at end** (m)	**Speed of vessel** (knots)	**Wind dir'n**	**Wind force** (B'fort scale)	**Sea state** (g/ s/ c/ r)	**Swell** (o/ m/ l)	**Vis.** (visual watch only) (p/ m/ g)	**Sun glare** (visual watch only) (n/ wf/ sf/ vf/ wb/ sb/ vb)	**Precip.** (n/ l/ m/ h/ s)

Visual watch or PAM: v = visual watch; p = PAM
Source activity: f = full power; s = soft start; r = reduced power (not soft start); n = not active; v = variable (e.g. tests)
Sea state: g = glassy (like mirror); s = slight (no/ few white caps); c = choppy (many white caps); r = rough (big waves, foam, spray)
Swell: o = low (< 2 m); m = medium (2-4 m); l = large (> 4 m)
Visibility: p = poor (< 1 km); m = moderate (1-5 km); g = good (> 5 km)
Sun glare: n = none; wf = weak forward; sf = strong forward; vf = variable forward; wb = weak behind; sb = strong behind; vb = variable behind
Precipitation: n = none; l = light rain; m = moderate rain; h = heavy rain; s = snow

MARINE MAMMAL RECORDING FORM - SIGHTINGS

Regulatory reference number (e.g. DECC no., BOEM permit no., OCS lease no., etc.)	**Ship/ platform name**	**Sighting number** (start at 1 for first sighting of survey)	**Acoustic detection number** (start at 500 for first detection of survey)
Date		**Time at start of encounter** (UTC, 24hr clock)	**Time at end of encounter** (UTC, 24hr clock)

Were animals detected visually and/ or acoustically?	**How were the animals first detected?**
☐ visual ☐ acoustic ☐ both	☐ visually detected by observer keeping a continuous watch ☐ visually spotted incidentally by observer or someone else ☐ acoustically detected by PAM ☐ both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	**Position** (latitude and longitude)	**Water depth** (metres)

Species/ species group	**Description** (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks)
Bearing to animal (when first seen or heard) (bearing from true north)	**Range to animal** (when first seen or heard) (metres)

Total number	**Number of adults** (visual sightings only)	**Number of juveniles** (visual sightings only)	**Number of calves** (visual sightings only)	**Photograph taken**
				☐ yes ☐ no

Behaviour (visual sightings only)

Direction of travel (relative to ship)		**Direction of travel** (compass points)	
☐ towards ship	☐ variable	☐ N	☐ W
☐ away from ship	☐ milling	☐ NE	☐ NW
☐ parallel to ship in same direction as ship	☐ stationary	☐ E	☐ variable
☐ parallel to opposite direction to ship	☐ other	☐ SE	☐ stationary
☐ crossing perpendicular ahead of ship	☐ unknown	☐ S	☐ unknown
		☐ SW	

Airgun (or other source) activity when animals first detected	**Airgun (or other source) activity when animals last detected**	**Time animals entered mitigation/ exclusion zone** (UTC, 24hr clock)	**Time animals left mitigation/ exclusion zone** (UTC, 24hr clock)
☐ full power ☐ not firing ☐ soft start ☐ reduced power (other than soft start)	☐ full power ☐ not firing ☐ soft start ☐ reduced power (other than soft start)	**Closest distance of animals from airguns (or other source)** (metres)	**Time of closest approach** (UTC, 24hr clock)

If seen during soft start give:	**What action was taken?** (according to requirements of guidelines/ regulations in country concerned)	**Length of power-down and/ or shut-down** (if relevant) (length of time until subsequent soft start, in minutes)	**Estimated loss of production (if relevant) due to mitigating actions** (km)
First distance **Closest distance** **Last distance** during soft start (metres)	☐ none required ☐ delay start of firing ☐ shut-down of active source ☐ power-down of active source ☐ power-down then shut-down of active source		

Appendix B

Noise Measuring Procedure

HOLD – To be agreed with NRW, Cefas and JNCC