MORAY EAST OFFSHORE WINDFARM

Offshore Transmission Infrastructure Cable Plan

Moray East Offshore Wind Farm Offshore Transmission Infrastructure (OfTI)

December 2020

Moray Offshore Windfarm (East) Limited

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Review / Approval

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AC	Alternating Current
AHTS	Anchor Handling Tug Supply [Vessel]
AIS	Automatic Information System
ALARP	As Low As Reasonably Practicable
AtoN	Aids to Navigation
BOWL	Beatrice Offshore Wind Ltd.
CAA	Civil Aviation Authority
CaP	Cable Plan
CBRA	Cable Burial Risk Assessment
CIRA	Cable Installation Risk Analysis (as trenched CBRA)
CMS	Construction Method Statement
CoP	Construction Programme
CPS	Cable Protection System
CPT	Cone Penetration Tests
DoC	Depth of Cover
DoL	Depth of Lowering
DP	Dynamic Positioning
DSLP	Development Specification and Layout Plan
DTS	Distributed Temperature Sensing
EDA	Eastern Development Area
EPCI	Engineering Procurement Construction Installation
ES	Environmental Statement
Fl	Flashing
FO	Fibre Optic
FPV	Fall Pipe Vessel
FPROV	Fall Pipe Remotely Operated Vehicle
HDD	Horizontal Directional Drill
HDPE	High Density Polyurethane
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
KP	Kilometre Point (with KP 0 at the TJB)
m	Metre
MCA	Maritime and Coastguard Agency
MFE	Mass Flow Excavator

MHWS	Mean High Water Springs
ml	Millimetre
Moray East	Moray Offshore Windfarm (East) Limited
MS-LOT	Marine Scotland Licensing Operations Team
Mte	Metric Tonnes
nm	Nautical mile
NSP	Navigational Safety Plan
O&M	Operation and Maintenance
OEC	Offshore Export Cable
OFCOM	Office of Communications
OfTI	Offshore Transmission Infrastructure
OfTI CaP	Offshore Transmission Infrastructure Cable Plan
OFTO	Offshore Transmission Owners
OMP	Operation and Maintenance Programme
OSP	Offshore Substation Platform
PLGR	Pre-Lay Grapnel Run
ROV	Remotely Operated Vehicle
RPL	Route Position List
SHET	Scottish Hydro Electric Transmission PLC
SNH	Scottish Natural Heritage
TI	Transmission Infrastructure
TJB	Transition Joint Bay
TSV	Trenching Support Vessel
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
UXO	Unexploded Ordnance
VMP	Vessel Management Plan
WTG	Wind Turbine Generator

Definitions

The following definitions have been used throughout this document with respect to the company, the consented wind farms and how these definitions have changed since submission of the Moray East Environmental Statement (ES) in 2012 and the Moray East Modified Transmission Infrastructure ES in 2014 and the Moray East Offshore Substation Platform (OSP) Environmental Report in 2017.

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- **Moray Offshore Windfarm (East) Limited (formerly known as Moray Offshore Renewables Limited and hereinafter referred to as Moray East)** – the legal entity submitting this Offshore Transmission Infrastructure (OfTI) Cable Plan;
- **Moray East Offshore Wind Farm** - the wind farm to be developed in the Moray East site (also referred as the Wind Farm);
- **The Moray East site** - the area in which the Moray East Offshore Wind Farm will be located. Section 36 Consents and associated Marine Licences to develop and operate up to three generating stations on the Moray East site were granted in March 2014. At that time the Moray East site was known as the "Eastern Development Area" (EDA) and was made up of three sites known as the Telford, Stevenson and MacColl offshore wind farm sites. The Section 36 Consents and Marine Licences were subsequently varied as described below;
- **Telford, Stevenson and MacColl wind farms** – these names refer to the three consented offshore wind farm sites located within the Moray East site;
- **Transmission Infrastructure (TI)** - includes both offshore and onshore electricity TI for the consented Telford, Stevenson and MacColl wind farms. Includes connection to the national electricity transmission system near New Deer in Aberdeenshire encompassing Alternating Current (AC) offshore substation platforms (OSPs), AC OSP interconnector cables, AC export cables offshore to landfall point at Inverboyndie continuing onshore to the AC collector station (onshore substation) and the additional regional Transmission Operator substation near New Deer. A Marine Licence for the offshore TI was granted in September 2014 (Modified Offshore Transmission Infrastructure (OfTI) Marine Licence) and varied in 2019. A further Marine Licence for two additional distributed offshore substation platforms (OSPs) was granted in September 2017 and subsequently varied in July 2019. The onshore TI was awarded Planning Permission in Principle in September 2014 by Aberdeenshire Council and a Planning Permission in Principle under Section 42 in June 2015. In June 2018 Aberdeenshire Council granted Approval of Matters Specified in Conditions for both the cable route and substation;
- **Offshore Transmission Infrastructure (OfTI)** – the offshore elements of the transmission infrastructure, comprising AC OSPs, OSP interconnector cables and AC export cables offshore to landfall (for the avoidance of doubts some elements of the OfTI will be installed in the Moray East site);
- **Moray East ES 2012** – The ES for the Telford, Stevenson and MacColl wind farms and Associated Transmission Infrastructure, submitted August 2012;
- **Moray East Modified TI ES 2014** – the ES for the TI works in respect to the Telford, Stevenson and MacColl wind farms, submitted June 2014;
- **Moray East OSP Environmental Report 2017** – the environmental report comprising of the "Statement Regarding Implications for the Modified TI ES 2014 and HRA". The report was produced in support of the application submitted in May 2017 for the Moray East OSP Marine Licence;

- **The Development** – the Moray East Offshore Wind Farm and Offshore Transmission Infrastructure (OfTI);
- **Design Envelope** - the range of design parameters used to inform the assessment of impacts;
- **OfTI Corridor** – the export cable route corridor, i.e. the OfTI area as assessed in the Moray East Modified TI ES 2014 excluding the Moray East site; and
- **the Applications** – (1) the Application letter and ES submitted to the Scottish Ministers on behalf of Telford Offshore Windfarm Limited, on 2nd August 2012 and the Additional Ornithology Information submitted to the Scottish Ministers by Moray Offshore Renewables Limited on the 17th June 2013; (2) the Section 36 Consents Variation Application Report for Telford, Stevenson and MacColl Offshore Wind Farms dated December 2017 and (3) the Marine Licence Applications and associated documents submitted for the OfTI Licences.
- **Moray East Offshore Wind Farm Consents** – are comprised of the following:

  <u>Section 36 Consents:</u>

  - Section 36 consent for the Telford Offshore Wind Farm (as varied on 22 March 2018) – consent under Section 36 of the Electricity Act 1989 for the construction and operation of the Telford Offshore Wind Farm assigned to Moray East on 19 June 2018.
  - Section 36 consent for the Stevenson Offshore Wind Farm (as varied on 22 March 2018) – consent under Section 36 of the Electricity Act 1989 for the construction and operation of the Stevenson Offshore Wind Farm assigned to Moray East on 19 June 2018.
  - Section 36 consent for the MacColl Offshore Wind Farm (as varied on 22 March 2018) – consent under Section 36 of the Electricity Act 1989 for the construction and operation of the MacColl Offshore Wind Farm assigned to Moray East on 19 June 2018.

  <u>Marine Licences</u>

  - Marine Licence for the Telford Offshore Wind Farm (as varied on 22 March 2018, 19 July 2019, 27 April 2020 and 25 November 2020) – Licence Number: MS-00009051 (formerly 04629/20/0) – granted under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on 19 July 2018.
  - Marine Licence for the Stevenson Offshore Wind Farm (as varied on 22 March 2018, 19 July 2019, 27 April 2020 and 25 November 2020) – Licence Number: MS-00008985 (formerly 04627/20/0) – granted under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on 19 July 2018.
  - Marine Licence for the MacColl Offshore Wind Farm (as varied on 22 March 2018, 19 July 2019, 27 April 2020 and 21 October 2020) – Licence Number: MS-00008972 (formerly 04628/20/0) - granted under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on 19 July 2018.
  - Marine Licence for Moray Offshore Windfarm (East) Limited (as varied on 31 July 20) – Licence Number: 07086/20/1– granted under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009 (as amended), Part 4 Marine Licensing to deposit, backfill of seabed depressions within the Scottish Marine Area and the United Kingdom Marine Licensing Area.

- **OfTI Licences** – are comprised of the following:
    - Marine Licence for the Offshore Transmission infrastructure (as varied on 19 July 2019) – Licence Number 05340/19/0 – granted under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the "OfTI Marine Licence")

Marine Licence for two additional distributed OSPs (as varied on 19 July 2019) – Licence Number 06347/19/0 – granted under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction, operation and maintenance works and the deposit of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the "OSP Marine Licence").

Executive Summary

This Offshore Transmission Infrastructure Cable Plan (OfTI CaP) has been prepared to address the specific requirements of the relevant condition attached to the OfTI Marine Licence issued to Moray Offshore Windfarm (East) Limited (Moray East).

The cable plan addresses each part of the condition as set out in Section 1.2.1 and provides supporting specifications, engineering, planning and construction details to confirm alignment with the original Application. A separate Wind Farm Cable Plan has been produced for the Moray East Offshore Wind Farm. Details of the Offshore Substations Platform (OSP) interconnector cables are primarily set out in the Wind Farm Cable Plan. Where this OfTI CaP provides information in relation to the OSP interconnector cables then this is clearly identified in the relevant sections.

1 Introduction

1.1 Background

Section 36 Consents were granted in March 2014 for the construction and operation of three offshore wind farms (Telford, Stevenson and MacColl) within the Moray East site. Marine Licences for the three offshore wind farms were granted in September 2014 (together the Section 36 Consents and Marine Licences for the Wind Farm are referred to as the Moray East Offshore Wind Farm Consents). The Wind Farm Section 36 Consents were varied in March 2018 and assigned to Moray East Offshore Wind Farm (East) Limited in June 2018. The Marine Licences were varied as detailed above and transferred to Moray East in July 2018.

Moray East was granted a Marine Licence for two Offshore Substation Platforms (OSPs) in September 2014 (OfTI Marine Licence) and subsequently varied in July 2019 and in 2017 a Marine Licence was granted for two additional distributed OSPs (OSP Marine Licence) and subsequently varied in July 2019 (together these licences are referred to as the OfTI Marine Licences). This OfTI Cable Plan (OfTI CaP) is also submitted in accordance with the OfTI Marine Licence.

Moray East is a joint venture partnership between Ocean Winds, Diamond Generating Europe and China Three Gorges and has been established to develop, finance, construct, operate, maintain and decommission the Moray East Offshore Wind Farm.

1.2 Objectives of this Document

The OfTI Marine Licence contains a variety of conditions that must be discharged through approval by the Scottish Ministers prior to the commencement of offshore construction. One such requirement is the approval of a Cable Plan, referred in this document as the OfTI CaP. The relevant conditions setting out the requirement for a CaP for approval are set out in full in Table 1-1 below.

This document is intended to satisfy the requirements of OfTI Marine Licence conditions by providing an OfTI CaP that can be practically implemented during the construction and operation phases of the Development. This OfTI CaP covers the offshore export cables (OEC) and a separate Wind Farm CaP has been produced to cover the inter-array cables and the OSP interconnector cables (Moray East, 2018a). The OSP interconnector cables have been included within the Wind Farm CaP on the basis that that a single contractor has been selected for the engineering and installation of the inter-array and OSP interconnector cables (with a consistent approach for the design and installation of the cables within the Moray East site).

At this time there is no change proposed to the OSP interconnector cables and this update only covers proposed changes to the Offshore Export Cables.

The objective of the document is to provide supporting descriptions, data and evidence that the planning for the installation and operation of the OECs within the Moray East site and OfTI Corridor are in accordance with the required consent conditions.

Table 1-1: Consent conditions to be discharged and reference sections

Consent Document	Condition Reference	Condition Text	Reference in this Cable Plan
OfTI Marine Licence	3.2.2.10	The Licensee must, no later than 6 months prior to the Commencement of the Works, submit CaP, in writing, to the Licensing Authority for their written approval. Such approval may only be granted following consultation by the Licensing Authority with the JNCC, SNH, MCA, and the SFF and any such other advisors or organisations as may be required at the	This document sets out the OfTI CaP for approval by the Scottish Ministers.

Consent Document	Condition Reference	Condition Text	Reference in this Cable Plan
		discretion of the Licensing Authority. The CaP must be in accordance with the Application. The CaP must include the following:	
		a. Details of the location and cable laying techniques for the cables;	Sections 3, 9 and 10
		b. The results of survey work (including geophysical, geotechnical and benthic surveys) which will help inform cable routing;	Section 8
		c. A pre-construction survey for Annex 1 habitat and priority marine features to inform cable micro-siting and installation methods in consultation with the Licensing Authority and their advisors;	Sections 8 and 9
		d. Technical specification of all cables, including a desk based assessment of attenuation of electro-magnetic field strengths and shielding;	Sections 7 and 11
		e. A burial risk assessment to ascertain if burial depths can be achieved. In locations where this is not possible then suitable protection measures must be provided;	Section 10
		f. Methodologies for over trawl surveys of the cables through the operational life of the Works where mechanical protection of cables laid on the sea bed is deployed; and	Sections 11 and 13
		g. Measures to address exposure of any cables.	Sections 10 and 12

1.3 Cable Plan Scope

This OfTI CaP covers the following areas, in line with the requirements of the OfTI Marine Licence condition 3.2.2.10:

- The technical specification of OECs and overall cable system including the thermal and electromagnetic field impact;
- OEC and OSP route description (for the OSPs and interconnector cables see Wind Farm CaP);
- The results of survey work including geophysical, geotechnical, UXO and benthic surveys which helped inform cable routing;
- The Cable Burial Risk Assessment (CBRA) results and measures to provide cable protection (including the as-trenched CIRA assessment);
- Pre-cable installation enabling and route preparation works;
- Cable laying techniques for the OECs;
- The method of cable burial and / or protection; and
- Measures which will be employed to monitor and address potentially exposed OEC throughout the life of the wind farm.

1.4 Cable Plan Document Structure

In response to the specific requirements of the OfTI Marine Licence condition 3.2.2.10, this OfTI CaP has been structured to clearly set out how each part of the specific requirements has been met and that the relevant information to allow the Scottish Ministers to approve the OfTI CaP has been provided. The document structure is set out in Table 1-2 below.

Table 1-2: Document Structure

Section		Summary of Contents
1	Introduction	Sets out the background, objectives and aims of the OfTI CaP, including the consent conditions related to the OfTI CaP.
2	Statements of Compliance	Sets out the statements of compliance in relation to the OfTI CaP consent conditions and the broader construction process.
3	Project Overview	Provides an overview of the whole project as background.
4	Timing of Construction Works	Sets out the key construction milestones.
5	Overall Construction Management	Sets out the manner of offshore construction management, coordination, operation and control.
6	OEC Supply and Installation Contractor	Identifies the key contractors and subcontractors for the OfTI installation.
7	OEC Specifications	Provides details of the cable specifications and the results of external electromagnetic field assessment.
8	Site Investigations	Provides information relating to survey work and routing of the OEC.
9	Cable Routing	Details the key constraints considered within route engineering and describes the geophysical, geotechnical and benthic surveys conducted to inform cable routing.
10	Cable Burial Risk Assessment	Provides details of the cable burial risk assessment conducted to determine the burial targets.
11	Requirements for the Design of the OEC Third Party Cable Crossing	Provides details on the crossing of the SHET HVDC cable.
12	Cable Installation Methodology	Briefly summarises the OEC installation methods.
13	Export Cable Operation and Maintenance	Sets out the operation and maintenance programme and remedial procedures in the event that the cables become exposed, damaged or fail.
14	Compliance with the Application	Sets out information from the Modified TI ES 2014 with regard to compliance.
15	Updated Cable Trenching Methodology	Provides a comparison of the Modified TI ES 2014 assessment of the OEC and the worst case scenario (WCS) assessment resulting from the proposed OEC installation tools.
16	References	Details all references used to develop this OfTI CaP.

1.5 Linkages with other consent plans

The consent conditions that require the development of a CaP do not explicitly identify linkages between this and other consent plans. However, other conditions require that several consent conditions plans be consistent with the OfTI CaP; these plans are identified in Table 1-3 below.

Table 1-3: Cable Plan consistency and links to other consent plans

Condition	Consent Plan	Consistency with and linkage to CABLE PLAN
Section 36 Condition 10; OfTI Marine Licence Condition 3.2.2.4	Construction Method Statement (CMS)	The purpose of the CMS is to detail the methods that will be implemented during the construction of the Development. The cable installation and burial methods detailed are consistent with the OfTI CaP.
Section 36 Condition 26; OfTI Marine Licence Condition 3.2.1.1	Project Environmental Monitoring Programme (PEMP)	Provides an overview of seabed scour and local sediment deposition monitoring. This shall be consistent with the OfTI CaP.
Section 36 Condition 12; OfTI Marine Licence Condition 5.2.6; and OSP Marine Licence Condition 3.2.2.7	Design Specification and Layout Plan (DSLP)	The details provided on the design, layout and specifications of the OECs shall be consistent with the OfTI CaP.
Section 36 Condition 16; OfTI Marine Licence Condition 5.3.2 and OSP Marine Licence Condition 3.2.3.11	Operation and Maintenance Programme (OMP)	The OMP sets out the procedures and good working practices for the operational and maintenance (O&M) phase of the Development. The OMP must be consistent with the OfTI CaP.
Section 36 Condition 18	CaP (Wind Farm)	The Wind Farm CaP sets out evidence that the installation and operation of the inter-array cable network within the Wind Farm site are in accordance with the required consent conditions. The OfTI CaP and Wind Farm CaP must be consistent.

2 Statements of Compliance

The following statements re-affirm the Moray East commitment to ensuring that the Development is constructed and operated in such a manner as to meet the relevant legislative requirements set out by the Section 36 Consents and OfTI Marine Licences.

2.1 Statements of Compliance

Moray East in undertaking the construction and operation of the Development will ensure compliance with this OfTI CaP as approved by the Scottish Ministers (and as updated or amended if required).

Where significant updates or amendments to this OfTI CaP are required, Moray East will ensure the Scottish Ministers (and relevant stakeholders) are informed as soon as reasonably practicable and where necessary the OfTI CaP will be updated and amended.

Moray East in undertaking the construction and operation of the Development requires compliance with other relevant Section 36 Consent condition plans as approved by the Scottish Ministers and identified in Section 1.5 above.

Moray East in undertaking the construction and operation of the Development ensures and will ensure compliance with the limits defined by the original Applications (including the project descriptions defined in the Moray East ES 2012 and Modified TI ES 2014) referred to in Annex 1 of the Section 36 Consents and Part 2 of the OfTI Marine Licence and in so far as they apply to this OfTI CaP (unless otherwise approved in advance by the Scottish Ministers) (see Section 2.2 below).

Moray East, in undertaking the design and construction of the Development, requires and will require compliance with the approved OfTI CaP (and all other relevant, approved Consent Plans) by the key contractors and subcontractors through condition of contract and by an appropriate auditing process.

2.2 Management of Change to the OFTI Cable Plan

Should there be a reason to modify methodologies brought about during the engineering stages of the project, such changes will be made to this document and resubmitted following the same review process as described above.

As required by the Marine Licence conditions, any updates or amendments made by the Licensee, will be submitted, in writing, by the Licensee to the Licensing Authority for their written approval.

3 Project Overview

The OfTI Marine Licence requires that the OfTI CaP includes the following:

> *"Details of the location and cable laying techniques for the cables."*

This section provides a brief overview of the Development relevant to the OfTI CaP, including details of the location, and sets out the main roles and responsibilities in relation to Moray East and the key contractors. Details of the cable laying techniques are provided in Section 12.

3.1 Development Overview

The Development will consist of the following main components:

- A total generating capacity of approximately 950 MW, however the total generation capacity will be constrained by the Development's grid connection transmission entry capacity of 900 MW (further details provided within the DSLP (Moray East, 2019a));
- 100 Wind Turbine Generators (WTGs) of no greater than 10 MW (further details provided in the DSLP);
- Jacket substructures each installed on three pile foundations driven into the seabed;
- Three AC OSPs to collect the generated electricity and transform the electricity for transmission to shore;
- A network of buried or (if sufficient burying is not possible) mechanically protected, subsea inter array cable circuits to connect strings of turbines together and to connect the turbines to the OSPs (as defined in the Wind Farm CaP (Moray East, 2019b));
- Two buried or (if sufficient burying is not possible) mechanically protected subsea inter-connector cable circuits that link the OSPs to one another;
- Three buried or (if sufficient burying is not possible) mechanically protected subsea export cable circuits to transmit the electricity from the OSPs to the landfall at Inverboyndie Bay and connecting to the onshore buried export cable circuits for transmission to the onshore substation and connection to the national electricity transmission system; and
- Minor ancillary works such as the deployment of met buoys and permanent navigational marks as defined in this OfTI CaP.

An overview of the OfTI boundary within the Moray Firth is provided in Figure 3-1 below.

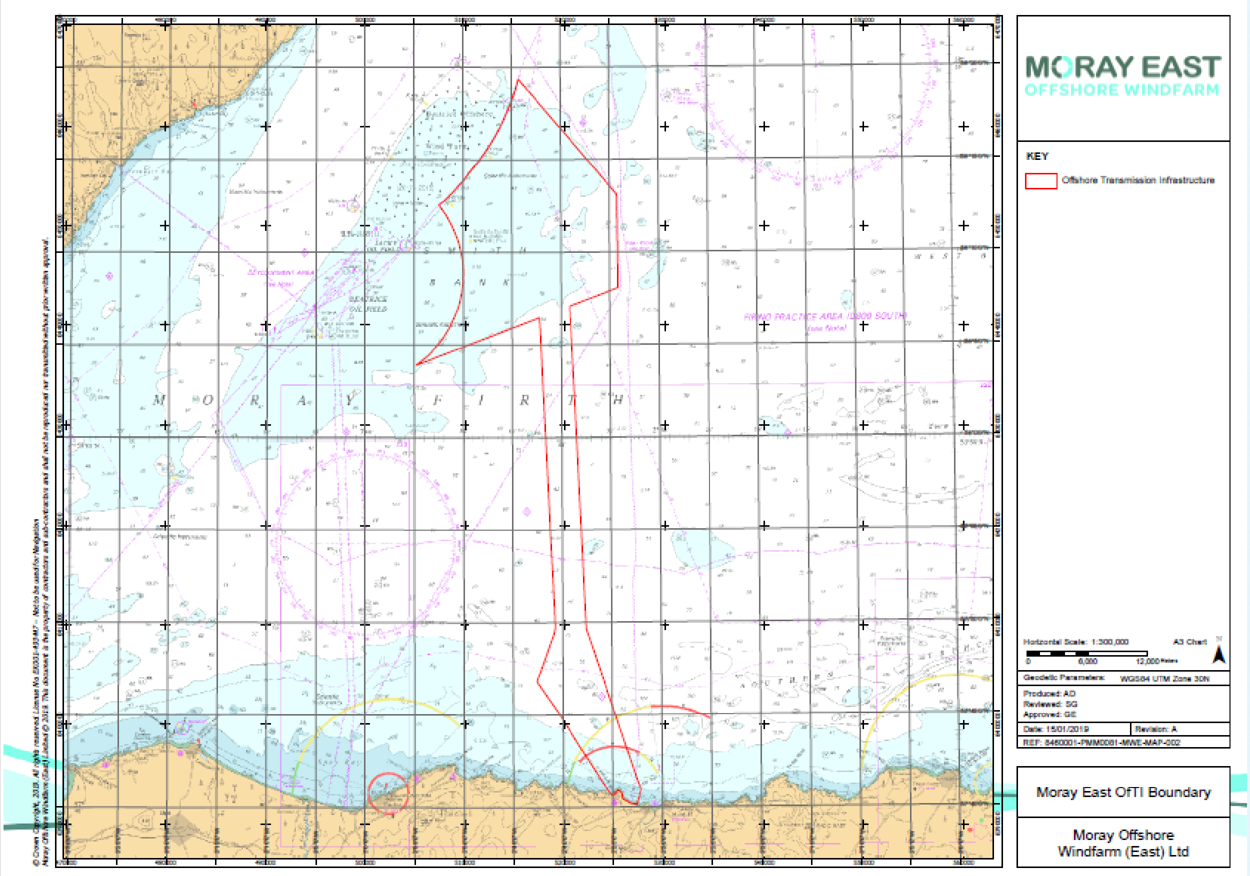


Figure 3-1: Overview of the OfTI Boundary

3.2 Project Location and Layout

Figure 3-2 below shows the final layout of WTGs and OSPs across the Moray East site, as detailed within the DSLP (Moray East, 2019) upon which this OfTI CaP is based. Further information on the layout of the Moray East site, including the specifications of the WTGs and OSPs and the location coordinates of each structure, is provided in the DSLP (Moray East, 2019). No spare locations were utilised Moray East will ensure that the OfTI CaP is aligned with the DSLP in case of any amendments to any of the documents. The information presented with this document is currently aligned with the latest version of the DSLP.

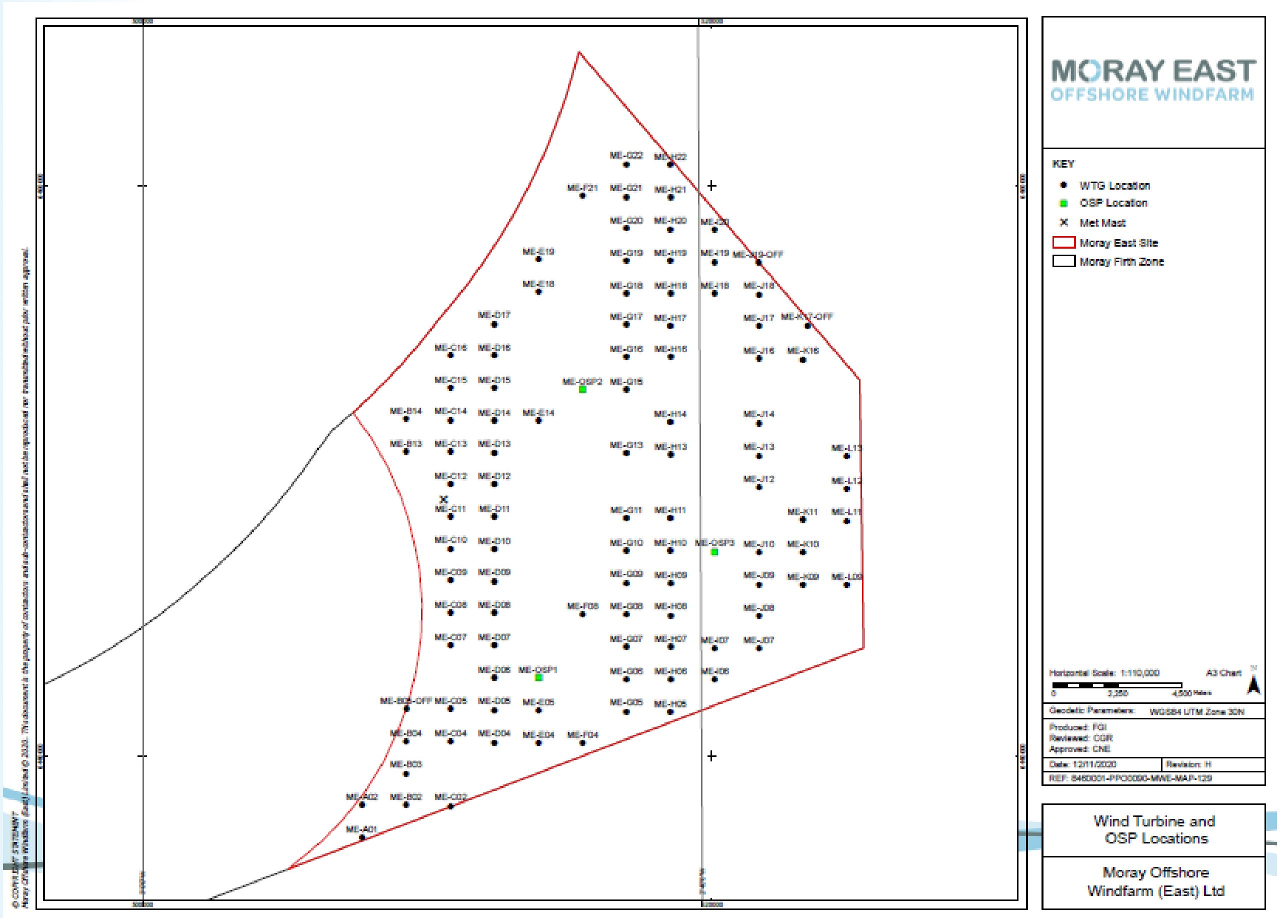


Figure 3-2: WTG and OSP Layout

Figure 3-3 below shows the final layout of three OECs from landfall into the Moray East site.

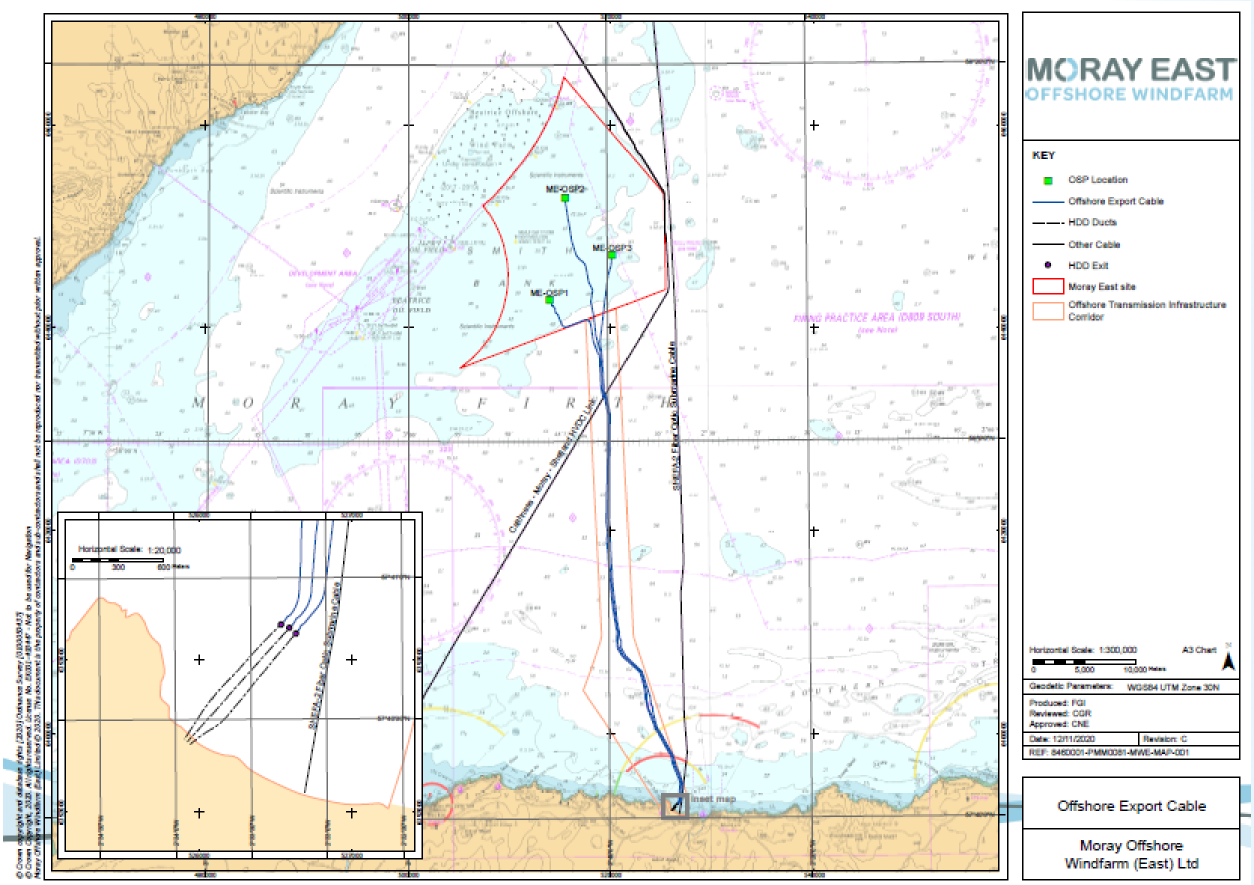


Figure 3-3: Offshore Export Cable Routes within the OfTI Corridor.

4 Timing of Construction Works

This section provides an overview of the Moray East Offshore Wind Farm development (as consented under the Section 36 Consents and OfTI Marine Licences) and presents the key milestone dates for the commencement of works, the main construction activity and the commissioning of the wind farm.

Construction works for the OECs have and will be undertaken as detailed in Table 4.1 (and up to date at time writing). Full details of the construction programme are provided in the combined Construction Programme (CoP) and Construction Method Statement (CMS) document (Moray East, 2020b), updated as relevant.

Table 4-1: Summary of key milestone dates

Milestone	Anticipated Programme
Mobilisation of Plant and Delivery of Materials	To match installation timings as set out below
Timing and Sequencing of Construction Work, inclusive of all cable terminations and commissioning	Horizontal drilling from onshore to offshore and installation of ducts at landfall: • May 2019 – November 2019 OSP Pile Foundations: • June 2020 OSP Jackets installation: • June 2020 OSP Topsides installation: • June 2020 – October 2020 Export Cable laying: • May 2020 – February 2021
Full Generation	October 2021
Final Commissioning of OfTI	October 2021

5 Overall Construction Management

The overarching offshore construction management of the OEC installation works will be coordinated under a centralised Moray East Marine Co-ordination function. Daily planning, movements, operations and permitting will be the responsibility of the function which will provide 24-hour coverage during the construction phase of the project.

The daily work planning and sequencing of offshore operations, vessels, crew transfer, equipment movement and permit applications as well as applicable safe systems of work is the responsibility of the key cable installation contractors; details of which are set out in Section 6 below.

6 Offshore Export Cable Supply and Installation Contractors

6.1 Key Contractors

The OEC supply, installation and completions works will be carried out under an Engineering, Procurement, Construction and Installation (EPCI) contract between Moray East and NKT HV Cables AB (NKT). NKT is a leading subsea cable manufacturing and installation contractor with significant experience in the offshore wind market.

The combined CoP and CMS document (Moray East, 2020b) provides an overview of the key Wind Farm and OfTI contractors.

6.2 Key Subcontractors

The cable burial activities for the OECs have been carried out by Deep Ocean Ltd, subcontracted to NKT.

Installation of horizontal directional drilling pipes (HDDs) was carried out by an experienced, specialist HDD installation contractor, LMR Drilling UK, subcontracted to NKT.

Examples of other services that have been subcontracted include support vessels, guard vessels, survey services, transport services, supply of minor components, waste services, vessel provisioning and bunkering services, and provision of equipment to be used in the construction works.

7 Offshore Export Cable Specifications

The OfTI Marine Licence requires that the OfTI CaP includes the following:

> *"Technical specification of all cables, including a desk based assessment of attenuation of electro-magnetic field strengths and shielding."*

The following section provides information relating to the specification and design of the OEC. Electro-magnetic field strengths and shielding is considered in Section 11.

7.1 OEC Cable Overview

A total of three export cables have been installed, one to each of the OSP. The cables are nominated from West to East as ME-OEC1 (56.312 km), ME-OEC2 (63.369 km) and ME-OEC3 (57.057 km), (Figure 3-3).

The OECs connect to the onshore export cable circuits at Transition Joint Bays (TJBs), located above Mean High Water Springs (MHWS) at the cable landfall site in Boyndie Bay, which will form the 0 (zero) point for the offshore cable lay i.e. KP0 at the TJB.

At this shore end, three HDD ducts were constructed in advance of cable installation, that exit at approximately -10 m LAT, around 1000m from the TJB

The route was designed as expediently as possible from the HDD exit point toward the OSPs. Along the route at kilometre point (KP) 43, or 43 kilometres from the TJBs, there is one subsea asset (a buried power cable owned and operated by Scottish Hydro Electric Transmission (SHET), the SHET High Voltage Direct Current (HVDC) cable, which runs from Caithness to Moray), is crossed by the 3No. Moray East OECs.

At the OSPs, each OEC accompanied with a Cable Protection System (CPS) has been pulled into and through a steel J-tube with a bellmouth approximately 2-3 m above seabed at the OSP, with sufficient cable being pulled up into the OSP to allow for it to be connected to the termination point on the topside unit of the OSP. The CPS is utilised as an installation aid and protection for the cable against hydrodynamic movement over time.

The cables have been laid in one continuous length with no offshore joints, only made factory joints.

7.1.1 Key Cable Data

For the purpose of installing cables within the HDD ducts up to 27 m depth, the cable properties use conductor cross sectional areas of 1000 mm^2 for the section installed by HDD and for the main offshore subsea cable. The joint between the two was performed in the factory in order that no offshore jointing operation would be required.

The following table provides pertinent data for the OECs.

Table 7-1: Key export cable data

Parameter	HDD 1000 mm^2 Size	1000 mm^2 Size	Unit
Cable Outer Diameter	240	240	mm
Conductor Material	Aluminium	Aluminium	
No. of individual cable	3 (1 per export circuit)	3 (1 per export circuit)	
Number of power cores within each individual export cable	3	3	-
Total Installed Cable Length	4,500 (HDD Section)	176,738 (from TJB to OSPs)	m

Parameter	HDD 1000 mm² Size	1000 mm² Size	Unit
Allowable Bending Radius (during installation)	5	5	m
Safe working axial load (pulling)	330	162	kN
Weight / m (in air)	74	74	kg/m
Weight / m (in seawater)	42	42	kg/m

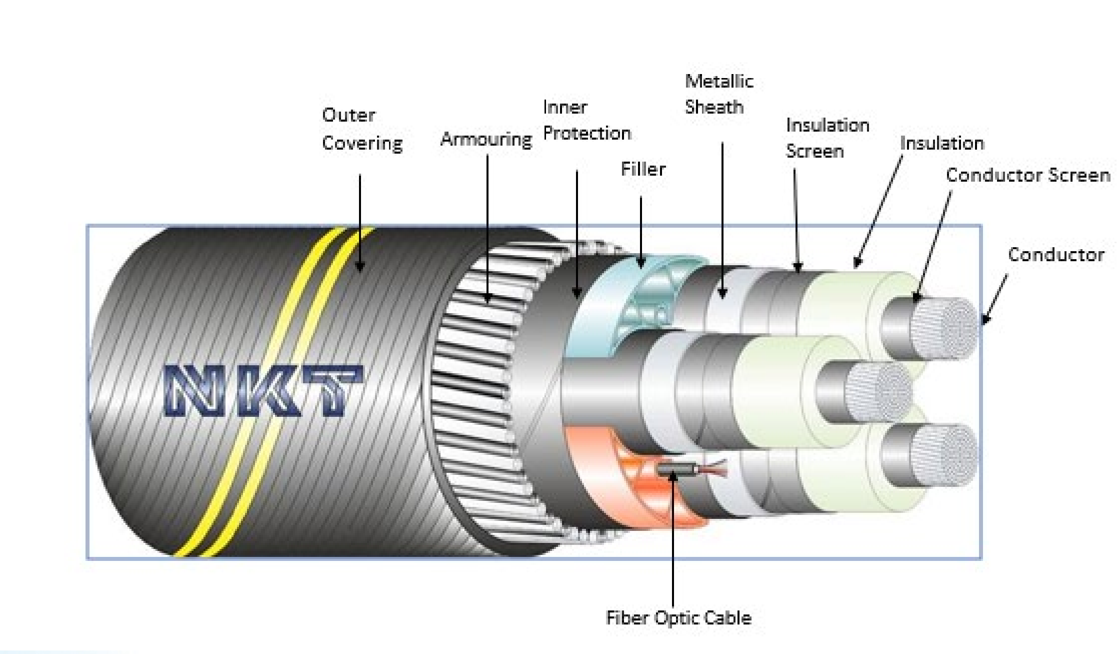


Figure 7-1: Offshore Export Cable configuration.

7.2 Export Cables Design and Construction

NKT have designed a 220kV OEC for the Moray East Offshore Wind Farm. The HVAC OECs were delivered in one length between each OSP and TJB at the landfall.

The main part of the submarine cable will be installed buried in the seabed, including a short crossing of the SHET HVDC cable. At the OSP a short section will be installed in a J-tube through a CPS, and at the landfall the cable will be installed through a HDD duct.

Due to the increased cable burial depth at the landfall within the HDD ducts (up to 27 m depth below seabed level) this section constitutes the most onerous area of the whole route in terms of current rating.

7.2.1 Power Cores

The cable design is a high voltage alternating current (HVAC) for 220kV, with Aluminium stranded conductors (3 phases) and XLPE (cross-linked polyethylene) insulation.

7.2.2 Fibre Optic

The constructed cable contains the associated metallic screens, sheaths, bindings and fibre optic elements, one fibre optic cable will be integrated into the three-core submarine cable. The fibre optic cable includes minimum 48 single mode fibres.

7.2.3 Armour wires and outer roving

The armouring of the cable, consists of galvanized steel and polyethylene. The armour layer is soaked in bitumen. The outer layer consists of one inner layer of polypropylene yarns soaked in bitumen and one outer layer of black polypropylene yarns with helical laid lines in high visibility colours as marking.

7.2.4 Cable Protection System at the OSP

A CPS was designed, procured and installed at the OSP ends of the OEC. Its purpose is to protect the cable where it is in a free span zone, from the OSP j-tube exit location and into burial. In this zone, the cable is affected by dynamic environmental loads (waves and current). The system protects the cable from these loads and also provides impact protection.

The design consists of a combination of polyurethane, cast iron, and polymer elements.

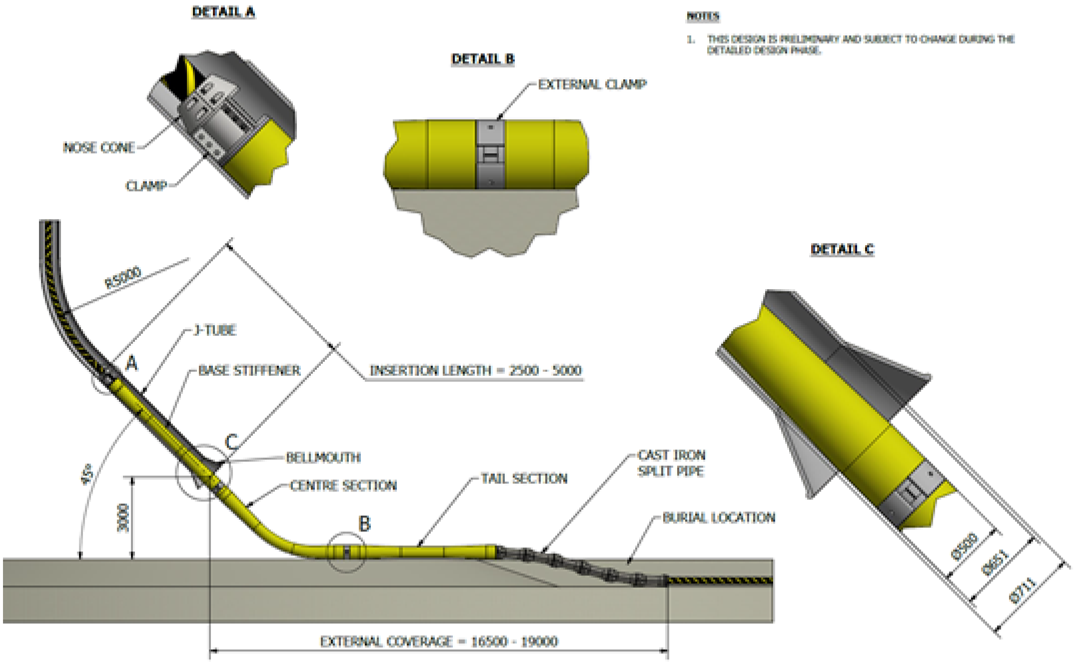


Figure 7-2: Indicative Cable Protection System.

7.2.5 Landfall Horizontal Directional Ducts

Ducts were pre-installed at the landfall following HDD, to allow installation of the OECs underneath the landfall point. This consists of 630 mm SDR17 HDPE100 Cable Duct formed as circa 1,000 m long extruded sections. Further information is provided within the CoP & CMS Document (Moray East, 2020b).

Figure 7-3: Example of HDPE duct been floated into HDD.

8 Site investigations

The OfTI Marine Licence requires that the OfTI CaP includes the following:

> *"The results of survey work (including geophysical, geotechnical and benthic surveys) which will help inform cable routing; and*
>
> *A pre-construction survey for Annex 1 habitat and priority marine features, to inform cable micro-siting and installation methods in consultation with the Licensing Authority and their advisors."*

The following section provides information relating to survey work and routing of the OEC. The section provides information on key constraints identified through survey.

8.1 Development Surveys

Table 8-1 below is taken from the Moray East PEMP (Moray East, 2018), and represents all relevant documents and data files utilised in the process of developing the cables routes and burial requirements. Further surveys carried out in 2020 have been added to the below table.

Table 8-1: Baseline Bathymetry and Geological Data

Survey	Survey Detail	Coverage	Date
Moray East site (relevant to the sections of the OEC located within the Moray East site)			
Geophysical Survey (Osiris Projects)	Multi-Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer / Gradiometer.	100 % of the Moray East site.	2010
Deep Geotechnical Site Investigation (Fugro)	Composite boreholes.	19 Boreholes across the Moray East site.	2010
Geophysical Survey (Gardline)	Multi- Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer / Gradiometer.	50 m corridor along possible inter- array cable routes.	2014
Shallow Geotechnical Site Investigation (Gardline)	Vibrocores and Cone Penetration Testing (CPTs)	43 Stations between possible WTG locations.	2014
Deep and Shallow Geotechnical Site Investigation (Calegeo)	Composite Boreholes and CPTs	26 Boreholes and 75 CPTUs stations within and around possible WTGs locations).	2014
Geophysical Survey (Horizon)	Multi- Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer	Infilling Survey in the eastern part of the site, 3 lines going through WTG locations	2017
Geotechnical Survey (Horizon/Fugro)	Sampling Boreholes, downhole CPT reading	19 sampling boreholes, 88-92 downhole CPT readings across the Moray East site	2017/2018

Survey	Survey Detail	Coverage	Date
Geophysical Survey & Shallow Geotechnical Site Investigation	Multi- Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer/ Gradiometer Seabed CPTs and vibrocores	100 m corridor along possible inter- array cable routes, shallow CPTs & vibrocores along inter-array cable routes	2018
Unexploded Ordinance (UXO) Survey (Bibby HydroMap)	Multi- Beam Echo Sounder, Side Scan Sonar, Magnetometer/ Gradiometer	Moray East site.	2018-2019 *(in progress)*
Offshore Corridor [relevant to sections of the OEC located within the OfTI Corridor]			
Geophysical Survey (Gardline)	Multi- Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer/ Gradiometer	1000 m corridor along the export cable route	2014
Shallow Geotechnical Site Investigation (Gardline)	Vibrocores and CPTUs	68 stations along the export cable route	2014
Topographic Beach Survey (Gardline)		Topographic coverage of an area around 250 m x 300 m	2014
Nearshore Shallow Geotechnical Site Investigation (Gardline)	CPTs	21 CPTs along the cable route in the nearshore area	2015
Nearshore Geophysical (Bibby HydroMap)	Multi- Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer/ Gradiometer	Coverage over an area of 800 m x 425 m	2017
Nearshore Geotechnical Site Investigation	Deep geotechnical survey using jack – up vessel with a full complement of drilling and testing equipment. Boreholes including cable percussion methods, SPTs and rotary coring.	25 m target depth for six offshore boreholes to encounter bed rock in the nearshore area. Furthest borehole location was approx. 1 km from shore following the OEC route.	2018
Geophysical Survey & Shallow Geotechnical SI	Multi- Beam Echo Sounder, Side Scan Sonar, Sub- Bottom Profilers, Magnetometer/ Gradiometer Seabed CPTs and vibrocores	Infilling survey for part of the OEC route, mainly inside the side boundaries	2018-2019
Geotechnical Survey	Cone penetration testing (infill to inform burial plan)	Offshore Export Cable Corridor	February 2020 – March 2020
Geophysical Survey	Pre and Post Route Clearance Survey: General Visual Inspection and Multibeam echo sounder	Offshore Export Cable Corridor	June 2020

Survey	Survey Detail	Coverage	Date
Visual Survey	Post Installation Inspection : Pre-Lay Crossing Installation	Offshore Export Cable Corridor	August 2020 – September 2020
Visual Survey	Installation Inspection: Touch Down Monitoring of Cable Lay	Offshore Export Cable Corridor	August 2020 – October 2020

Bathymetry was measured for engineering requirements prior to installation, providing a suitable baseline from which to monitor any future changes in seabed topography.

8.1.1 Geophysical coverage

Bathymetry surveys were undertaken along the OfTI Corridor to inform the initial route planning in 2014 and 2017 and to revalidate and micro route in 2018 as per Figures 8-1 and 8-2 below.

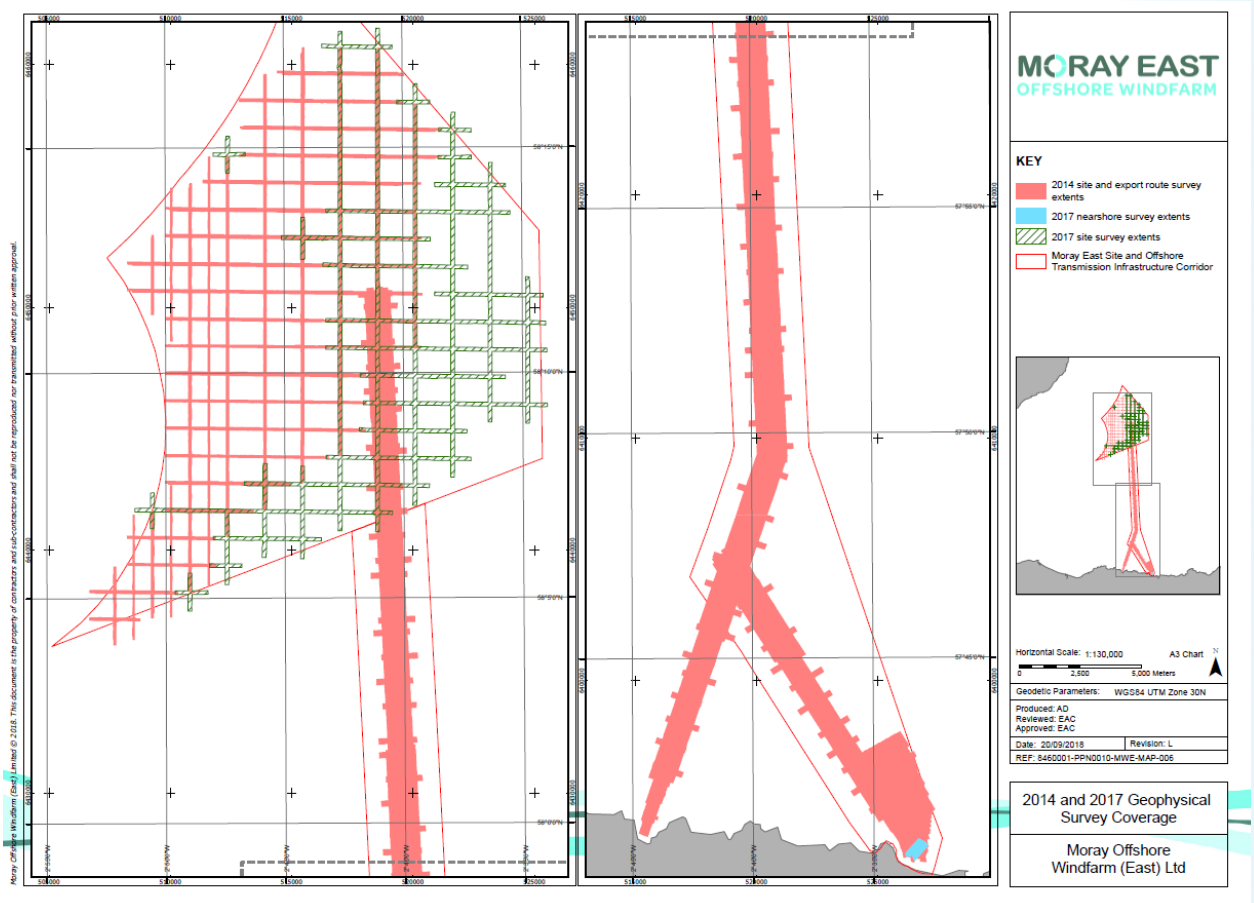


Figure 8-1: Geophysical Coverage 2014 and 2017.

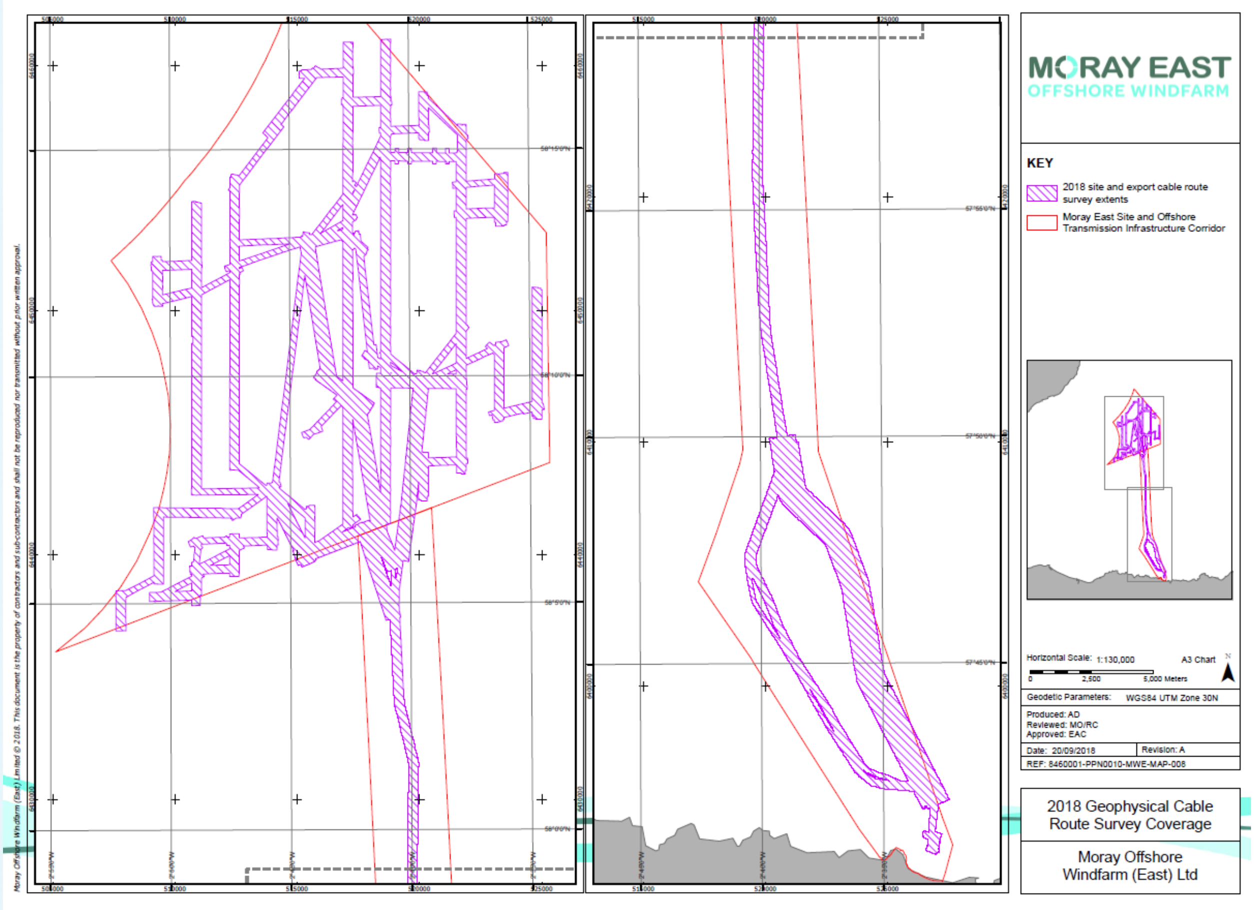


Figure 8-2: Geophysical Coverage 2018.

8.1.1.1 Bathymetric characterisation

From shoreline, water depths increase along the export corridor from ~10m LAT at ~KP1.1 to a maximum of ~-100m LAT at ~KP12. The seabed then undulates for several kilometres, with a shallow point of ~-60m LAT at KP27 before undulating and descending to ~-88 mLAT at KP32. The seabed then gently shallows towards and entering the array, being ~-56 mLAT at KP47 and shoaling to between -40m and -50m LAT inside the array. Figure 8-3 provides information on the bathymetry along the OfTI Corridor.

Many boulders are recorded along the OfTI Corridor, with numerous 'boulder fields' (see Section 12.1.14 below). These are associated with areas of seabed sediment interpreted as boulder clay, gravel and sand.

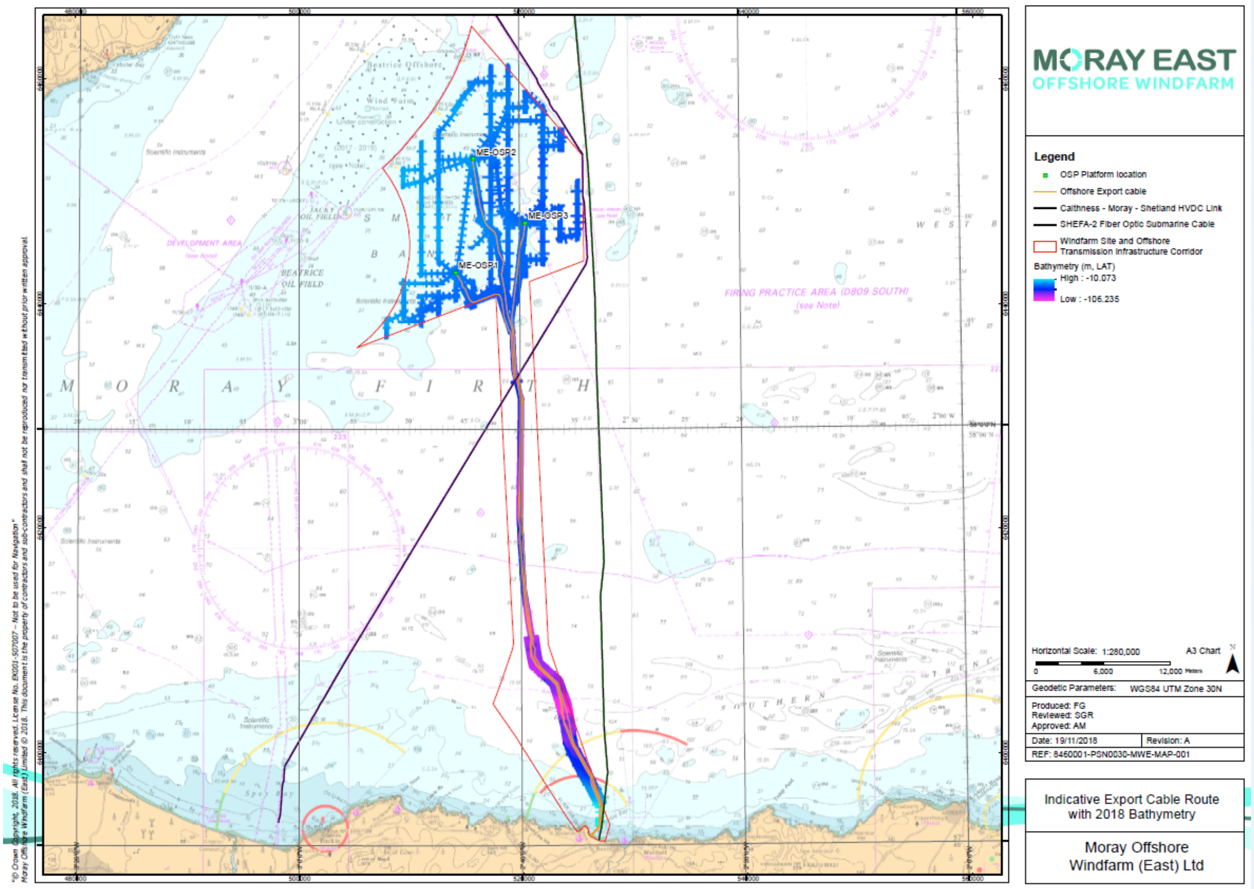


Figure 8-3: Indicative Offshore Export Cable Route with Bathymetry 2018.

8.1.2 Geotechnical coverage

Vibrocore and Cone Penetration Tests (CPT) were undertaken along the OfTI Cable Corridor to inform the initial burial risk assessment planning in 2014, and to revalidate and micro route in 2018 as per Figure 8-4 below. In order to acquire additional soil data pertinent to the burial of the OEC, a short campaign shallow CPT was carried out in February 2020.

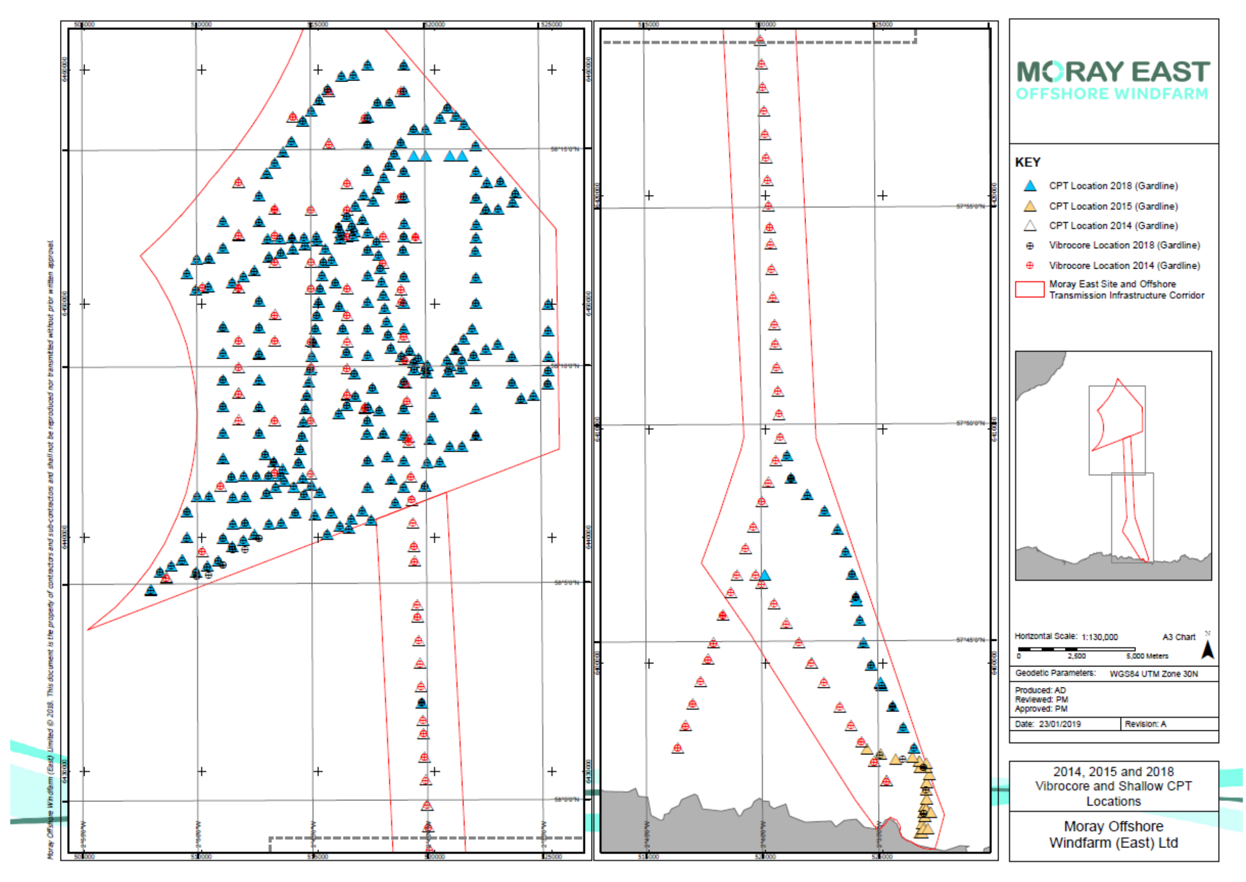


Figure 8-4: Geotechnical Coverage 2014 - 2018.

8.1.2.1 Shallow geology

A veneer of Holocene sand, with gravel and mud content overlies clay, and varies in thickness from 0.5 m for the majority of the route and thins above sub-cropping / outcropping quaternary deposits as imaged by the geophysical survey. Localised outcrops of Boulder Clay at seabed surface are noted between KP1.5 and KP2.25, between KP7.4 and KP12.3, and between KP24.1 and KP31.4 KP values are relevant to the central route OEC2).

From the trenching results, the sub-cropping stiffer materials are present also intermittently between approximately KP9.0 and KP24.1.

8.2 Benthic Surveys

Benthic ecology data for the export cable route were collected in 2014, using digital video and stills cameras (Export Cable Route Biotope Assessment, Appendix 2). Observations of the borehole samples collected during the geotechnical campaigns (Section 8.1.2 above) were used to corroborate the seabed video/photographic data. Section 9.4 below provides detail on the cable routing and benthic analysis.

8.3 UXO Survey and Clearance

As part of the 2018 site investigation a survey using multi-beam echo sounder, side scan sonar, and magnetometer has been conducted to identify any potential Unexploded Ordnance (UXO) targets on the Moray East site and OfTI Cable Corridor.

9 Cable Routing

9.1 Objectives

The main objectives during the engineering of Moray East OEC routes can be identified as follows;

- Consideration of all the constraints within the consented OfTI Cable Corridor that bound the cable route such as anomalies identified by geophysical surveys, or existing infrastructure on the seabed;
- Minimising likelihood of interactions with fishing activities and shipping exclusion zones etc if applicable;
- The shortest or most efficient path between different offshore assets (WTGs and the OSPs);
- Reduction in the number of alter courses (curve in route) to reduce installation time, and cable damage risk;
- Mitigation of identified hazards by avoidance or sympathetic routing;
- Mitigation of identified known undesignated cultural heritage assets such as wrecks by micrositing and re-routing in order to avoid them;
- Consideration of all constraints regarding operational limitations (slope, offset distance, turning radius); and
- Additional consideration for the radius of routes to allow for the post lay trenching activities.

9.2 Constraints

Route constraints are viewed as three types; hard constraints, soft constraints and operational constraints.

Hard constraints are those based upon such items as existing infrastructure exclusion zones and required buffers to facilitate anchoring of the installation barge. These hard constraints governed the space remaining within the export cable corridor in which the route could be engineered.

The identified hard constraints on the route consist of:

- Cable crossing with SHET (all three cables will cross this system once at the same location) HVDC;
    - HV interconnector cable between convertor stations in Spittal in Caithness, and Blackhillock in Moray
    - Cable runs SW-NE across the route at KP43 (43 km from shore end at Invergordon)
    - Cable is buried to approx. 1m at crossing point
- TJB locations (3) at landfall;
- OSP locations (3);
- WTG locations (~100);
- Inter OSP Cables (2);
- Other in field array cables (100); and
- Other cables in proximity (1) the SHEFA 2 cable
    - Fibre Optic (FO) Cable routing from the beach at Boyndie Bay to Faroe Islands via Orkney and Shetland

- Cable is buried to 1m and proximity is 75m East of the most easterly cable route.

Soft constraints are those which require mitigation via routing; this can also be accommodated via displacement / relocation of the constraint or varying installation methods. Where possible soft constraints were mitigated via routing, though consideration was also given to where significant savings on cable length or vessel time could be made by transiting through soft constraints and selecting to displace / relocate them.

Operational constraints are dependent on the installation method and available offshore assets / equipment (such as trenchers). Operational constraints can be seen as additional hard constraints, which cannot be avoided due to their nature such as bending radii for route deviations and the drafts of cable laying and trenching vessels (in order to maintain sufficient under keel clearances).

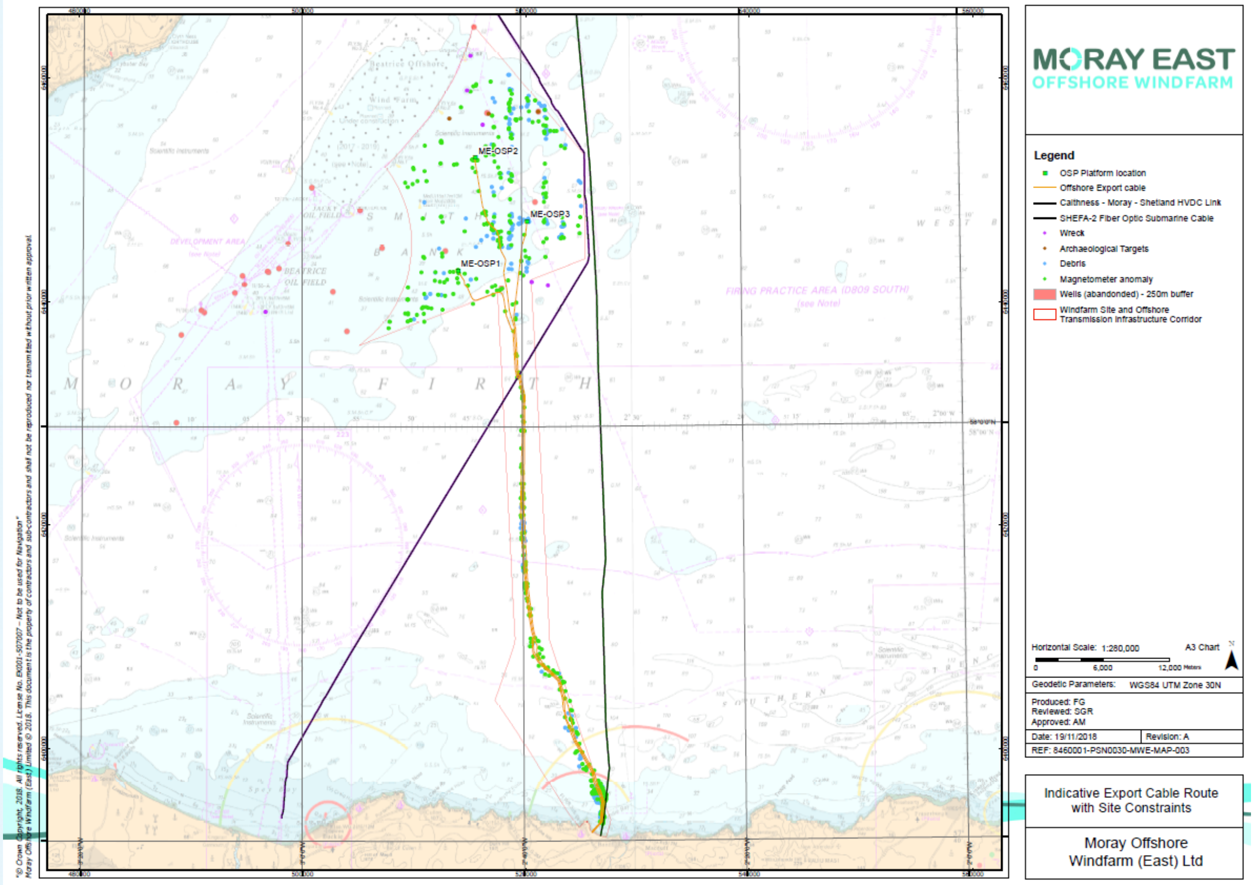


Figure 9-1: Offshore Export Cable Route Indicative Key Constraints.

9.3 Cable routing and unexploded ordnance

Each of the three OECs (one from each OSP) converge immediately south of the Moray East site and, from there as they traverse in a southerly direction towards the landfall, the separation distance between each of the three OEC circuits (where no major seabed constraints exist) is approximately four times water depth along the OfTI Cable Corridor (see Figure 3-3). The maximum cable corridor width, from one outer circuit to the other outer circuit, is up to 1,200 m.

A number of surface contacts were identified within the OfTI Cable corridor by geophysical surveys in 2018. These contacts are comprised of boulders and magnetic contacts.

The appointed OEC installation contractor and Moray East project team performed a joint micro routing study to establish which contacts modelling as UXO could be avoided, and which require further inspection.

A UXO specific site investigation campaign took place in early 2019 with the purpose of inspecting each target and assessing whether the item is UXO or not and thereafter assessing whether any UXO can be avoided or required to be detonated. (subject to a separate Marine Licence).

9.4 Benthic analysis of cable route

Four habitats / biotopes were classified within the OfTI Corridor, although these often occurred both singly and as twinned mosaics:

- Level 3 main habitat SS.SSa (subtidal sands and muddy sand);
- Level 4 biotope complex SS.SMx.CMx (circalittoral mixed sediment);
- Level 5 biotope SS.SMu.CFiMu.SpnMeg (seapens and burrowing megafauna in circalittoral fine mud); and
- Level 6 Sub-biotope CR.MCR.EcCr.FaAlCr.Pom (faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately exposed circalittoral rock).

In addition, it was noted that some areas of the OfTI Cable Corridor comprised a dominant muddy sand substrate which was overlaid by veneers of coarser sand and gravelly sand of various thicknesses. This resulted in a patchwork or mosaic of sediment biotopes across some areas. From the video and stills images it appeared that the overlying deposits were transient and / or mobile, as indicated by the presence of coarse sediment ripples or waves lying over the finer sand substrata.

The main biotope (SS.SSa) and the biotope complex (SS.SMx.CMx) are broad classifications encapsulating a range of more detailed biotope types some of which may have been present within the study area at a finer spatial scale.

The Level 5 SS.SMu.CFiMu.SpnMeg biotope was attributed to the majority of the OfTI Corridor below approximately the 50 m contour based on the widespread occurrence of “sea-pen and burrowing megafauna communities” evident from the video and stills images. The SS.SMu.CFiMuSpnMeg biotope is a component of the “burrowed mud” habitat which is a priority marine feature (PMF) in Scotland and which is one of a number of PMF’s identified by the Scottish nature conservation agencies to help focus conservation action within Scotland’s seas.

The CR.MCR.EcCr.FaAlCr.Pom biotope is illustrative of the Annex I (EC Habitats Directive 92/43/EEC) geogenic reef and includes areas of cobbles, boulders and rocky outcroppings.

Observations of subtidal mixed coarse sediments and muddy sand sediments match historic records of this area, with two broad habitats and two detailed biotopes being classified and mapped by the acoustic and seabed video data. The two detailed biotopes are indicative of valued seabed features including a Scottish PMF and an Annex I (EC Habitats Directive) habitat.

9.5 Final Cable route definition and micrositing

Following the outcome of further engineering works and surveys, minor modifications to the Route Position List (RPL) were made and changes to the protection of the OEC are proposed. As described within Section 2.2 above, this OfTI CaP will be reviewed in case of significant changes in the information provided. Once operational, final as-built data will be provided to the United Kingdom Hydrographic Office (UKHO) for aviation and nautical charting purposes. Discussions are also ongoing with the fishing industry regarding how best this information can be shared. Moray East have committed to providing maps and co-ordinates of the as built cables and areas of remedial rock placement to the fishing industry when these are available.

10 Cable Burial Risk Assessment

Condition 3.2.2.10 of the OfTI Marine Licence requires that the OfTI Cable Plan includes the following:

"A burial risk assessment to ascertain if burial depths can be achieved. In locations where this is not possible then suitable protection measures must be provided."

The primary means of protecting the cables from the hazards that are presented to the cable, both natural (seabed mobility, wave action etc.) and man-made (shipping, fishing etc.), will be achieved by lowering of the cable into the seabed (burial). Secondary measures of protection which are required are also detailed in this report and consist of the use of rock armour, mattressing (at OSPs) and CPS.

A Cable Burial Risk Assessment (CBRA) for the Moray East site and OfTI Cable Corridor was completed in 2015 by Senergy 'Burial assessment and trenching Risk Assessment Export Cable Corridor' (Senergy, 2015)2303-MOR-TEC-06-02 (Rev 2 – 29-1-15) to establish the target cable lowering depth relative to mean seabed level in order to procure the cable installation contract.

This CBRA was re-validated in 2018 'C950RO2-03 Moray East Offshore Windfarm Export Cable CBRA 08-10-2018 Rev 03' (Finalised October 2018) in order to more accurately define the zones of burial, and to further define the burial depths to aid installation. This further development of the CBRA was initiated following recommendations within the original Senergy report to perform surveys for additional bathymetry data (to assist seabed mobility analysis), and to obtain a longer period of AIS ship tracker data to validate vessel types and frequencies upon which the Senergy report was based.

Following completion of trenching, the Cable Installation Risk Analysis (CIRA - the as-trenched CBRA) was performed according to the as-achieved Depth of Lowering (DoL) in order to quantify the risks to the cables from both shipping and fishing, and as such allows an optimised risk profile to be proposed for adoption. For this project, the results demonstrate that any areas of the cable routes which achieve less than 0.7m DoL will require remedial rock placement. Other areas where this value is exceeded are considered acceptable, despite being below the target DoL. This level of protection mitigates the risk to As Low As Reasonably Practicable (ALARP). Moray East expect to complete the work associated with the CIRA in December 2020.

In summary, the risk assessments consider all potential hazards that are presented to the OEC (as described in the following section), and as such the level of protection afforded by the seabed soils (or soil strength) when the cable is lowered into the seabed to a particular depth.

10.1 Minimum burial requirements for the OEC

10.1.1 Consideration for Commercial Fisheries

A hazard assessment of the site determined that commercial fishing vessels and commercial and marine service vessels are the most common operators within the vicinity of OfTI Corridor. These are considered within the CBRA/CIRA.

The predominant fishing types in the area are demersal trawling (otter trawling) for nephrops, squid and finfish and scallop dredging. Some limited lobster/crab potting activity occurs in inshore areas. Interaction with demersal fishing gear such as otter board trawls has been assumed to have the potential to cause localised damage to the export cables if not protected. The probability of damage is dependent upon the trawl gear dimensions and cable (armour) specifications. It is also important to consider that exposed cables pose a risk to the fishing equipment and fishing vessels if snagged on a significant obstruction such as a cable.

A detailed fishing study was undertaken on behalf of Moray East in June 2015. As part of the CBRA an AIS dataset for the export cable routes has been examined with specific reference to fishing vessels. The vessel tracks indicate that fishing activity appears to be occurring in particular parts of the site which are investigated in the CBRA.

To protect the cables from fishing gear damage and to prevent snagging, the following minimum burial depths below a reference seabed level (or non-mobile layer) are advised. It has been calculated that these depths would protect the cable against impact and snagging from all types of demersal fishing gear indicated to be in use in the area, as discussed above:

- 0.2 m in sand or high strength clay (>40kPa)
- 0.3 m in low strength clay (<40kPa)

That these calculations have been incorporated into the target Depth of Lowering which is discussed below in 10.1.3.

Moray East will also provide the proposed and as-built locations of the areas where remedial rock placement is required to the fisheries stakeholders and Marine Scotland Licensing Operations Team (MS-LOT), in the form of maps and coordinates, as soon as these become available. Details for the proposed OEC-2 remedial rock placement locations have already been provided. Moray East will also provide the new positions of boulders relocated during operations.

10.1.2 Consideration for Commercial Shipping

To assess the potential impact of shipping on the proposed OfTI Corridors, an analysis of AIS data for the Moray Firth (in the vicinity of the OfTI Corridor and Moray East site) for a 5 year period up to 2018 was undertaken through the CBRA/CIRA. This is to gain a greater understanding of seasonal shipping frequencies (noting that monthly and yearly variation in shipping traffic is likely).

Being designed to penetrate the seabed to achieve a holding capacity, anchors can be particularly damaging to cable systems. The closest anchoring zone to the OfTI Corridor is at Banff Harbour, approximately 1 km or 0.5 NM from the edge of the consented corridor.

The results of the vessel traffic informed the CBRA. Additional information on designated anchoring sites is detailed in the Vessel Management Plan (VMP) and Navigational Safety Plan (NSP) document (Moray East, 2020a). The principal risk from anchoring lies in the occasions where a vessel is forced to anchor due to mechanical failure or the need to prevent collision. These are taken into consideration in the calculations within the CBRA and CIRA assessment.

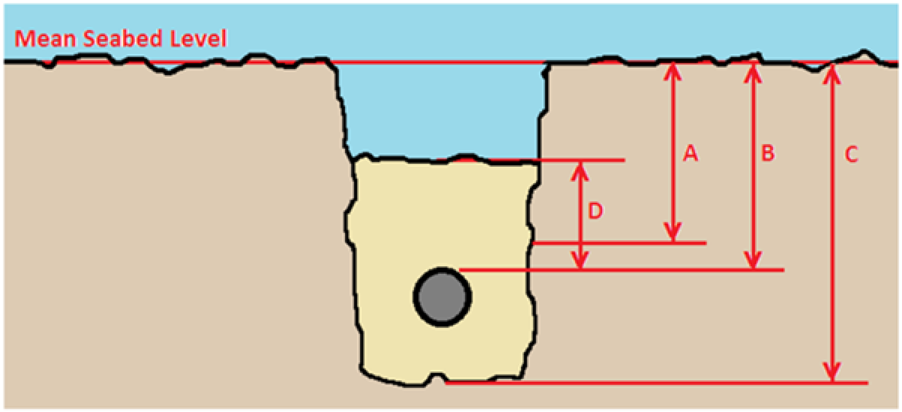
10.1.3 Target and Minimum Depth of Lowering

The CBRA and CIRA has been conducted in accordance with the Carbon Trust, Cable Burial Risk Assessment Methodology, Guidance for the preparation of Cable Burial Depth of Lowering specification, CTC835. The following recommendations are made on the minimum depth of lowering which is required to protect the OEC circuits.

The geology along the OfTI Corridor is a key consideration in the CBRA and CIRA as it influences the depth of penetration of significant hazards e.g. anchoring and fishing activities.

Target burial depths have been established based on threat lines (depths of interaction) for fishing and vessel anchors transiting across the OfTI corridor. An additional allowance has been made where bedforms were identified on the geophysical survey (Section 8).

Terms used to define the trenching specifications are presented in Figure 10-1:



A	**Recommended Minimum Depth of Lowering**
B	**Target Depth of Lowering**
C	**Target Trench Depth**
D	**Depth of Cover**

Figure 10-1: Trenching Specification Terminology.

A detailed sediment mobility assessment is presented in the CIRA.

To determine the minimum DoL, results from the probabilistic anchor penetration assessment indicated overall risk for the currently achieved burial to be at DNV Category 2 for all cables in both average and worst case scenarios. This remains in line with the results of the original CBRA assessment (2018), where at 1.2m burial for the full cable, the overall risk was also DNV Category 2.

Due to the low risk from shipping, it was determined that the risk from fishing was more applicable for shallow buried cables defining the risk into three categories;

1. High risk – Cable burial less than 0.3m
2. Medium Risk – Cable burial between 0.3 and 0.6m
3. Low Risk – Cable burial greater than 0.6m

Based on the risks assessed and expert third party advice, Moray East have concluded that remedial cable protection methodologies will have to be undertaken where cable burial is less than 0.7m by means of remedial second pass trenching or by rock placement. The additional 0.1m (above 0.6m) accounts for acoustic survey equipment tolerances and limited degree of seabed movement over the design life of the cable.

An assessment was then undertaken to estimate the reduction of risk should these areas be protected by mean of rock placement or remedial trenching. Therefore, as also mentioned above, anywhere where burial was less than 0.7m a theoretical value of 1.2m DoL was assumed, which accounts for the increase in protection afforded via remedial rock placement.

Table 10-1 below demonstrates the current various burial requirements along the route based on Cathie Associates CIRA 2020.

Table 10-1: OEC Target and Minimum Burial Depths

Zone	Location (KP)		Target Depth of Lowering (m)	Minimum Depth of Lowering (m)	Notes
	From	To			
HDD	0	1.0*	As per HDD	As per HDD	*The end KP (and start KP of Zone 1) shall be the as built position of the punch out. The end of the HDD has been lowered and covered with concrete kennels which have been buried.
Zone 1	1.0*	2.6	1.2	0.7	Section between KP1.5 and KP2.1 on OEC-2 is surface laid due to bedrock outcrop and will feature 1.0m DoC.
Zone 2	2.6	47.0	1.2 CM Crossing 0.5m Depth of Cover (DoC)	0.7 CM Crossing 0.5m DoC	With exception of SHET HVDC crossing which will be 0.5m . KP47 represents the split of the cables in toward the windfarm.
Zone 3	47.0	OSP	1.2	0.7	Seabed mobility of +/-0.4m.

The Modified TI ES (2014) assessments were based on a target depth lowering of 1.0m. Following further review and to reduce the rock quantities required there is no technical reason to adopt 1.0m instead, adopting the target of 1.2m and a minimum of 0.7m in difficult ground conditions, as demonstrated by the CIRA (as trenched CBRA) is adequate to protect the cable.

10.2 Cable burial techniques

The routes were zoned by the cable trenching contractor to define which trenching tool (as described further below) would be utilised on which section according to the seabed conditions.

The OEC route features a variety of soils along the routes, representative of the various geological and bathymetric conditions, some of which are more suited to jet trenching and some which are more suited to chain cutting. The most appropriate tool is selected to achieve the best possible cable burial and sediment cover above the cable.

10.2.1 Post Lay Burial – Chain cutting (T3200)

The trenching machine is a high performance heavy soil chain cutter capable of 2.0m trench depth as shown in Figure 10-2 below. This machine is suitable for localised high strength clays. The trencher is launched from the vessel and lowered onto the cable. The cable is loaded into the trencher which then progresses along the cable route creating a trench into which the cable is lowered. The cable is pushed into the trench by means of the depressor assembly as shown below.

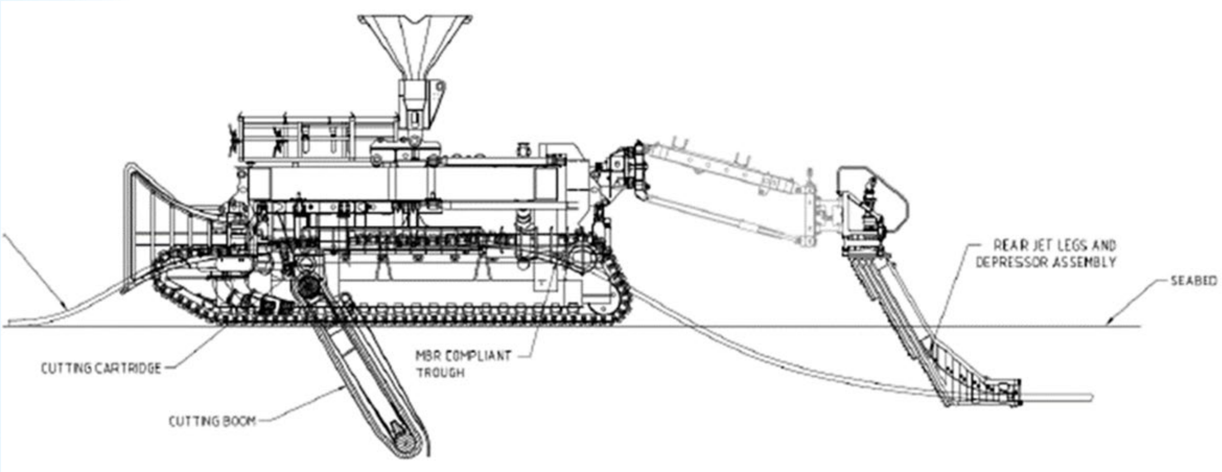


Figure 10-2: T3200 Trencher.

10.2.2 Post Lay Burial – Water jet trenching (T1000)

T1000 is a high powered fluidising jet trencher capable of 3.0m burial depth. The trencher is launched from the vessel and lowered onto the cable. Water jet trenching is suitable for sand and soft clays which are the most prominent soil type across the site.

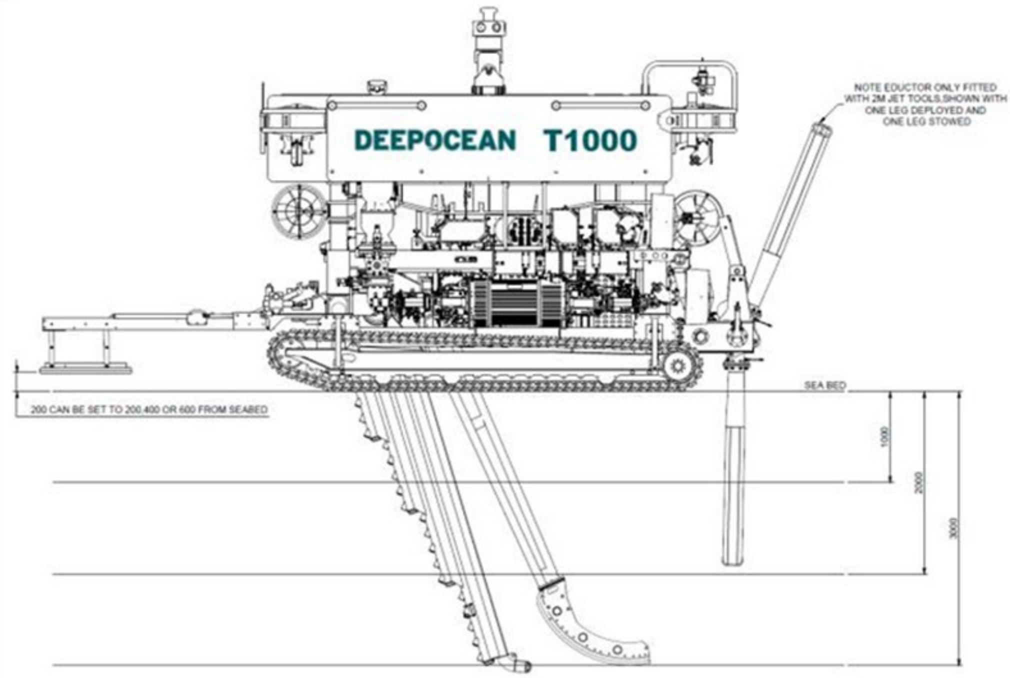


Figure 10-3: T-1000 Trencher.

10.3 Cable Burial Performance

Cable burial was performed between late August and late November 2020 using the Trenching Support Vessel (TSV) Havila Phoenix and the trenching tools described above. The trenching performance for a project of this scale and geological complexity has achieved highly satisfactory results (with only approximately 8% of each cable requiring rock placement). Over 99% of the linear length of each cable was attempted to be trenched following extensive boulder clearance operations performed in the summer 2020. For the less than 1% of the cable that was not trenched, specific physical constraints prevented trenching. Some of these were foreseen e.g. the SHET Cable Crossing, and some were not foreseeable pre-construction, e.g. where the boulder clearance revealed extensive subsurface boulders and hence trenching could not safely take place.

The section of cable between approximately KP25 to KP31 was specifically onerous following boulder clearance activities due to very soft pockets of seabed overlying stiffer materials. However, this area was nevertheless subject to jet trenching and remedial jet trenching, and it is where the vast majority of post-trenching remedial rock placement is required (approximately 2/3 of the total remedial rock protection).

The first cable trenched was OEC-2 and from the results achieved and the feedback from the trencher telemetry, trenching tool configuration improvements were implemented during and after to increase compliance with the target DoL. This primarily comprised swapping to the mechanical trencher (T-3200) and jet leg nozzle / configuration improvements for T-1000.

After first pass trenching approximately 60% of each cable met or exceeded the target DoL of 1.2m and 80% met or exceeded the target DoL of 0.7m.

Where the target depth of lowering of 1.2m was not achieved a second trenching pass was performed in the majority of the areas (with exceptions being described in the paragraphs below) - this comprised a total length of 56.1km of second pass trenching. This resulted in a significant reduction in the required remedial protection but it is not universally possible to lower the cable further in all seabed conditions.

After first and second pass trenching approximately 66% of each cable met or exceeded the target DoL of 1.2m and 92% met or exceeded the target DoL of 0.7m.

Remedial trenching was largely focussed on three key areas of the routes:

- Between KP9 to KP20 (OEC-2); KP11 to KP20 (OEC-3 and OEC-1 - the seabed surface comprises very soft cohesive materials overlying stiffer materials. In this situation the seabed is not suitable to support the weight of the mechanical trencher, even with added buoyancy, and therefore only the jet trencher can be used. The trenching in these areas were generally successful in lowering the cable to at least 0.7m after second pass trenching but strong underlying materials prevented further burial and results in remedial rock placement. The presence of these underling stronger materials in the areas that did not achieve even the minimum DoL after second pass trenching demonstrates that further trenching passes would not achieve the minimum DoL. From the trencher telemetry it is clear that the jet leg depth was restricted by the presence of these materials on both passes.
- KP25 to KP31 on all 3 routes – this section is located in a known boulder field and was extremely challenging, and despite extensive boulder clearance activities the seabed condition was not specifically favourable for trenching. During the engineering phase, this section was deemed as unsuitable to support the weight of the mechanical trencher and hence had to be jet trenched. Two passes were performed but the underlying seabed was found to be highly variable as expected and the cable DoL is highly variable in this area. Areas where the cables are out of specification are consistent between both trenches passes e.g. poor trencher trafficability and jet leg penetration leading to poor burial. No further burial passes were performed due to these issues. This was the same on all 3 routes which are adjacent to each other.
- Nearshore Areas, between the HDD and KP4 - the cable was mostly mechanically cut however in some areas the seabed was extremely hard, resulting in high levels of chain wear. Small areas required to be jet trenched as a result of earlier boulder clearance activities. Where the trencher achieved no penetration, no second pass trenching was performed. However this was limited to 39m on OEC-2, 223m on OEC-3 and 582m on OEC-1, the increase in linear length being related to order of remedial trenching and no appreciable improvement in DoL being achieved on adjacent cables i.e. irrespective of the execution of additional trenching passes, remedial rock placement would still be required.

Other local areas where stiffer materials or less jettable materials were encountered were also subject to remedial trenching however these were very limited e.g. near OSP.

Where second pass trenching was successful, it was due to a combination of good trenching speeds and sword depth penetration resulting a fluidised trench allowing the cable to sink to the base of the trench, where the trenching specification was not achieved, this was due to slower speeds (<150m/hr) and, or, poor jet leg penetration, and this could be seen in both trenching passes.

Whilst second pass trenching did improve the specification compliance in comparison to the first pass achievements, in some sections, for the reasons described above, a third pass trenching is not expected to achieve further reasonable improvements due to nature of the trenching process e.g. materials at the base of the trench which are un-jettable, materials within trench depth which are gravelly.

Only areas where the seabed was hard and jet leg penetration was extremely limited were not subject to remedial trenching passes, as to do so would have had very limited returns and would still require remedial rock placement.

Whilst other trenching tools are available on the market, the Havila Phoenix was equipped with a multi-tool trenching spread comprised T-3200 (mechanical trencher) and T-1000 (jet trencher) which are considered suitable equipment to execute the works.

On average, 8% of each cable route - totalling approximately 14km of 176km (HDD to OSP) - requires remedial protection with approximately 2/3rds of the linear length of these requirements being concentrated in the KP25 to KP31 area.

In summary, Moray East are confident that the need for rock placement has been minimised to ALARP through:

- Appropriate levels of trenching engineering and trenching telemetry review throughout the execution phase, including independent review of remedial trenching proposals and trenching data review.
- Feedback from the OEC-2 (first cable trenched) was used to update the Cable Burial engineering to optimise the trenching based on trencher telemetry providing further input data to adjacent cables (OEC-1 and OEC-3).
- Extensive remedial trenching has been performed where the target DoL was not achieved and geology allowed.
- The as-trenched data has been subject to a start-of-the-art process (CIRA) to re-evaluate the cable risk with the as-trenched results, allowing significant reduction of the required rock volumes.
- Moray East have employed HR Wallingford to undertake an independent 3rd party review of the rock placement design to ensure the design is optimised as far as practicable to further reduce rock volumes.

Table 10-2: OEC Remedial Rock Protection

Cable	Cable Length (m) excl. HDD and Crossing	Design Length of Remedial Rock Protection (m)	Percentage of Route Requiring Remedial Work
OEC-1	55,365	4,014	7%
OEC-2	62,394	4,815	8%
OEC-3	55,498	5,229	9%

10.4 Areas Requiring Rock Placement

As per Table 10-2 above, approximately 8% of each cable route requires both planned (e.g. CMS Crossing) and remedial rock placement. These have been detailed in individual maps and the start and end coordinates of each berm is being made available separately to the stakeholders for all three cables.

An overview chart for the areas requiring remedial rock placement on each cable is presented in the below figures. While it is not possible to determine the exact quantity required due to various installation factors; e.g. variations in rock density and particle packing, penetration into the seabed the likely volume required for the OEC cables is approximately 66,000m³ (circa. 100,000Te).

Moray East will provide the proposed and as-built locations of the areas where remedial rock placement is required to the fisheries stakeholders, Marine Scotland Licensing Operations Team (MS-LOT), and NatureScot (formerly known as SNH), in the form of maps and coordinates, as soon as these become available.

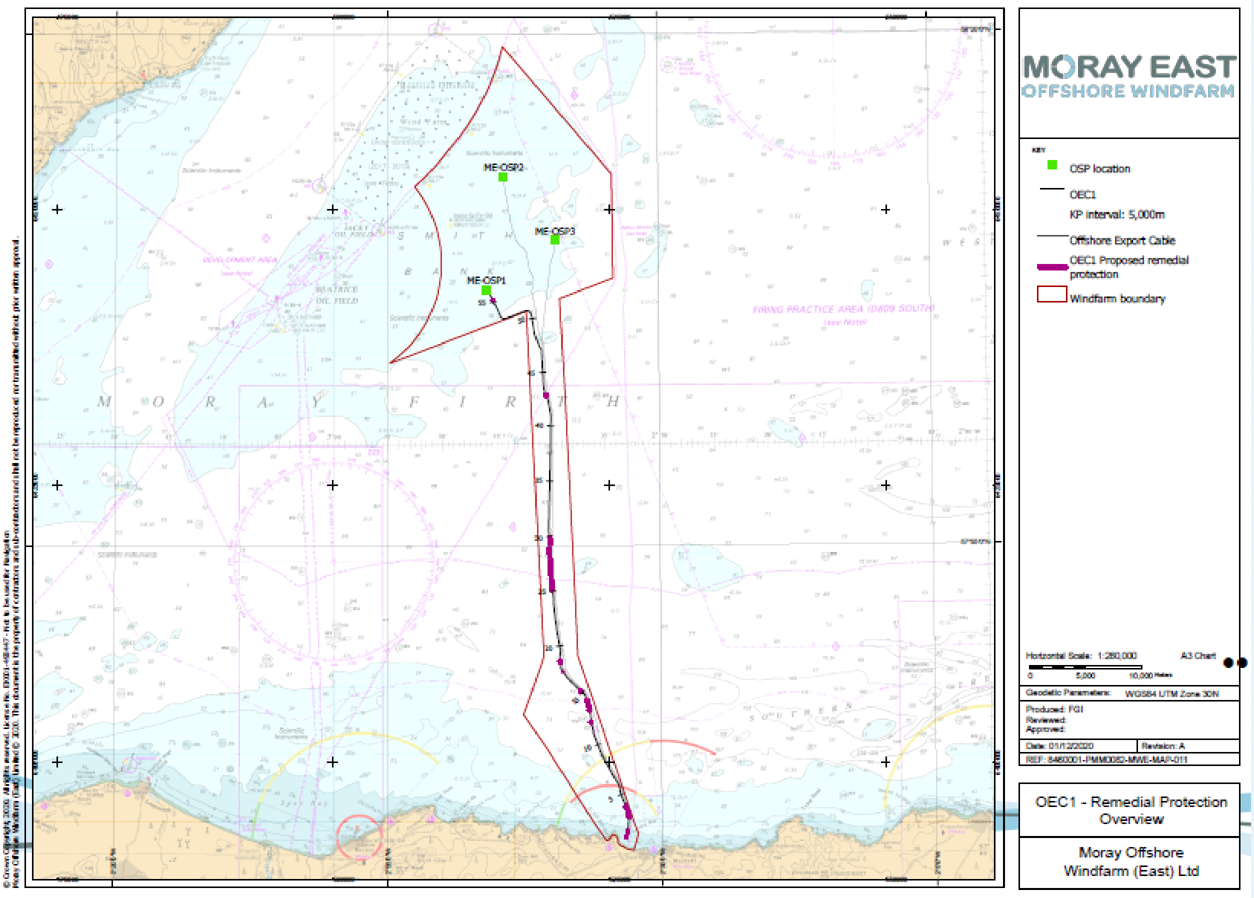


Figure 10-4: Proposed rock placement areas for OEC-1

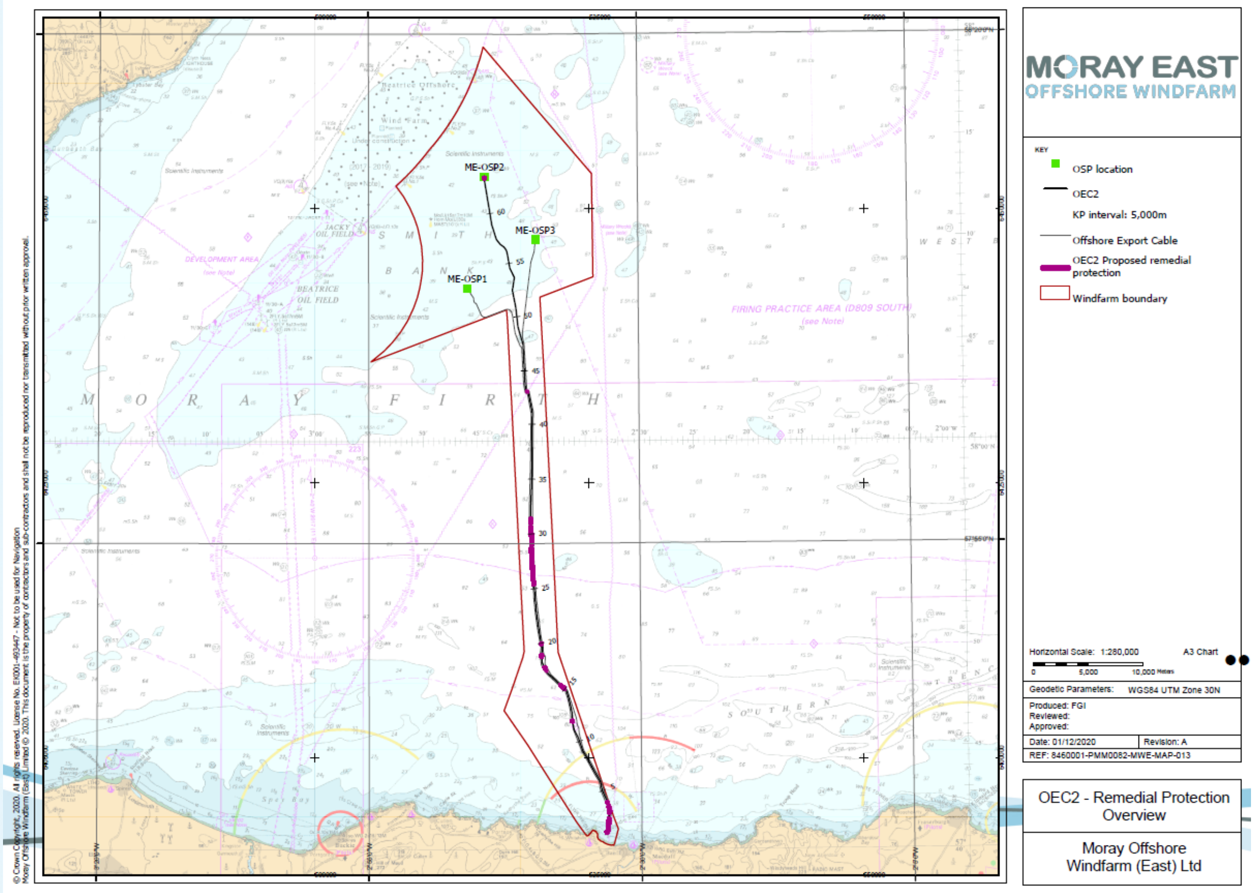


Figure 10-5: Proposed rock placement areas for OEC-2

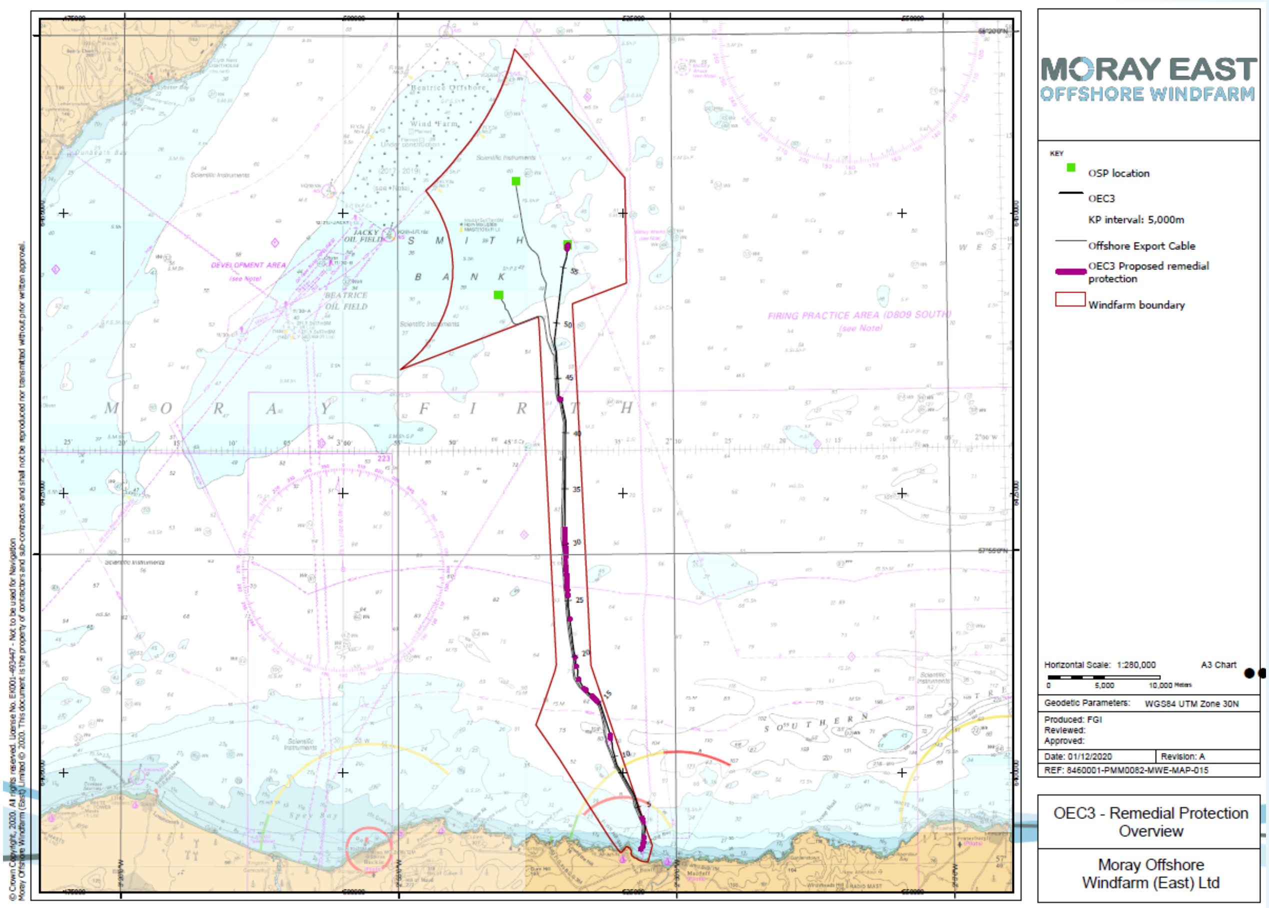


Figure 10-6: Proposed rock placement areas for OEC-3

The rock placement will comprise typical North Sea rock berm designs with nominally 1 to 3 in slopes, 1m crest width and a height which varies depending on the DoL up to 1.0m. Where the cable is partially buried the majority of the berm designs vary between 0.4m are 0.6m high.

Due to the hydrodynamic conditions over the site there are some specific design considerations as described below:

- In the nearshore area between the HDD and KP1.5, i.e. the first 500m only, a two layer rock berm is required for hydrodynamic stability over the design life and comprises a 1-5" (25-125mm) rock core stabilised with 5-40kg armour rock (up to 600mm). In this area the slopes vary between 1 in 5 at the HDD to 1 in 3 at 500m from the HDD.
- The next 600m nearshore section (KP1.5 to KP2.1) specifically requires 2-8" rock with varying side slopes dependent on water depth varying between 1 in 5 and 1 in 3 due to hydrodynamic stability.
- Adjacent to the OSP to tie-into the scour protection for the OSP, the last 40m is proposed as 2-8" rock 50-200mm.
- The CMS crossing specifically requires 1-5" rock (25-150mm) for other design reasons.

All other rock berms are to be constructed from either 1-5" (25-150mm) or 2-8" (50-200mm) rock and feature 1m crest width and 1 in 3 slopes.

Remedial rock placement operations are currently underway from the nearshore area working northwards towards the OSPs. Work has been completed up to KP19 on all three cable routes, with the exception of the first 500m (HDD to KP1.5).

11 Requirements for design of the OEC third party cable crossing

Three crossings (one for each OEC) have been engineered to sufficiently separate and protect the Moray East OECs from the single SHET HVDC cable bundle as shown in Figure 11-1 below (the hatched grey represents the post lay berm as depicted in Figure 11-2).

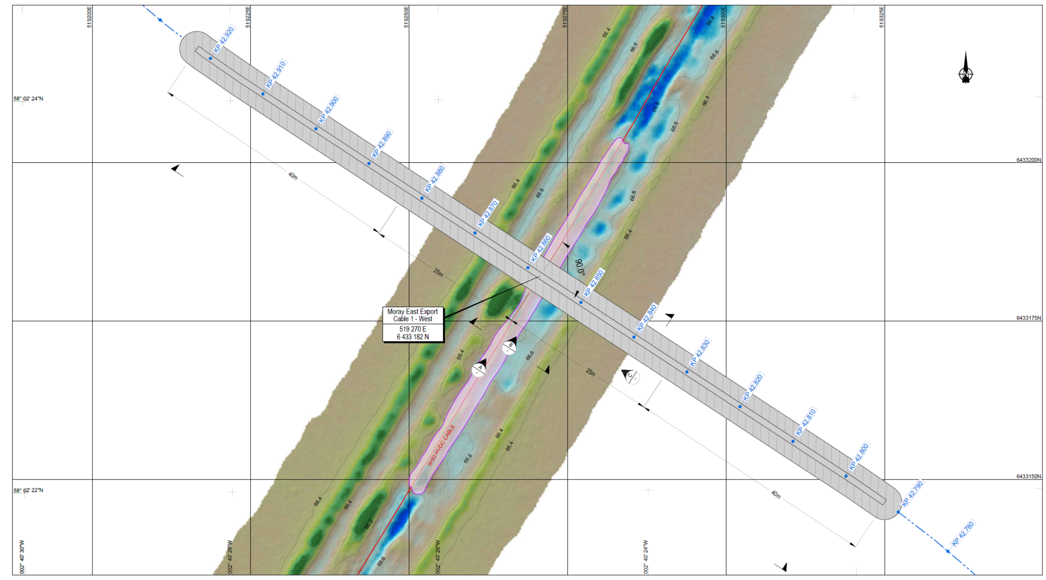


Figure 11-1: Indicative cable crossing arrangement of OEC 1 and SHET HVDC cable.

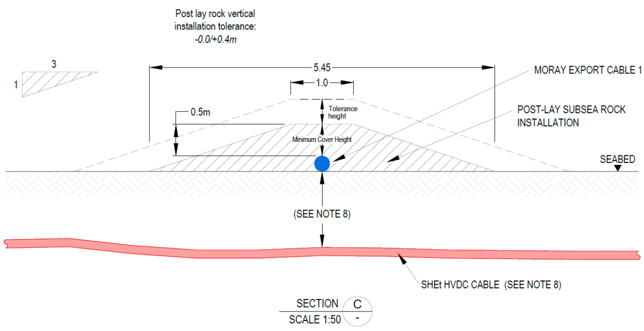


Figure 11-2: Indicative cable crossing arrangement (profile view) of OEC 1 and SHET HVDC cable.

11.1.1 Crossing Construction design

The Contractor has designed a rock berm crossing using industry standard engineering solution consisting of specific rock type and quantities, (expected to be standard quarried granite / gneiss) and installed a post-lay rock berm upon completion of the cable lay.

The berms are hydro-dynamically stable in the subsea environmental conditions and the design considers the potential for overtrawling.

Pre-lay berms were not required and instead a small rock installation of circa 4Te was installed on OEC-2 and OEC-3, existing natural or mechanically placed backfill was sufficient on OEC-1.

It is anticipated from these dimensions that the total rock amour quantity will be approximately 2,500 Metric Tonnes (Mte) for all three cables.

11.2 Requirements for OEC third party cable proximity

SHEFA owns and operates the circa 1,000 km SHEFA-2 fibre optic submarine cable running from Torshavn in the Faroe Islands to Maywick in Shetland, from Sandwick inland and onwards to Ayre of Caira in Orkney and from Manse Bay in Orkney to Banff in Scotland.

The SHEFA-2 Cable and the Moray East OECs reach landfall in proximity to each other in the vicinity of Inverboyndie Beach, west of Banff, Aberdeenshire and the SHEFA Cable runs adjacent to the consented corridor for the Moray East OECs.

An agreement has been negotiated relating to the construction and operation of the Moray East OECs and the SHEFA-2 fibre optic cable. This is accounted for in the route engineering of the project to maintain the maximum possible distance from this hard constraint.

11.3 Electromagnetic Fields

Table 11-1 below summarises the results of a desk based assessment carried out by Cable Consulting Limited (Cable Consulting Limited, 2018).

The study calculated the magnetic field magnitudes at a given distance. The magnetic fields generated from a 1,000 mm^2 AC 220kV Export Cable at a trench depth of 1 m is expected to reach a maximum value of 16.58 µT.

Note: magnetic field decreases rapidly with burial depth, vertical distance from the seabed and horizontal distance from the cable. For context, a reference magnitude of the earth's magnetic field can be estimated from models available in the public domain. Across the Moray East site and from sea level to maximum water depth the geomagnetic total field is estimated as 50.4±0.1µT. Hence the predicted magnetic field levels at seabed level associated with the buried cables if they are buried to 1.0 m is lower than the value associated with the earth's magnetic field.

Table 11-1: 1,000mm^2 cable maximum EMF strength (values in µT).

Measurement point height above seabed surface	Cable depth of lowering			
	-0.240m (i.e. surface laid)	0.5m	1.0m	2.0m
0m	1439 µT	54.31 µT	16.58 µT	4.618 µT
5m	0.8697 µT	0.6554 µT	0.5525 µT	0.4079 µT
10m	0.2115 µT	0.1829 µT	0.1668 µT	0.1403 µT

12 Cable Installation Methodology

The OfTI Marine Licence requires that the OfTI CaP includes the following:

> *"Details of the location and cable laying techniques for the cables."*

The Cable Installation Methodology is largely covered within the CMS and CoP (Moray East, 2020b); however, this section briefly outlines the key methodologies to be utilised for the OEC. Details of the cable locations are provided in Section 3 above.

For the OEC cables the following stages apply:

- HDD preparation — Complete
- Boulder clearance — Complete
- Pre-lay Grapnel Run (PLGR) — Complete
- Crossing preparation — Complete
- Pre-lay survey — Complete
- OSP preparation — Complete
- Cable landfall pull in — Complete
- Cable free lay onto seabed — Complete
- Cable wet storage — Complete – required on all 3 OECs
- Cable 2nd end pull in at OSP — Complete
- Cable trenching — Complete
- Crossings remedial installation — Planned for Q4 2020
- Remedial protection — Commenced Mid November 2020

12.1 Installation Methodology OEC

12.1.1 Installation Vessels OEC

Details of the proposed construction vessels used on the OEC are set out in the combined VMP and NSP (Moray East, 2020a).

Figure 12-1: Cable Lay Vessel *NKT Victoria*.

12.1.2 Landfall preparation and HDD works

These works have been completed

To bring the OECs into shore to connect to the onshore export cables, a total of three circa 1,000m long HDD ducts were installed, one at a time at the landfall location at Boyndie Bay as detailed in the CoP & CMS document (Moray East 2020).

The HDD works were undertaken in such a way as to cause minimum disruption to members of the public. The working area was contained by fencing and access to the works restricted for health and safety reasons. HDD drilling activities were undertaken from shore and an offshore diving vessel assisted the punch out of the drill. Once the drilling was completed, a High Density Polyurethane (HDPE) duct was pulled in from the marine side, controlled in place by a tug and assisted by divers.

Once installation of HDD ducts was completed, and before the cable lay operations commenced, each HDD end was be flanged and temporarily stabilised (with concrete mattress or similar) and buried until cable lay operations commenced.

12.1.3 OSP preparation

These works have been completed

The cable installation contractor prepared the OSPs ready to pull in the cables direct from the cable lay vessel in such a manner as to not delay the vessel upon its arrival. Messenger lines have been passed through the J-tubes, winches fitted and tested and all pull in equipment loaded and set up both in the fabrication yard and offshore.

12.1.4 Boulder displacement/relocation

These works have been completed

Along the Moray East OEC route multiple sections are found with a high density of boulders. Boulders can be a hazard for lay, trenching and longevity of the cable system. Where cable route engineering was unable to ensure the route is boulder free, a vessel was mobilised to relocate any boulders along the route which could have affected the installation. The actual boulder clearing was carried out by the boulder grab system which is a hydraulic subsea tool launched via the vessel crane and capable of manoeuvring subsea in conjunction with surveillance equipment to pick up and move objects up to 7 tonnes in weight from the seabed.

Figure 12-2: Boulder Grab System.

In the case of significant aggregations of boulders where the above system (boulder clearance) would be inefficient, a plough was used to create a path through the boulder field for the cable to be laid. The plough was deployed from an Anchor Handling Tug Supply (AHTS) vessel and towed across the seabed displacing boulders either side to create a swath to lay the cable into.

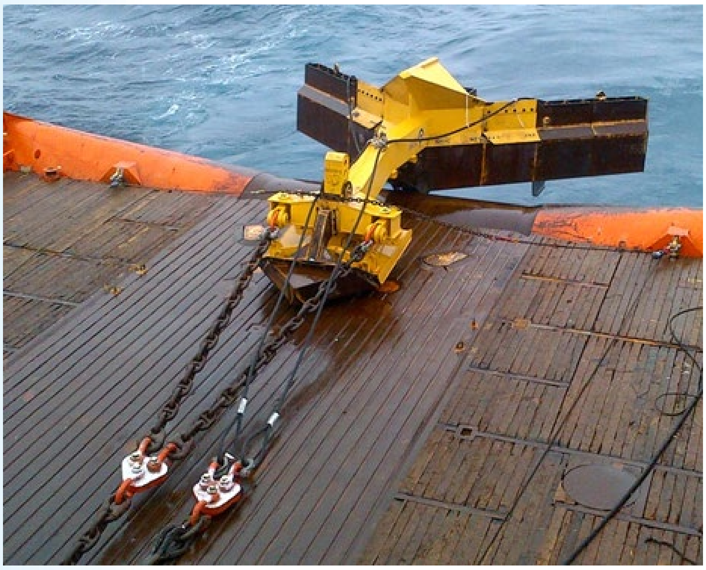


Figure 12-3: Scar Plough.

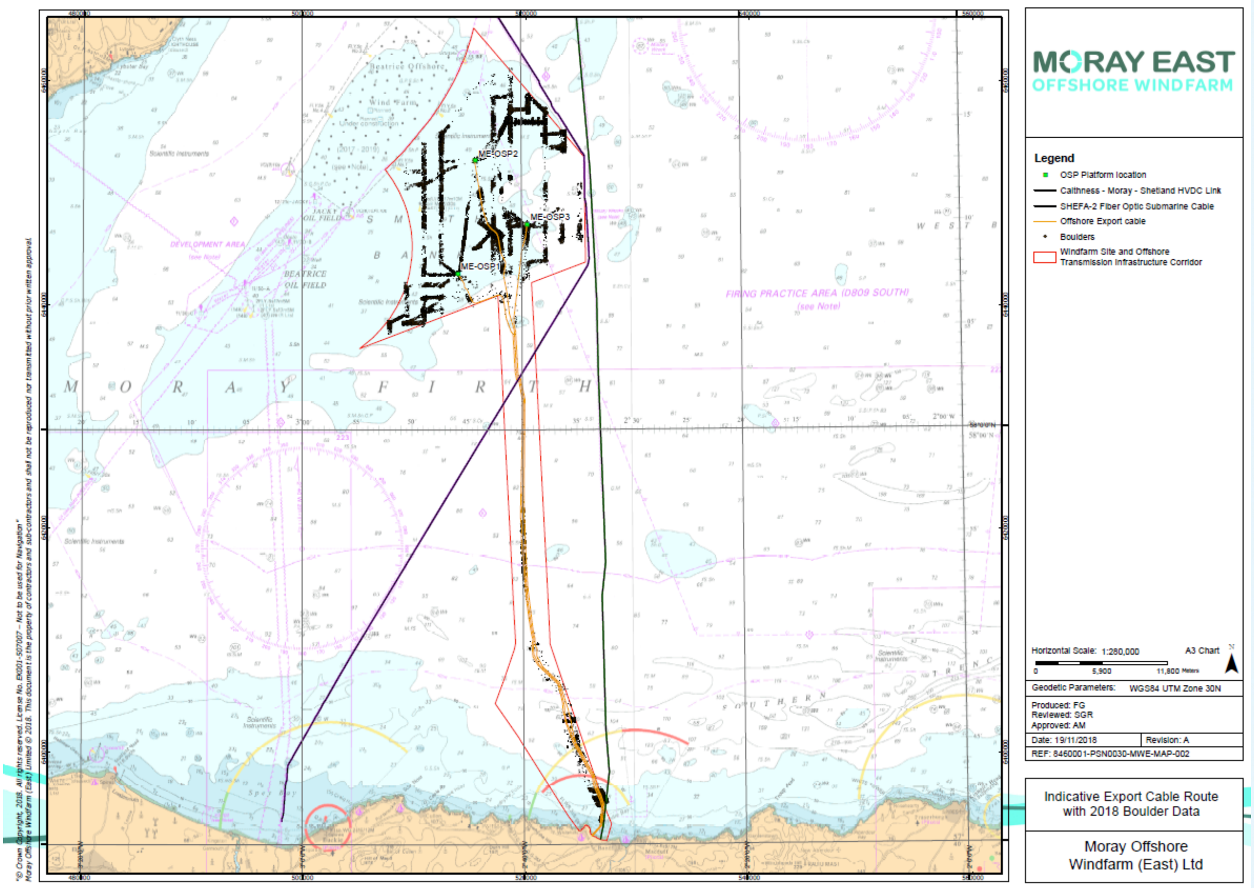


Figure 12-4: 2018 Boulder data recorded.

12.1.5 PLGR

These works have been completed

Prior to cable lay operations offshore, in order to reduce the risk of cable being laid on debris, a Pre-Lay Grapnel Run (PLGR) was performed using the CLV NKT Victoria. The PLGR operations completed prior to cable laying operations.

Figure 12-5: PLGR train.

12.1.6 Crossing preparation

These works have been completed

Before laying the OEC over the SHET HVDC cable crossing some enabling works were required at two of the cable crossing locations in advance of the commencement of cable lay activities. This included:

i. Seabed inspection of crossing location including positive identification of SHET HVDC cable and measurement of the XYZ position and depth of cover of the cable.

ii. Placement of 4Te of rock at the crossing locations on OEC-2 and OEC-3.

12.1.7 Pre-lay survey

These works have been completed

Pre-lay inspection survey of the OEC route and the cable crossing was undertaken to ensure cable lay area was free from any debris or hazard that can damage the cables.

12.1.8 Cable landfall pull in

These works have been completed

Before cable pull in from the landfall starts, some preparation works were done at shore including installation of winches and hang offs to hold cables etc. Once the landfall had been prepared, the cable was pulled in through the HDD ducts from the landfall, to achieve the pull-in of the cable from the cable lay vessel through the landfall ducts to its planned location within the transition joint bay.

12.1.9 Cable free lay

These works have been completed

The installation vessel then laid the cable to the seabed along the preset route, monitored by the Work Class Remotely Operated Vehicle (ROV) tethered from the vessel. This is especially important to ensure the cable was accurately laid across the pre-installed rock berm at the crossings and through boulder fields.

12.1.10 Cable 2nd end pull in at OSP

These works have been completed

The preferred method for installation of the final end of the OEC is through the use of a quadrant from the deck of the cable lay vessel, whereby a “bight” of cable will be supported from deck to seabed during the pull in. The OEC end will be pulled into the OSP using a platform-mounted winch, and cable protection will be attached to the export cable on board the cable laying vessel prior to the pulling operation. Alternatively, the cable may be laid on the seabed within the CPS and close to the J-tube exit, then pulled up into the J-tube across the seabed a short distance in line with the route. The CPS is around 20m long on each OEC at each OSP.

12.1.11 Cable trenching

These works have been completed

Following cable lay, the T-1000 and T-3200 tracked trenching ROVs were deployed from the DP2 vessel Havila Phoenix to trench the Moray East OECs. They can be configured in cutting or jetting mode. Where cutting is performed by chain cutters, the cutting chain was fitted with an array of cutting picks, positioned to efficiently and effectively cut the full width of the cutting boom. A slot trench defined by the cutter will provide protection in areas of hard clays. Where the soils were less difficult (sands or soft clays), the trenching mode was set to water injection jetting from the same trenching vehicles. The maximum affected trench width for each OEC circuit during construction was 13 m using the largest trencher (T-3200) (see Section 15 below).

Trenching was undertaken on a “Reasonable Endeavours” basis whereby certain areas, as described in Section 10.3, are subject to remedial works (additional trenching and/or rock placement).

Figure 12-6: Cable Trenching Vessel.

12.1.12 Crossings remedial installation

The rock installation vessel will be required to place three berms of rock across the cable at the crossing points. An as-built survey shall then be performed by the same vessel, a Fall Pipe Vessel (FPV), to accurately record the as-built conditions of the seabed e.g. the shape of the berms and confirm they are within the design tolerance.

The structures are anticipated to consist of a rock berm of 500 mm min. height covering an area of (3x) 130 m x 10 m, it is estimated that this shall be 2,500 MT, of 1-5” rock is required.

The length of the berms will be reduced based on the results of the trenching.

12.1.13 Remedial protection

Remedial protection comprises largely rock placement, utilising the same rock berm vessel and similar designs as above to afford sufficient protection for the lifetime of the cable. Remedial rock placement operations are currently underway from the nearshore area working northwards towards the OSPs. Work has been completed up to KP19 on all three cable routes, with the exception of the first 500m (HDD to KP1.5), which require a two layer rock berm and comprises a 1-5” (25-125mm) rock core stabilised with 5-40kg armour rock (up to 600mm).

Please refer to Section 10 for further details.

12.1.14 Post Installation Survey

The final position of the cable will be determined by means of a post installation survey. This will be carried out followed by either a WROV or Fall Pipe ROV, moving along the cable route and recording the horizontal and vertical position of the cable relative to the seabed. This shall be performed from the trenching vessel using a WROV with TSS-440 or PanGeo Sub Bottom Imager (SBI) and where remedial rock placement works are required it will be performed from the FPV using MBES coupled with the TSS-440 data.

13 Export Cable Operation and Maintenance

The OfTI Marine Licence requires that the OfTI CaP includes the following:

> *"Methodologies for over trawl surveys of the cables through the operational life of the works where mechanical protection of cables laid on the seabed is deployed.*
>
> *Measures to address exposure of any cables."*

The following section provides information relating to post-installation surveys and potential remedial actions to be taken should cable exposure occur.

13.1 Post Installation Surveys

Prior to completion of installation, a full set of as built documentation will have been obtained as the baseline for the as-left condition of the OEC. Post-construction surveys will be undertaken immediately following installation, in order to verify the as built conditions.

These as-built records will consist of survey data for all aspects of the lay and burial and include updated charts, acceptance tests etc. In addition, ROV footage of the seabed will be collected during the installation of the cables, where visibility allows.

The design and frequency of further post-construction surveys will be determined from the evaluation of asset integrity risks presented by the site conditions, asset design and results from through-life surveys.

The OEC will be subject to periodic inspection. In the Operation Phase, further cable and / or seabed surveys will be undertaken to confirm that cables remain buried to the required depths or the existing seabed remains unchanged. The method of survey will be similar to other construction surveys, though likely restricted to bathymetric survey from small vessel or free flying ROV.

The results of the CBRA combined with the proposed installation methods suggest that target DoL should be achieved along the majority of the route, the minimum largely achievable elsewhere. However, should minimum DoL not be achieved in areas of high fishing intensity and substantial lengths of OEC require mechanical protection, any requirement for overtrawlability surveys and the appropriate methodologies will be discussed with the local fishing industry and agreed with MS-LOT. Moray East have liaised with the SFF and committed to further discussions on the methodologies for overtrawl surveys with stakeholders, and as soon as as-built information is available this will be provided for review. Following the review of the as built information Moray East has committed to discuss the scope and timings of overtrawl trials, if and where they are required.

Furthermore, the cables and OSPs are equipped with Distributed Temperature Sensing (DTS) equipment to detect changes in the burial depth over time. Whilst this technology is in its early development the Topside and Subsea equipment has been installed to allow this to potentially be used in future.

13.2 Further potential Remedial Actions

In the event of cable failure or exposure, cable sections will be replaced and / or reburied, or cable protection will be applied.

Additional equipment not previously selected for cable installation may be required, which may include a Mass Flow Excavator (MFE) (subsea water jetting excavation device), hydraulic subsea cable cutter, and similar vessels to the nominated installation vessels already on the project.

Cables may already be buried and as such will require partial retrieval, commonly via a method using the MFE of opening "box cuts", these are small excavations using the MFE to expose approximately 5 m by 5 m space around the cable so that an ROV may access the cable and use the hydraulic cable cutter.

Alternatively, cables may be grappled for, which requires an operation similar to the PLGR operation (Section 12.1.5 above) to positively attach onto a damaged cable at a known location to retrieve to the vessel.

In both above cases the cable ends are then recovered on board the vessel using the ROV and recovery rigging, and/or the cable ends will be relaxed out of their hang-offs on the OSPs if required, before being cut and prepared to be jointed.

The installation of cable repair joints along the route would be performed by a cable installation vessel or specialist repair vessel. Two joint boxes would be utilised either end of a new replacement section, before the whole jointed system being laid back to the seabed and buried.

The new route will remain at all times within the consented area and the area that has been cleared of potential UXO, avoiding any other identified impact.

It is likely that the cable will be buried in parallel with the original burial route rather than in the exact same trench, but this would not be expected to be more than 10 m from the original location.

In the case of a cable replacement at the OSP, it is likely that a new CPS would also be used of the same or similar design as the original, to this effect a spare unit has been ordered.

14 Compliance with the Application

14.1 Introduction

As presented in Table 1-1 above, Condition 3.2.2.10 of the OfTI Marine Licence states:

> *"The CaP must be in accordance with the application."*

Section 14.2 below sets out information from the Modified TI ES 2014 with regard to compliance with the cable installation and burial proposals assessed.

14.2 Compliance with the Modified TI ES 2014

The Modified TI ES 2014 described a range of specification and layout options that could be applied during the construction of the Development. This took the form of a broad "Design Envelope" incorporating a variety of options. The ES defined likely cable installation specifications for the Development, based upon these broad options.

Since the Moray East Offshore Wind Farm Consents were granted, the cable installation details have been substantially refined as detailed in this document. In order to demonstrate continued compliance of this refined design, Appendix 1 provides a tabulated comparison of cable specifications as presented in the ES and this OfTI CaP.

15 Updated Cable Trenching Methodology

Since publication of the Modified TI ES in 2014 a significant amount of cable design engineering has been carried out as detailed within this OfTI CaP. A number of tools were used by contractors during the installation of the OEC. The following provides a comparison of the Modified TI ES 2014 assessment of the OEC and the worst case scenario (WCS) assessment resulting from the proposed OEC installation tools for the Moray East Transmission Infrastructure. This comparison has been undertaken by Royal HaskoningDHV. The changes in OSP interconnector trench length are considered in this document as the original assessment of the OSP interconnector cables was carried out jointly with the export cables assessment as part of the Moray East Modified TI ES 2014. However, the same cable trencher will be used for the interarray cables and the OSP interconnector and the trenching methodology for the OSP interconnector is therefore considered in the Wind Farm Cable Plan and not in this document.

The dimensions of the proposed cable trenchers for the OEC and area of seabed disturbed during the cable installation are shown in Table 15-1 below in comparison to the consented parameters.

Table 15-1: Parameters relevant to the cable trenching methodology

Relevant Parameters	Consented Parameters	Proposed / Actual Trencher Parameters
Trench depth	1.0m target (WCS 3m, as assessed in Modified TI ES 2014, Chapter 3.1)	2.05m (DoL + OD + Margin)
Trench affected width	6.0m	8.0m
Trench width	WCS 3.0m, as assessed in Modified TI ES 2014, Chapter 3.1	Varies depending of soil type but 1.0m would be typical.
Vehicle tracks	Not considered in ES as information was not available	T-3200 is 13.0m wide (tracks are 2 x 2.0) T-1000 is 5.1m wide (tracks are 2 x 0.5)
Cable length	Approximately 278km (70 km of OSP interconnector and export cable within Moray East site plus 208 km – 4 cables x 52 km within OfTI Corridor) Overall Development (inter-array, OSP interconnector & export cables) = 850 km	**OEC Cables** ME-OEC1 (56.312 km) ME-OEC2 (63.369 km) ME-OEC3 (57.057 km) **Inter OSP Cables** OSP2-OSP3 As Laid length: 9210.5m OSP1-OSP2 Proposed length: 10344.2m Approximately 196km (43km OSP interconnector and export cable within Moray East site plus 154 km within OfTI Corridor) Overall Development (inter-array, OSP interconnector & export cables) = 352 km
Profile	'V' shape	'U' shape

The dimensions of the OEC trenches have reduced in comparison to the WCS assessed in the Modified TI ES 2014. However, the proposed trencher to be used for the OEC will have greater contact with the seabed either side of the trench through the trench affected width and due to vehicle tracks on either side of the trench affected width. Therefore, there is up to 13.0 m (up to 8.0 m trench affected width and up to 4.0 m trencher tracks) of potential seabed disturbance for the OEC.

Due to the change in parameters of the proposed trenchers for the OEC and OSP interconnector cables there is a requirement to assess the potential seabed disturbance caused by the proposed trenchers.

In order to assess the impacts of seabed disturbance from the proposed trencher the quantity of SSC expected to arise has been calculated (Section 15.1 below) and disturbance from contact with the seabed has been assessed (Section 15.2 below).

The outputs have been used to assess the impacts to the relevant environmental receptors, specifically:

- Benthic ecology;
- Intertidal ecology;
- Fish and shellfish ecology; and
- Archaeology.

The results of the impact assessment are provided in Sections 15.3 to Section 15.6 below.

15.1 Suspended Sediment Concentrations

A worst-case scenario for sediment release was calculated within the Modified TI ES 2014, expressed as per metre of trench sediment. The assessment was completed by ABPmer (Modified TI ES 2014 ES, Chapter 3.1) using the methodology / assumptions set out below.

- The total mass of sediment (9,540 kg) is re-suspended evenly up to a (variable) ejection height;
- The time required for sediment to settle (at 0.05 m/s or 0.0001 m/s) through the total height of ejection is calculated to yield the duration of the effect;
- The length scale of the effect is the furthest distance travelled by the plume (in a downstream direction) and is the product of the ambient current speed (0.25 m/s) and the duration of the effect;
- The estimate of mean suspended sediment concentration is estimated by dividing the total dry mass of sediment by the volume of the triangular wedge of water through which the sediment will settle (ejection height multiplied by downstream distance divided by two); and
- The average thickness of any resulting sea bed deposit is estimated by dividing the total volume of sediment (4.5 m^3) by the footprint (length scale of the effect multiplied by 1 m).

The outcome of the calculations for the consented trencher is set out in Section 15.1.1 and the calculations for the proposed trenchers for the OECs are provided in Section 15.1.2 below.

15.1.1 Consented Cable Trencher

The worst-case scenario for sediment release, expressed as per metre of trench length for the consented trencher for the OEC (including OSP interconnector) in the Modified TI 2014 ES is:

- The maximum trench dimension is 3m wide x 3m deep with a ‘V’ shaped profile = 4.5 m^3/m sediment disturbance, all of which is released into the water column;
- The porosity of the material is conservatively estimated as 20 % void = 3.6 m^3/m sediment material release
- The sediment is assumed to be quartz with a density of 2,650 kg/m^3 = 9,540 kg/m dry mass sediment release;
- All the sediment is released as a fully fluidised mixture. The cable route consists of mixed sands and gravels, with a low fines content, becoming progressively finer in deeper water along the route; and
- A wider area of seabed (trench affected width, up to 6.0 m centred on the trench route) might be affected by some contact with the trencher but is not considered to contribute to the displacement of sediments.

The range of possible effects on SSC and deposition for a cable trench of this dimension are provided in Table 15-2 below, which quantifies the total effect per metre of trench length dug (from the Modified TI ES 2014 Chapter 3.1). The assessment shows that a lower height of ejection will result in a greater SSC and thickness of deposition, but with a smaller footprint of effect, and *vice versa*.

Table 15-2: Extent and magnitude of effect of cable trenching in medium sands (top) and fine sediments (bottom) for the original trenching method assessed in the EIA (Moray East, 2014)

Ejection Height (m)	Duration of Effect (s)	Length of Scale of Effect (m)	Indicative Mean SSC (mg/l)	Average Thickness of Deposit (m)
Medium Sands – Settling Velocity 0.05m/s				
1	20	5	3,816,000	0.9
5	100	25	152,640	0.18
10	200	50	38,160	0.09
25	500	125	6,106	0.036
Fine Sediments - Settling Velocity 0.0001m/s				
1	10,000	2,500	7,632	0.0018
5	50,000	12,500	305	0.00036
10	100,000	25,000	76	0.00018
25	250,000	62,500	12	0.000072

According to ABPmer (Modified TI ES 2014, Chapter 3.1), a critical thickness of sediment deposition for medium sands with relevance to benthic ecology is 0.05 m. The maximum possible distance from the trench over which displaced sediment of any type might deposit to a thickness of 0.05 m is 106 m (affecting an area of 106 m^2 per metre of trench installed).

For fine sediments, the effect of cable trenching on SSC would initially have a magnitude potentially more than the natural range of variability. However, the effect will be localised and temporary. Deposition would be followed by re-suspension, and sediments would disperse further throughout the water column with the result that SSC and the thickness of any subsequent deposits would be very small and within the range of natural variability.

15.1.2 Proposed Trenchers

To assess the significance of the volume of disturbance from the proposed trenchers, the method adopted by ABPmer (Modified TI ES 2014, Chapter 3.1) has been replicated. The worst-case scenario for sediment release (using the dimensions of the proposed trencher for the OEC) are provided in Table 15-3 below:

Table 15-3: Parameters of the export cable and OSP interconnector cable used to determine SSC and deposition

WCS Parameter	Export cable trench	OSP interconnector trench
Maximum trench dimensions	1.0m wide x 2.05m depth with a ‘U’ shaped profile = 2.05 m^3/m	1.0m wide x 1.5m depth with a ‘U’ shaped profile = 1.5 m^3/m
Porosity of the material (20% void)	1.64m^3/m sediment material release	1.2m^3/m sediment material release
Sediment density (2,650kg/m^3)	4346kg/m dry mass	3180kg/m dry mass

The range of possible effects on SSC and deposition for the proposed trench for the OEC are shown in Table 15-3 and Table 15-4 respectively.

Table 15-4: Extent and magnitude of effect of cable trenching in medium sands (top) and fine sediments (bottom) for the proposed trencher (OEC).

Ejection Height (m)	Duration of Effect (s)	Length of Scale of Effect (m)	Indicative Mean SSC (mg/l)	Average Thickness of Deposit (m)
Medium Sands – Settling Velocity 0.05m/s				
1	20	5	1,738,400	0.4100
5	100	25	69,536	0.0820
10	200	50	17,384	0.0410
25	500	125	2,781	0.0164
Fine Sediments - Settling Velocity 0.0001m/s				
1	10,000	2,500	3,477	0.0008200
5	50,000	12,500	139	0.0001640
10	100,000	25,000	35	0.0000820
25	250,000	62,500	6	0.0000328

Table 15-5: Extent and magnitude of effect of cable trenching in medium sands (top) and fine sediments (bottom) for the proposed trencher (OSP interconnector cable).

Ejection Height (m)	Duration of Effect (s)	Length of Scale of Effect (m)	Indicative Mean SSC (mg/l)	Average Thickness of Deposit (m)
Medium Sands – Settling Velocity 0.05m/s				
1	20	5	12,72000	0.3000
5	100	25	5,0880	0.0600
10	200	50	12,720	0.0300
25	500	125	2,035	0.0120
Fine Sediments - Settling Velocity 0.0001m/s				
1	10,000	2,500	2,544	0.0006000
5	50,000	12,500	102	0.0001200
10	100,000	25,000	25	0.0000600
25	250,000	62,500	4	0.0000240

In the method adopted by ABPmer (Modified TI ES 2014, Chapter 3.1), the ejection height, duration of effect and length of scale of effect are kept constant regardless of volume of sediment released. Given these parameters are constant, but the volume of sediment released decreases, the estimated indicative mean SSC for both proposed trenchers compared to the original trenching method assessed in the Modified TI ES 2014 are estimated to be more than 50 % smaller.

The average thickness of the deposit also decreases by 50 % to mirror the decrease in SSC, meaning the absolute estimates of thickness are very small. For both proposed trenchers, the maximum thickness is estimated to be below 1 mm compared to 2 mm for the original trenching method.

The maximum possible distance from the trench over which displaced sediment of any type might deposit to a thickness of 0.05 m is 45 m for the OEC and 33 m for the OSP interconnector cable compared to 105 m for the original method.

15.1.3 Summary of Disturbance for Proposed Trenchers

The following conclusions can be drawn from the comparative analysis on the two trenching methods:

- SSC is estimated to decrease by more than 50 % for the proposed trenching methods compared to the original trenching method;
    - This does not affect the outcome of the original assessment because, for both the original and proposed trencher methods, they would eventually reduce to be within the range of natural variability, through continued deposition and re-suspension (although quicker for the proposed trencher).
- The average thickness of the deposit is also estimated to decreased by over 50 % for the proposed trenching methods compared to the original trenching method;
    - This does not affect the outcome of the original assessment because the absolute estimates of thickness are smaller for the proposed trenchers, decreasing from a maximum of only 2 mm for the original method to a maximum of less than 1 mm for the proposed trenchers.

In both methods, there was contact of the trencher with the seabed. In the Modified TI ES 2014, it was stated that a wider area of seabed (up to 6.0m centred on the trench route, referred to as 'trench affected width') might be affected by some contact with the burial machine, but was not considered to contribute to the disturbance and release of sediments. The WCS for the trench affected width for the OEC and OSP interconnector cables is now 8.0 m, as shown in Table 15-1 above. Additionally, for both the OEC and the OSP interconnector cables, the proposed trenchers also have contact on either side of the trench due to trencher tracks, which are 2.0m either side of the trench affected width. This additional seabed contact was not included in the Modified TI ES 2014 and has been considered in Section 15.1.4 below.

15.1.4 Trencher Tracks / Seabed Contact

The effect of vehicle tracks on the seabed (2.0 m wide on either side of the trench affected width), created by the cable installation equipment, was not considered as part of the Modified TI ES 2014 assessment due to lack of information on the trencher at the time of writing. Additionally, there is potential for a small increase in trench affected width for the OECs and OSP interconnector cables (an additional 2.0 m) due to the proposed trencher to be used for the OECs and OSP interconnector cables. An assessment is therefore required to determine whether this change in the project description is significant compared to the consented project description (i.e. no trencher tracks).

There is potential for the tracks of proposed trenchers used during the installation of the OECs and OSP interconnector cables to directly impact the seabed. Where the trencher moves over the seabed, there is potential for the seabed to be compressed vertically downwards and displaced laterally. An indentation will be created, the same size as the dimensions of the trencher tracks (i.e. two times 2.0 m = 4.0 m wide). It is estimated that an indentation would be created that is a maximum of 0.2 m deep compared to the surrounding seabed. On either side of the tracks there is the potential for the seabed to be slightly raised in a series of linear pressure ridges. After the trencher has passed, some of the slightly raised sediment would return to the track indentation via slumping under gravity until a stable slope angle is achieved. Over the longer term (months), the track indentation would become shallower, less distinct and return to its original profile, due to infilling with mobile seabed sediments.

In addition, the creation of the track indentations will release a negligible volume of sediment into the water column compared to the creation of the trench itself. Hence, the effects of the proposed trenchers on SSC and sediment deposition would be the same as those for the original consented assessment.

Given the small magnitude of the track indentation, its short-term nature (i.e. the seabed will recover over months), and the negligible changes in SSC and sediment deposition due to the tracks, the original consented assessment remains valid for the proposed trenchers.

In addition, the consented length of the OECs and OSP interconnector cables combined is 278 km, whereas the cable length to be installed is only 196 km, as set out in Table 15.1 above. The length of cable to be installed is significantly less than the consented length. Hence, any increase in sediment disturbance caused by the use of the proposed trencher tracks, as highlighted above, is minimal and would be expected to recover within months. Additionally, as determined in Section 15.1 above, the amount of SSC expected to arise has reduced by 50 %. Therefore, any increase in seabed disturbance caused by use of the proposed trencher tracks would be compensated by the reduction in the overall cable length the trencher would be operated over and by the reduction in SSC from the proposed trenchers compared to the consented trencher.

Although there is a very small increase in trench affected width for the OECs where the trencher may come into contact with the seabed (an additional 2 m), as described above, the consented cable length is much larger than the cable length to be installed therefore this very small increase in trench affected width is expected to be compensated by the reduction in the overall cable length. In accordance with the original assessment, this contact is not considered to contribute to the displacement of sediments and has therefore not been considered further.

An assessment of the seabed disturbance from the updated trenching methodology on the relevant environmental receptors is provided in Sections 15.3 to 15.5 below.

15.2 Benthic Ecology

As highlighted in Section 15.1, the proposed trenches have a smaller depth than the WCS assessed in the Modified TI ES 2014, meaning less sediment will be removed per metre of trench in comparison to the consented trencher. However, the proposed trenchers have vehicle tracks on either side of the trench affected width, meaning there is up to 10.0 m of potential seabed disturbance for the OSP interconnector and up to 12.0 m of potential seabed disturbance for the OEC.

The impact of the proposed trenchers has been assessed in relation to benthic ecology. The only impacts of relevance to the new trenching method is temporary habitat loss, increased SSC and seabed disturbance.

With regards to temporary habitat loss, the overall length of the trench has reduced from the consented 278km to 197km, meaning the total footprint of temporary habitat loss due to trenching has reduced. Therefore, temporary habitat loss during the construction phase due to the trench footprint has not been considered further.

With regards to SSC, the Modified TI ES 2014 showed that installation activities will increase SSC by one or two orders of magnitude above the range of that which occurs naturally but only over a very small distance from the point of disturbance (i.e. to 125 m) and for a very short duration (i.e. minutes) (Modified TI ES, 2014 Chapter 3.1).

The effect of SSC was determined in the Modified TI ES 2014 to be highly localised and of short duration, resulting in a low magnitude of effect. Biotope and species receptors were determined to be of low sensitivity due to being widely distributed throughout the region and tolerant to the predicted sediment effects. Therefore, the impact significance was predicted to be **minor**.

With regards to seabed disturbance, the proposed trenchers have a slight increase in temporary disturbance from the trencher tracks (as discussed in Section 15.1.4 above); however, the reduction in

SSC from the trenchers and the reduction in length of cable corridor means overall the magnitude of the effect is still considered to be low. Additionally, biotope and species receptors will be the same, meaning receptor sensitivity is still considered to be low. Therefore, overall the impact significance of the proposed trenchers is predicted to be **minor**.

15.3 Intertidal Ecology

The Modified TI ES 2014 assessed the impact of cable installation within the intertidal area. Installation activities are likely to be undertaken during low tide periods therefore the potential for re-suspension of material due to construction activities and subsequent settlement is limited. The degree of sediment re-suspension likely to occur with the flooding tide is expected to be low due to the relatively coarse nature of the sediment (sand), which will settle back to the sea floor very rapidly and close to the site of initial disturbance. The spatial extent of any sediment settlement is therefore expected to be very localised and will occur over the short-term so that the overall magnitude of the effect will be very low (Moray East, 2014).

The sensitivity of the intertidal biotopes to the effect of temporary sediment disturbances and re-settlement is also considered very low as a result of the naturally perturbed environment at Inverboyndie and associated effects of sediment suspension, scour and deposition.

The overall effect of increased SSC on intertidal ecology was assessed to be **not significant** with low uncertainty within the Modified TI ES 2014. The installation method at the landfall is HDD from above Mean High Water Springs out to approximately 1 km seaward and as such **no impacts** are predicted within the intertidal area and are therefore are no worse than those assessed within the Modified TI ES 2014.

15.4 Fish and Shellfish Ecology

Impacts to fish and shellfish vary depending on the type of species resulting in the sensitivity of the receptor ranging from medium to low. Increased SSC and sediment re-deposition due to installation of the export cable (including OSP interconnector cables) was assessed in the Modified TI ES 2014, in relation to fish and shellfish ecology. The impacts of relevance to the new trenching methods are therefore increased SSC and seabed re-deposition and disturbance.

With regards to SSC, the Modified TI ES 2014 assessment shows that increased SSC may result in localised avoidance of the area by mobile and migratory fish, leading to limited disturbance. Additionally, sediment re-deposition has the potential to smother fish and shellfish species which lay their eggs on the seabed. However, the impact magnitude of increased SSC and sediment re-deposition was determined to be small due to the localised and short-term nature of the impact. Due to the sensitivity of the fish and shellfish receptors being medium to low and the impact magnitude being small the impact was assessed to be negative of **minor** significance for all fish and shellfish species.

With regards to seabed disturbance, given the small level of disturbance predicted from the increased trencher tracks as described above and the decrease in amounts of SSC due to the proposed trenchers in comparison to the consented trencher, the impact of increased SSC and sediment re-deposition as a result of the proposed trenchers is still considered to be of negative **minor** significance.

15.5 Archaeology

Within the Modified TI ES 2014, **no significant** indirect effects were identified from changes to seabed processes which may induce adverse effects upon Cultural Heritage receptors. In fact, minor positive effects from increases in SSC may benefit Cultural Heritage receptors by increasing protective sediment cover. The small increase in seabed disturbance from the proposed trencher tracks has not changed the outcome of the assessment in the Modified TI ES 2014. **No significant** indirect effects have been identified and there is still potential for protective sediment cover due to SSC.

15.6 Summary

Following an update to the quantities of SSC and deposition reported in the Modified TI ES 2014, to take into account the dimensions of the proposed trenchers for the OEC, an impact assessment was carried out on all receptors with the potential to be affected by SSC and sediment deposition and disturbance from trencher tracks. A summary of the outcome of the impact assessment of the proposed trenchers in comparison to the consented trencher is presented in Table 15-6 below.

Overall, due to the small disturbance as a result of the proposed trencher tracks, the reduction in SSC now expected and the reduction in the cable corridor length (when compared to the consented cable trencher parameters; Modified TI ES 2014), no changes to the assessed impacts are predicted.

Table 15-6: Summary of impacts of the proposed trencher

Receptor	Impact	Impact Significance		
		Consented Trencher	Proposed export trencher	Proposed OSP interconnector trencher
Benthic Ecology	Indirect disturbance (increased SSC and sediment deposition)	Minor	Minor	Minor
Intertidal Ecology	Indirect disturbance (increased SSC and sediment deposition)	Not significant	Not significant	Not significant
Fish and Shellfish Ecology	Temporary disturbance of the seabed (increased SSC and sediment re-deposition)	Minor	Minor	Minor
Archaeology	Increased SSC and sediment re-deposition	Minor positive	Minor positive	Minor positive

16 References

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Moray East (2020b) Construction Management Strategy and Construction Programme, Moray Offshore Wind Farm and Associated Transmission Infrastructure. Document approved 2020.

Appendix 1 Compliance with cable installation parameters assessed and commitments in the Modified TI ES 2014

Source	Cable element	Modified TI ES parameter/commitment	Final design parameter/relevant section of OfTI CaP
Moray East Modified TI ES 2014	General cable specifications	Cable configuration: 4 cables each in triplecore (offshore) arrangement	3 cables each in triplecore (offshore) arrangement (as detailed in the DSLP)
		Cable bundle separation distance: 4 x water depth	Up to 1,200 m (Section 9.3)
		Voltage of cabling: 220 kV (AC)	220 kV (AC) (as detailed in the DSLP)
		Entry / exit method from OSPs: J–tube	J-tube (as detailed in the DSLP)
		Target burial depth in seabed: 1 m	Depth of lowering varies from 1.3 to 1.6 m (Section 10.1.3)
		Protection where target burial not achieved: Concrete mattresses or rock placement	12.1.14: Where the minimum Depth of Lowering (DoL) cannot be achieved, then appropriate means of additional protection will be employed. Likely protection measure will be rock placement
		Trench affected width: 6 m per cable	8 m (Section 15)
		Cable corridor length (from Moray East wind farm area): approximately 52 km	Cable length is 52 km from Moray East wind farm area ((as detailed in Section 4.6.1.1 of the DSLP)
		Cable corridor width: up to 1,200 m	Up to 1,200 m (Section 9.3)
	Cable installation	The available techniques for creating the cable trenches are ploughing, jetting, jet assisted plough, tracked devices or mechanical cutting. The technique used is chosen so it is suitable for the seabed conditions.	Section 10.2 details the cable installation.
		The techniques which could be used for the modified export cable landfall and intertidal area include open cut trenching, ploughing, dredging, mechanical cutters and HDD.	Section 12.1.2 details the cable installation at the landfall.
	CBRA	Further analysis will be carried out on the site seabed conditions as part of the cable protection and burial study. The study will consider the technically and economically	Section 10 details the CBRA.

Source	Cable element	Modified TI ES parameter/commitment	Final design parameter/relevant section of OfTI CaP
		achievable burial depths based on the export cable corridor site specific ground conditions.	
		Cables will be buried to a target depth of 1 m, where it is technically practicable to do so, which will reduce the risk to fishing vessels from snagging. In instances where adequate burial cannot be achieved an appropriate cable protection will be used. Over-trawlability surveys will be undertaken as necessary along areas of the cable route where potential snagging risks could be located, to reduce risks to the vessels operating trawled gear.	Section 13: the results of the CBRA combined with the proposed installation methods suggest that DoL will be achieved along the majority of the route. However, should DoL not be achieved in areas of high fishing intensity and substantial lengths of OEC or OSP interconnector cable require mechanical protection, any requirement for overtrawlability surveys and the appropriate methodologies will be discussed with the local fishing industry and agreed with the Marine Scotland Licensing Operations Team.
	EMF	The sheathing and armoured cores prevent the propagation of E fields into the environment, however, these materials are permeable to B fields, which therefore emanate into the surrounding environment. The expected B fields generated by OEC and inter-platform AC cables are, taking cable burial to 1 m, well below the Earth's magnetic field (assumed to be 50 NT).	Section 11.3: the predicted magnetic field levels at seabed level associated with the buried cables if they are buried to 1.0m is lower than the value associated with the earth's magnetic field.
		Cable burial will reduce exposure of electromagnetically sensitive species to the strongest EMFs that exist at the "skin" of the cable owing to the physical barrier of the substratum (OSPAR, 2008). Similarly, where burial is not feasible, cable protection will ensure that fish and shellfish receptors are not in direct contact with the cable and will not be exposed to the strongest EMFs.	Section 12.1.14: where the minimum Depth of Lowering (DoL) cannot be achieved, then appropriate means of additional protection will be employed.
	Remedial protection	Where burial depth cannot be achieved, cable armouring will be implemented (e.g. rock placement or concrete mattressing). The suitability of installing rock or concrete mattresses for cable protection, especially around the structure bases, will be assessed based on the seabed current data across the proposed development area and the assessed risk of impact damage.	Section 12.1.14: where the minimum Depth of Lowering (DoL) cannot be achieved, then appropriate means of additional protection will be employed.

Source	Cable element	Modified TI ES parameter/commitment	Final design parameter/relevant section of OfTI CaP
		The use of best practice to minimise the quantities of scour and cable protection material will reduce loss of original seabed habitat and habitat change.	Section 10 details the CBRA. Scour protection is detailed within the combined CoP and CMS.
		For most of the OEC route it is expected that the cables will be in trenches for protection. However, should the seabed contain areas of rock at, or close to the surface which is potentially unsuitable for trenching, cables may be laid on the seabed. Where this occurs, the cable will be protected by graded rock placement, concrete mattresses or other suitable protective coverings.	Section 12.1.14: where the minimum Depth of Lowering (DoL) cannot be achieved, then appropriate means of additional protection will be employed.
	Mitigation of impacts on other users of sea	Embedded mitigation for Shipping and Navigation: • Burial of the cable to a minimum of 1m and/or protection; • Charting of cables as per UKHO requirements; • Monitoring – depth and coverage surveys during the operational phase of the cables.	Section 10 details the cable burial specifications. Section 13.1 details post installation surveys.
		Sections of the cable route identified to be high risk areas from anchoring and fishing activity will be buried to a suitable depth to protect against vessel anchors and fishing gear. Where a suitable burial depth is unachievable, the cables will be protected with concrete mattresses and / or rock placement.	Section 10 details the CBRA and 12.1.14 details remedial protection.
	Mitigation of impacts on archaeology	Avoidance of known undesignated Cultural Heritage Assets by micrositing where possible within the modified OfTI export cable route corridor.	Section 9.1
	Third party cables in proximity and cable crossings	Consultation has been undertaken with Faroese Telecom (the operator of the SHEFA–2 cable) and they have not raised an objection to the Moray East Project. Further discussions will result in cable crossing / proximity agreements being secured which will include detailed crossing conditions and methodology. Faroese Telecom will also be notified of any Moray East works within 1,000 m of the SHEFA–2 cable.	Section 11.2 details the third party cables in proximity to the OEC.
		Where the cable must cross existing infrastructure, such as other cables, special arrangements will be required. For example, a layer of concrete mattresses or grout bags may be fitted over the top of the existing cable. The new cable will be run over this	Section 11 provides detail on cable crossing.

Source	Cable element	Modified TI ES parameter/commitment	Final design parameter/relevant section of OfTI CaP
		protective layer and then itself protected with a further layer of mattresses or grout bags. The methodology for crossing arrangements will be developed in agreement with third party cable owner / operators where relevant.	
	Post installation surveys	During operation, the export cable will be monitored to ensure that cables remain buried and any scour effects remain within the range of that predicted in the ES.	Section 13.1 details post installation surveys.
		Periodic and planned surveys of the export cable routes will be carried out to monitor burial depths / protection and seabed mobility.	Section 13.1 details post installation surveys.

Appendix 2 Export Cable Route Biotope Assessment

EXPORT CABLE ROUTE BIOTOPE ASSESSMENT

August 2018

Moray Offshore Windfarm (East) Limited

Produced by Fugro GB Marine Ltd. on behalf of Moray Offshore Windfarm (East) Limited	
Produced by	PAE
Reviewed by	
Document Status	Final
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Review / Approval

Moray East Ecological Cleck of Works	**Moray East**
Fiona Moffatt [Royal Haskoning DHV]	Peter Moore [OFTO Development Manager]

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CaP	Cable plan
CMS	Construction method statement
CoP	Construction programme
EC	European Community
EDA	Eastern development area
EIA	Environmental impact assessment
ES	Environmental statement
JNCC	Joint Nature Conservation Review
MNCR	Marine Nature Conservation Review
OfTI	Offshore transmission infrastructure
OSP	Offshore substation platforms
PEMP	Project environmental monitoring programme
PMF	Priority Marine Feature
SACFOR	Superabundant, abundant, common, frequent, occasional, rare
SSS	Sidescan sonar
TI	Transmission infrastructure

Definitions

The following definitions have been used throughout this document with respect to the company, the consented wind farms and how these definitions have changed since submission of the Moray East Environmental Statement (ES) in 2012 and the Modified Transmission Infrastructure ES in 2014.

- **Moray Offshore Windfarm (East) Limited (formerly known as Moray Offshore Renewables Limited and hereinafter referred to as Moray East)** – the legal entity submitting this Construction Programme (CoP) and Construction Method Statement (CMS) document;
- **Moray East Offshore Windfarm** - the wind farm to be developed in the Moray East site (also referred as the Wind Farm);
- **The Moray East Site** - the area in which the Moray East Offshore Wind Farm will be located. Section 36 Consents and associated Marine Licences to develop and operate up to three generating stations on the Moray East site were granted in March 2014. At that time the Moray East site was known as the "Eastern Development Area (EDA)" and was made up of three sites known as the Telford, Stevenson and MacColl offshore wind farm sites; The Section 36 Consents and Marine Licences were subsequently varied in March 2018;
- **Telford, Stevenson and MacColl wind farms** – these names refer to the three consented offshore wind farm sites located within the Moray East site;
- **Transmission Infrastructure (TI)** - includes both offshore and onshore electricity transmission infrastructure for the consented Telford, Stevenson and MacColl wind farms. Includes connection to the national electricity transmission system near New Deer in Aberdeenshire encompassing AC offshore substation platforms (OSPs), AC OSP interconnector cables, AC export cables offshore to landfall point at Inverboyndie continuing onshore to the AC collector station (onshore substation) and the additional regional Transmission Operator substation near New Deer. A Marine Licence for the offshore TI was granted in September 2014 and a further Marine Licence for two additional distributed offshore substation platforms (OSPs) was granted in September 2017.The onshore TI was awarded Planning Permission in Principle in September 2014 by Aberdeenshire Council and a Planning Permission in Principle under Section 42 in June 2015;
- **Offshore Transmission Infrastructure (OfTI)** – the offshore elements of the transmission infrastructure, comprising AC OSPs, OSP inter-connector cables and AC export cables offshore to landfall (for the avoidance of doubts some elements of the OfTI will be installed in the Moray East site);
- **Moray East ES 2012** – The ES for the Telford, Stevenson and MacColl wind farms and Associated Transmission Infrastructure, submitted August 2012;
- **Moray East Modified TI ES 2014** – the ES for the TI works in respect to the Telford, Stevenson and MacColl wind farms, submitted June 2014;
- **The Development** – the Moray East Offshore Wind Farm and Offshore Transmission Infrastructure (OfTI);
- **Design Envelope** - the range of design parameters used to inform the assessment of impacts; and
- **OfTI Corridor** – the export cable route corridor, i.e. the OfTI area as assessed in the Moray East Modified TI ES 2014 excluding the Moray East site.

- **Moray East Offshore Wind Farm Consents** – are comprised of the following:

  <u>Section 36 Consents:</u>

  - Section 36 consent for the Telford Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the Telford Offshore Wind Farm assigned to Moray East on 19 June 2018.
  - Section 36 consent for the Stevenson Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the Stevenson Offshore Wind Farm assigned to Moray East on 19 June 2018.
  - Section 36 consent for the MacColl Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the MacColl Offshore Wind Farm assigned to Moray East on 19 June 2018.

  <u>Marine Licences</u>

  - Marine Licence for the Telford Offshore Wind Farm (as varied) – Licence Number: 04629/18/0 – consent under the Marine (Scotland) Act 2010 and Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area[1].
  - Marine Licence for the Stevenson Offshore Wind Farm (as varied) – Licence Number: 04627/18/0 – consent under the Marine (Scotland) Act 2010 and Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area[1].
  - Marine Licence for the MacColl Offshore Wind Farm (as varied) – Licence Number: 04628/18/0 (as varied) - consent under the Marine (Scotland) Act 2010 and Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area[1].

- **OfTI Licences** – are comprised of the following:
  - Marine Licence for the Offshore Transmission infrastructure – Licence Number 05340/14/0 – consent under the Marine (Scotland) Act 2010 and Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the "OfTI Marine Licence").
  - Marine Licence for two additional distributed OSPs – Licence Number 06347/17/1 – consent under the Marine (Scotland) Act 2010 and Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction, operation and maintenance works and the deposit of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the "OSP Marine Licence").

[1] Transfer of the Marine Licence to Moray East was requested on the 25 June 2018.

Executive Summary

This document has been prepared by Fugro GB Marine Ltd. on behalf of Moray Offshore Wind Farm (East) Limited. It presents a map of classified seabed habitats and biotopes, including valued benthic features, within the boundaries of the offshore export cable route, and is intended to inform the final Offshore Transmission Infrastructure (OfTI) Cable Plan (CaP) and to also meet the benthic ecological monitoring obligations of the Project Environmental Monitoring Programme (PEMP).

Site specific benthic ecological and geophysical data were used to prepare the map. Despite some variation in substrate composition throughout the cable corridor, seabed habitats fell within two broad habitat types and two detailed biotopes.

The broad habitats were identified and classified as SS.SSa and SS.SMx.CMx defining a range of sand and mixed coarse sediment biotopes respectively. These habitat types reflected historic observations from previous benthic studies at Smith Bank and the Jacky oil field.

The two detailed biotopes included SS.SMu.CFiMu.SpnMeg and CR.MCR.EcCr.FaAlCr.Pom. The former detailed biotope is a component of Scotland's '*burrowed mud*' Priority Marine Feature (PMF) and is known to dominate the seabed within the wider southern Moray Firth area. It describes seapens and burrowing megafauna in muddy circalittoral sand and was found throughout much of the export cable corridor below 50 m depth. It has previously been allocated to similar seabed areas at the adjacent Beatrice offshore wind farm development (located approximately 20 km west of the current route) and was attributed to the comparatively deeper water sections of the Beatrice export cable corridor (BOWL, 2012; 2013). Furthermore, the Joint Nature Conservation Committee (JNCC) has recorded this biotope within the vicinity of the current study area as indicated by JNCC non-core records.

The latter detailed biotope describes encrusting fauna on moderately exposed rock and is illustrative of Annex I (EC Habitats Directive 92/43/EEC) stony and rocky (geogenic) reef rock habitat. It was comparatively restricted in its distribution within the consented offshore cable corridor and was only found within the shallow nearshore waters close to the cable landfall site at Inverboyndie. While only recorded across a limited area within the current cable corridor, rocky habitats appear to be well represented throughout the coast and nearshore regions of the southern Moray Fifth and were recorded at the Beatrice offshore wind farm export cable site.

The map delineates the extents of the classified habitats and biotopes in relation to the cable corridor and thus informs the final CaP design and meets the PEMP requirements with respect to benthic ecological monitoring.

1 Introduction

Following successful award of respective Marine Licences and positive Section 36 consent decisions for the wind farm, Moray Offshore Windfarm (East) Limited (Moray East) are now seeking to prepare for the construction of the Moray East Offshore Wind Farm and associated transmission infrastructure. Construction of the Offshore Transmission Infrastructure (OfTI) will include the installation of three export cable circuits (the OfTI corridor) between the area of the Moray East Offshore Wind Farm and the landfall site located near Inverboyndie.

Environmental considerations relating to the construction and operation of cables have been addressed in detail in the Moray East Modified TI ES (2014) and have informed the development of a number of conditions attached to the current OfTI Marine Licence. The methods by which environmental conditions will be met are explained in the Project Environmental Monitoring Programme (PEMP) and the OfTI Cable Plan (CaP) and include *inter alia* presentation of pre-construction benthic survey data and the distribution and extents of Annex I and Priority Marine Features (PMF) to inform cable micro-siting and installation methods.

This document is intended to accompany the OfTI CaP and contributes to both the discharging of OfTI CaP licence conditions and meeting the PEMP requirements with regards to informing cable installation and benthic ecological monitoring. Specifically, it presents the findings of a synthesis of site specific geophysical and benthic ecological data to identify and delineate the Annex I and PMF habitats and to help position and install the export cables so that potential adverse effects on environmentally sensitive seabed features are minimised. Habitats are presented for the currently preferred 'primary' export cable route in the form of a habitat distribution (biotope) map. The biotope map fulfils the PEMP requirement for benthic monitoring and provides the basis for the delivery of the OfTI CaP. In addition, habitat and biotope observations are compared with those found previously during other studies within the outer Moray Firth to provide wider context.

2 Methodologies

2.1 Benthic Ecology Data Collection

Benthic ecology data for the export cable route were collected over ten days (16 to 26 May 2014) using digital video and stills cameras. The survey was conducted in accordance with the following guideline;

- Cefas guidance on the conduct of benthic studies at aggregate dredging sites (Ware & Kenny, 2011).

Cameras were fixed to a seabed sledge and towed from a vessel throughout the length of the OfTI corridor, from the offshore wind farm to a point located just offshore of the proposed landfall site, typically around the 5 m contour. The work was undertaken on a 24-hour basis and provided a continuous video record of the seabed habitats and epifaunal species between the wind farm and local shallow waters just offshore of the landing site. The video was overlaid with real-time differential GPS positions with appropriate lay-backs applied for geo-referencing. Observer records were collated throughout the video deployment including substrate type and conspicuous epifauna together with any observations of burrows and tubes, (i.e. *Nephrops* burrows). Photographic stills of representative habitat types and species were also collected during the survey.

The continuous video and stills cameras collected geo-referenced information on the presence and status of seabed habitats and conspicuous epibenthic (seabed surface dwelling) species. Physico-chemical sediment data were collected using a 0.1 m^2 grab sampler also deployed from the vessel.

Benthic ecology survey methods were approved by Marine Scotland Science prior to mobilisation and followed Cefas Guidelines described in Ware & Kenny (2011). Methods were also consistent with those applied at the three consented wind farms and at the Beatrice Offshore Wind Farm to ensure data compatibility across the Moray developments and to allow a consistent EIA and cumulative effects assessment. Details of the survey methodology, together with the full results of the benthic ecology survey of the OfTI corridor, are presented in Technical Appendix 4.4 A of the Modified TI Environmental Statement (ES).

2.2 Geophysical Data Collection

Geophysical (acoustic) data, including sidescan sonar (SSS) and swath bathymetry, were collected separately from the ecology survey and were provided to Fugro by Moray East. Figures 2-1 and 2-2 present the extents of the SSS and swath bathymetry data respectively.

The data provided included mosaiced acoustic datasets collected in 2014, 2017 and 2018 as ArcGIS shapefiles showing the distribution of seabed reflectivity, textures and depth gradients throughout the cable corridor between the wind farm and a point offshore of the landfall site. In addition to the acoustic data sets, the results of geophysical borehole sampling surveys conducted in 2014 and 2018 along the route of the export cables were also provided to Fugro (see Figures 2-3). These included visual descriptions of the surficial and sub-surface seabed sediments obtained from borehole samples.

2.3 Data Analysis

Video and photographic stills data were analysed following Joint Nature Conservation Committee (JNCC) Marine Monitoring Handbook. Procedural Guideline No. 3.5. Identifying biotope using video recordings (JNCC, 2001).

In addition to the on-site observer records, the entire seabed video footage for the cable corridor survey area was reviewed at 4 times normal speed and the positions of the boundaries between different sediment habitats were recorded. Determination of the different sediment habitat types was undertaken following the Folk classification (Long, 2006) in conjunction with the Wentworth (1922) classification as presented within Table 2-1. Observations of the borehole samples collected during the geotechnical campaigns were used to corroborate the seabed video/photographic data.

Table 2-1: Sediment Particle Sizes and Classification Terms

Particle Size	Corresponding Folk Class	Wentworth (1922) Classification
> 256 mm	NA	Boulder
> 64 to 256 mm		Cobble
> 2 to 64 mm	Gravel	Gravel/Pebble
> 62.5 µm to 2 mm	Sand	Sand
> 4 to 62.5 µm	Mud	Silt
> 1 to 4 µm		Clay

The video footage was then viewed again at normal speed, on software which enabled freeze frame, and slower than normal playback to allow the faunal component to be assessed. High resolution stills were used to aid identification of fauna where necessary.

Epifauna observed from the video were recorded and semi-quantified using the SACFOR abundance scale (Hiscock, 1996) (Table 2-2). Where the abundance of taxa could not be estimated, these were recorded as Present (P) only.

Table 2-2: Marine Nature Conservation Review (MNCR) SACFOR Abundance Scale

Growth Form			Size of Individuals/Colonies				
%Cover	Crust/	Massive	< 1 cm	1-3 cm	3-15 cm	>15 cm	Density
> 80 %	S		S				> 1/0.001 m^2
40 – 79 %	A	S	A	S			1 - 9/0.001 m^2
20 – 39 %	C	A	C	A	S		1 - 9/0.01 m^2
10 – 19 %	F	C	F	C	A	S	1 - 9/0.1 m^2
5 – 9 %	O	F	O	F	C	A	1 - 9/ m^2
1 – 5 %	R	O	R	O	F	C	1 - 9/10 m^2
< 1 %		R		R	O	F	1 - 9/100 m^2
					R	O	1 - 9/1000 m^2
						R	< 1/1000 m^2

Notes:
S = Superabundant, A = Abundant, C = Common, F = Frequent, O = Occasional, R = Rare

2.4 Geophysical Data Treatments

Upon receipt, the sidescan sonar (SSS) and swath bathymetry mosaics were uploaded to ArcGIS. Within the SSS data, the boundaries of each sediment acoustic region were determined and mapped to create a wire-frame diagram of polygons illustrating the distribution and extents of distinct seabed habitat types. Discrimination between sediment acoustic regions was largely undertaken by eye within ArcGIS to determine differences in reflectivity and texture. Lighter reflectivity was generally indicative of softer seabed substrates such as sand and muddy sand while areas of darker reflectivity corresponded to areas of coarser gravel and cobble substrate and rock. Bathymetry data were used to corroborate the boundary locations visible in the SSS data as necessary. Each polygon was then attributed a biotope classification based on the associated sediment type and conspicuous epifauna identified from the video and stills images as described below.

2.5 Biotopes Classification

The sediment and species data derived from the seabed video and still image analyses were used to classify a series of biotopes which were then used to attribute each polygon. The system used to classify each biotope was the 'The Marine Habitat Classification for Britain and Ireland – Version 15.03' (JNCC, 2015) habitat classification system and the allocation of biotopes was based on Joint Nature Conservation Review (JNCC) guidance (Perry, 2015).

Note that biological communities and marine environments can be highly dynamic and temporally variable, and therefore the biotopes and habitats identified by the current assessment are representative of the survey area at the time of sampling only. Although a biotope can be assigned to any sized area of seabed, for the purposes of this assessment the commonly accepted minimum habitat size of 25 m^2 (Connor et al., 2004) was adopted.

Key to a successful CaP is the accurate mapping of potentially sensitive habitats so that these can be considered during cable installation activities. This includes the identification and mapping of cobble and/or stony reef features which have been noted during similar surveys at the adjacent Beatrice offshore wind farm and which have been considered as being potential Annex I (EC Habitats Directive 92/43/EEC) geogenic reef. To assist the identification and delineation of potential Annex I geogenic reef, the following definitions for 'reefiness' were used as presented in Table 2-3.

When considering the potential of an area as stony reef, the composition of the substrate is an important characteristic. Stony reef is defined as comprising coarse sediments with a diameter greater than 64 mm (cobbles and boulders) that provide a hard substratum. The relationship between the coarse material and sediment in which it lies is integral in determining 'reefiness'. Matrix (soft sediment) supported material is likely to have a patchier distribution than clast (coarse sediment) supported and so have lower 'reefiness', additionally matrix supported material is likely to have a larger infaunal component which again reduces its 'reefiness' (Irving, 2009). Reefs are also defined as having relief from the seafloor, and as such relief is used as another criterion for assessment. The epifaunal community of potential reef habitat is also a key determinant of its 'reefiness' and percentage cover of fauna is therefore included as an assessment criterion. Within the Irving (2009) scheme, areas of potential stony reef habitat must have an area of greater than 25 m^2 to be classified as reef; this report also adopts this minimum area.

Table 2-3: Measure of Geogenic (stony) 'Reefiness'

Measure of 'Reefiness'	Reef Category			
	NOT REEF	LOW	MEDIUM	HIGH
Composition Diameter of cobbles/boulders being greater than 64 mm. Percentage cover relates to a minimum area of 25 m^2. This 'composition' characteristic also includes 'patchiness'.	< 10 %	10 – 40 % Matrix supported	40 % - 95 %	>95 % Clast support ed
Elevation Minimum height (64 mm) relates to minimum size of constituent cobbles. This characteristic could also include 'distinctness' from the surrounding seabed. Note that two units (mm and m) are used here.	Flat seabed	< 64 mm	64 mm – 5 m	> 5 m
Extent	< 25 m^2	> 25 m^2		
Biota				> 80 % of

3 Results

The biotope map showing the extents and distribution of seabed habitats within the boundaries of the OfTI corridor is presented in Figure 3-1. A summary of the sediment types and epibenthic assemblages for each of different variants of each of the biotopes found is presented in Table 3-1. Figure 3-2 presents the distribution of the principal sediment types (gravel, sand and silt) throughout the OfTI corridor collected by the grab sampler during the site-specific benthic ecology survey (see Technical Appendix 4.1A).

Four habitats/biotopes were classified along the OfTI corridor although these often occurred both singly and as twinned mosaics. In addition, it was noted that some areas of the OfTI corridor comprised a dominant muddy sand substrate which was overlaid by veneers of coarser sand and gravelly sand of various thicknesses. This resulted in a patchwork or mosaic of sediment biotopes across some areas. From the video and stills images it appeared that the overlying deposits were transient and/or mobile, as indicated by the presence of coarse sediment ripples or waves lying over the finer sand substrata.

While it was possible to discern the coarser substrate from the finer substrate within the side scan sonar data, it was decided to map these as one unit in those places where they co-occurred. This not only facilitated the mapping process but also partitioned areas where habitat boundaries may be variable over time because of the influence of naturally mobile or transient sediments. Furthermore, the sediment composition of the biotopes varied along the length of the cable corridor, possibly in response to the differing influences of transient sediments in some places and differing quantities of shell material. These variations were detectable within the SSS data in places.

Despite apparent variations, all sediment and species associations were allocated to one of the four biotope classifications as follows;

- Level 3 main habitat SS.SSa (subtidal sands and muddy sand)
- Level 4 biotope complex SS.SMx.CMx (circalittoral mixed sediment)
- Level 5 Biotope SS.SMu.CFiMu.SpnMeg (seapens and burrowing megafauna in circalittoral fine mud)
- Level 6 Sub-biotope CR.MCR.EcCr.FaAlCr.Pom (faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately exposed circalittoral rock.

The main biotope (SS.SSa) and the biotope complex (SS.SMx.CMx) are broad classifications encapsulating a range of more detailed biotope types some of which may have been present within the study area at a finer spatial scale. For example, sediment conditions and associated epibenthos in some places supported the presence of the Level 5 biotope '*Flustra foliacea and Hydrallmania falcata on tide- swept circalittoral mixed sediment*', SS.SMx.CMx.FluHyd although the patchy distribution and generally low growth of the characterising species did not warrant separate mapping of this biotope. Similarly, the presence of tubes of the polychaetes worms *Owenia fusiformis* and *Lanice conchilega* within areas of sand may have indicated the presence of certain types of polychaete dominated biotopes.

The Level 5 SS.SMu.CFiMu.SpnMeg biotope is a detailed biotope describing '*Seapens and burrowing megafauna in circalittoral fine mud*'. It was attributed to the majority of the OfTI corridor below approximately the 50 m contour based on the widespread occurrence of 'sea-pen and burrowing megafauna communities' evident from the video and stills images.

Rather than the high levels of mud normally associated with this biotope, historic grab sampling along the OfTI corridor (see Technical Appendix 4.1 A of the ES) revealed a predominately slightly gravelly muddy sand sediment within the areas designated as SS.SMu.CFiMu.SpnMeg (Figure 3-2). On average, sand comprised 73% and mud comprised 27%. The geotechnical vibrocore campaign conducted at this time (Gardline, 2014) also indicated a predominately silty fine to medium sand within the area with varying proportions of broken shell gravel.

JNCC (2014) notes the there is no direct relationship between the habitat classification biotopes and 'sea pens with burrowing megafauna communities' because of the presence of gaps and variant biotope forms and that additional data, such as seabed imagery, would be required to classify potentially representative biotopes as this habitat. While it is acknowledged that a broader SS.SMu.CFiMu classification matched the observations made, the presence of a consistently highly bioturbated seabed with dense burrows and mounds together with characterising sea pen species such as *Virgularia mirabilis* and *Pennatula phosphorea*, seemed to warrant a more detailed definition. Furthermore, this biotope was allocated to similar areas of seabed at Beatrice (BOWL, 2012, 2013).

Referring back to the findings of the original benthic ecology study (see Technical Appendix 4.1A of the modified OfTI ES), and which has been reviewed and accepted by Marine Scotland, the presence of a comparatively sandy seabed was remarked upon but a SS.SMu.CFiMu.SpnMeg classification was allocated, nonetheless. Specifically, Technical Appendix 4.1A noted that;

"*when first encountered, the sea pen and burrowing megafauna community SS.SMu.CFiMu.SpnMeg occurred in the form of a coarse sediment variation of this biotope. SpnMeg was clearly indicated but the sedimentary conditions excluded the classical representation associated with Nephrops grounds. The main fauna noted were flat fish, gurnards, a few starfish and pagurid crabs. Hydroid/bryozoan turf of largely indefinable composition was scattered throughout. King scallop occurred sporadically. Of note was the abundance of the slender sea pen Virgularia mirabilis which was very evident and occurred frequently whilst only one phosphorescent sea pen Pennatula phosphorea was noted*".

Additionally, it is worth noting JNCC (2014) guidance on this matter which states that;

"The [sea pen and burrowing megafauna communities] habitat occurs predominately in fine mud sediments. However some examples of this habitat have been identified in areas of sandy muds. As such, where there is clear evidence of the relevant biological assemblages (burrowing megafauna and in some examples, sea-pens), such habitats can be classified as 'Sea-pen and burrowing megafauna communities' regardless of the grain size composition of the sediment"

Sediment composition notwithstanding, the SS.SMu.CFiMu.SpnMeg was used here to represent the sea pen and burrowing megafauna habitat which was clearly present within the OfTI corridor. This biotope is known to occur within the general area of the outer southern Moray Firth, as indicated by JNCC non-core records[1] (see http://jncc.defra.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001218), and previous benthic ecology investigations at the now consented Beatrice offshore wind farm

[1] While core records include those on which the biotope description has been based, non-core records represent other certain records where this biotope has been found (http://jncc.defra.gov.uk/page-3106).

have already allocated this biotope to large areas of adjacent seabed (BOWL, 2012; 2013). Thus, while it is possible that other classifications could also be applied to bioturbated seabed areas with sea pens and burrowing megafauna within the current OfTI corridor, the previous use and acceptance of the SS.SMu.CFIMu.SpnMeg in the locale and presence of JNCC non-core records would seem to suggest that it is an acceptable alternative to use on this occasion.

It is also worth considering that the SS.SMu.CFiMuSpnMeg biotope is a component of the 'burrowed mud' habitat which is a priority marine feature (PMF) in Scotland and which is one of a number of PMF's identified by the Scottish nature conservation agencies to help focus conservation action within Scotland's seas. Scottish records of the burrowed mud habitat are considered to be of international importance (Tyler-Watts et al, 2016). Burrowed mud is also a cited interest feature underpinning the proposed Southern Trench Marine Protected Area (MPA) and which is likely to be intersected by the current export cable route. The allocation of this biotope both here and the adjacent Beatrice development, thus serves to flag the likelihood of the presence a potentially significant habitat within planned development footprint and supports good practice in highlighting valued benthic receptors.

Given the wide spread distribution of this habitat type throughout the wider region, it will not be possible for the cable to avoid the area designated as SS.SMu.CFiMu.SpnMeg. However, any construction effects on the seabed are expected to only affect a very small proportion of total habitat available within the southern Moray Firth.

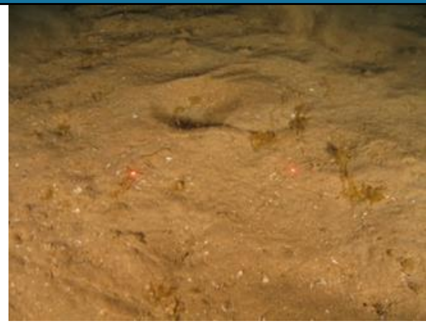
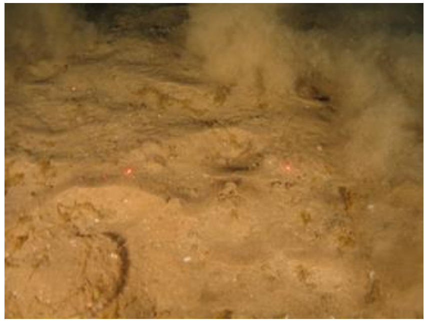
The CR.MCR.EcCr.FaAlCr.Pom biotope is also a detailed biotope describing '*Faunal and algal crusts with Pomatoceros triqueter and sparse Alcyonium digitatum on exposed to moderately wave-exposed circalittoral rock'*. It is illustrative of the Annex I (EC Habitats Directive 92/43/EEC) geogenic reef and includes areas of cobbles, boulders and rocky outcroppings. Matching the attributes of these habitats from the video with the criteria showed in the Table 2-3 suggested a low to medium resemblance with Annex I geogenic reef.

Within the acoustic datasets, the stony and rocky habitats were readily identifiable as areas of particularly dark and variable reflectivity and were topographically distinct from the surrounding sand seabed area allowing confident mapping of reef boundaries.

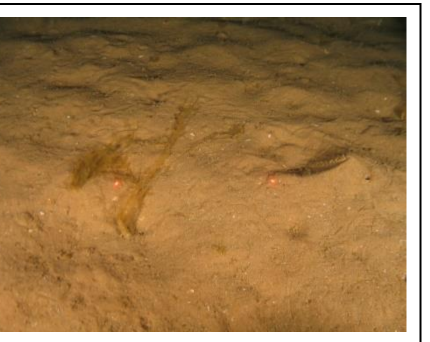
The data showed that hard stony and rock habitats were limited in distribution within the cable corridor and only occurred as a relatively small discrete area located close to the shore at the cable landfall site at Inverboyndie. Nonetheless, JNCC online mapping of potential reef across the wider Moray Fifth http://jncc.defra.gov.uk/default.aspx?page=5201&LAYERS=Reef_All,TwelveTS,UKCS shows that much of the adjacent Moray comprises stony and bedrock and stony reef and it is likely that the local feature within the cable corridor is contiguous with the wider rock and stony reef within the region.

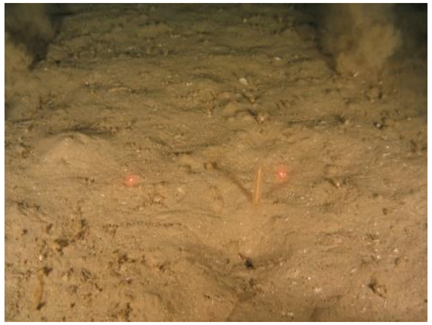
Moray Offshore Windfarm (East) Limited Export Cable Route Biotope Assessment

Table 3-1. Biotope classifications and summary epibenthic species and sediment descriptions

Biotope	Sediment and Fauna Description	Species	Representative Images
Biotope SS.SSa (Variant 1) (Offshore Area) Sublittoral sand and muddy sands.	**Sediment Description** Slightly shelly, slightly muddy sand. Small holes or burrows in the seabed were regularly recorded across the area of habitat. Fauna within them were not evident. Small areas of dense and coarse shelly sand forming sand ripples with coarse shell aggregations in the troughs were noted. **Fauna** Fauna included Pagurid crabs, and fish including gurnards, thick backed sole, flat fish, (often plaice), and gadiform fish. Occasional King scallops (*Pecten maximus*) and small numbers of starfish were also seen. Mixed hydroid/bryozoan turfs and the erect bryozoan *Flustra foliacea* were rarely observed and were confined to the small amounts of slightly coarser sediment present. Across the habitat area a gelatinous, filamentous substance, believed to be a diatomaceous floc was observed. It occurred as small oozes from the sediment and formed long filaments. At times, it was observed as a coating on other hydroid/bryozoan growths.	*Alcyonidium diaphanum* *Alcyonium digitatum* *Asterias rubens* Asteroidea Callionymidae *Chaetopterus* tubes Decapoda Diatomaceous aggregation *Flustra foliacea* Gadiformes Hydroid/Bryozoan mixed substrate Inachinae *Luidia ciliaris* *Microchirus variegatus* Paguridae *Pecten maximus* PLEURONECTIFORMES Triglidae	  

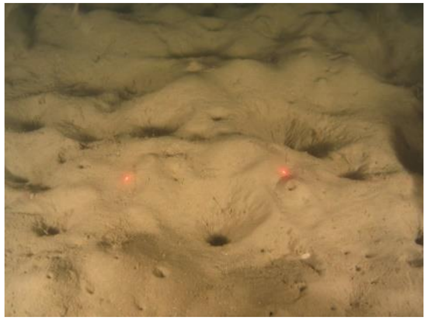
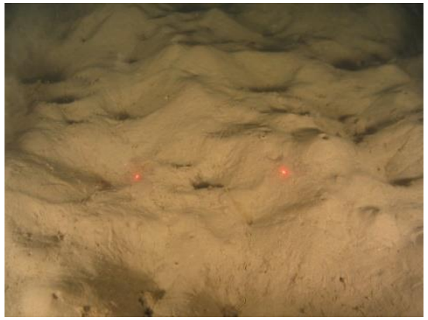
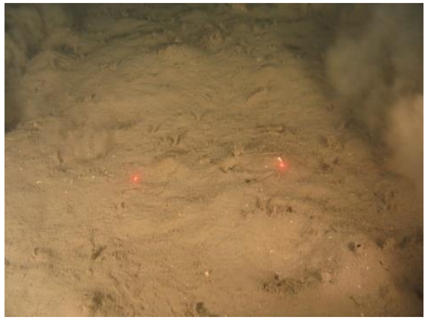
SS.SSa with SS.SMx.CMx (Variant 1) Sublittoral sand and muddy sands with circalittoral mixed sediment. (Offshore Area) An additional biotope FluHyd may be appropriate to classify the biotope in some areas.	Slightly shelly, slightly muddy rippled sand. Sediment ripples comprising coarse shelly sand occurred across the habitat area with mixed gravel, pebbles and cobbles present within the troughs between sediment ripples. Areas of coarse mixed sediment supported sessile epifauna comprising foliose hydroids and bryozoans. Small holes and small burrows within the seabed sediment were recorded across the area. **Fauna** The fauna comprised pagurid crabs, a few small crabs (notably *Liocarcinus*) and flat fish including plaice and thick backed sole. A variety of starfish were distributed across the area. The foliose hydroid/bryozoan turf including *Flustra* and *Hydrallmania* were largely concentrated on the areas of coarse mixed sediment. A rare occurrence of the anemone *Metridium senile* was seen on a large cobble. King scallops (*Pecten maximus*) were more notable across both the sandy and coarser sediments of the site. One gadoid fish was seen, potentially hake. **Note** Area noted for sand eels (Ammodytidae). WGS84 Degminsdecmins 58 09.2191N, 002 40.8778W To 58 09.2923N, 002 40.8623W Area with noted greater density of King scallops (*Pecten maximus*) 58 09.4445N, 002 40.8467W	?*Pleuronectes platessa* ?*Thuiaria thuja* *Alcyonium digitatum* Ammodytidae *Aphrodita aculeata* *Asterias rubens* ASTEROIDEA *Astropecten irregularis* *Buccinum undatum* Callionymidae *Cancer pagurus* CARIDEA *Chaetopterus* tubes *Crossaster papposus* DECAPODA (?*Liocarcinus*.) *Tubularia indivisa* *Echinus esculentus* *Flustra foliacea* Gadiformes *Hydrallmania falcata* Hydroid/Bryozoan mixed substrate *Liocarcinus* *Luidia sarsi* *Metridium senile* *Microchirus variegatus* *Ophiura ophiura* Paguridae *Pecten maximus* PLEURONECTIFORMES Plumulariidae *Securiflustra securifrons* *Spirobranchus* Triglidae *Trisopterus lamarkii*	  

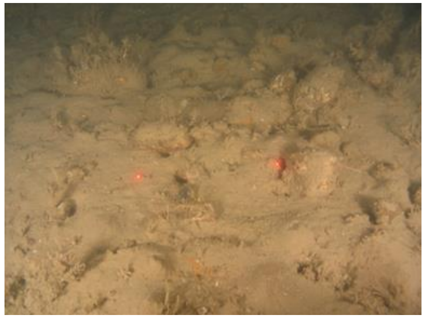
Biotope SS.SSa (Variant 2) Sublittoral sand and muddy sands	**Sediment Description** Slightly shelly, slightly muddy rippled sand. Coarse shelly sand waves occurred overlaid the area in places. Broken shell hash and a few pebbles were noted within the troughs between the sand waves. Small holes and small burrows were present across the area. **Fauna** The main fauna noted were occasional flat fish, gurnards, one gadiform fish, occasional starfish and pagurid crabs. Mixed hydroid/bryozoan turfs were frequently observed on areas of coarse sediment throughout the habitat area. One brittlestar (*Ophiura ophiura*) and one sea mouse (*Aphrodita*) was observed. The potential diatomaceous floc material was present across both sand and coarse sand wave areas.	?*Pleuronectes platessa* *Aphrodita aculeata* *Asterias rubens* *Astropecten irregularis* Callionymidae *Flustra foliacea* Gadiformes *Hydrallmania falcata* Hydroid/Bryozoan mixed substrate *Liocarcinus* *Microchirus variegatus* *Ophiura ophiura* Paguridae *Pecten maximus* Pectinidae PLEURONECTIFORMES Triglidae	 

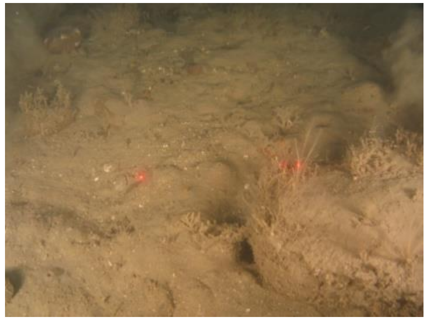
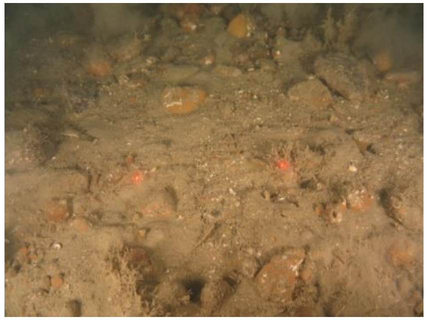
Biotope SS.SMu.CFiMu.SpnMeg (Variant 1) Seapens and burrowing megafauna in circalittoral fine mud	**Sediment Description** Slightly shelly, slightly muddy rippled sand. Small holes and small burrows present across the habitat area. Larger fractions of shell hash visible in places. **Fauna** The main fauna noted were flat fish, gurnards, a few starfish and pagurid crabs. Hydroid/bryozoan turfs were occasionally recorded throughout the habitat. One *Ophiura ophiura* was seen. King scallops (*Pecten maximus*) occurred sporadically. The diatomaceous floc was present across the area. The seapen *Virgularia mirabilis* occurred frequently. Only one individual of *Pennatula phosphorea* seapen was noted.	*Alcyonium digitatum* *Asterias rubens* *Astropecten irregularis* Callionymidae *Chaetopterus* tubes Diatomaceous aggregation Echinoidea *Henricia* Hydroid/Bryozoan mixed substrate *Ophiura ophiura* Paguridae *Pecten maximus* *Pennatula phosphorea* PLEURONECTIFORMES Triglidae *Virgularia mirabilis*	 

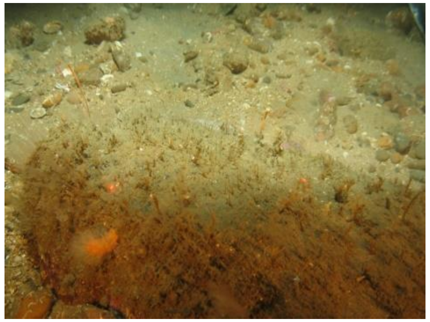
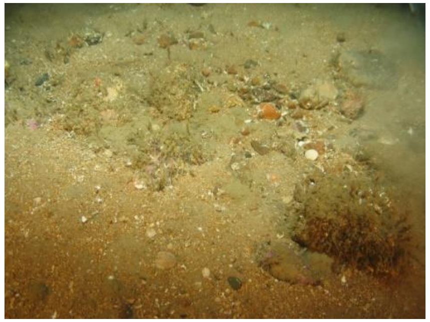
Biotope	**Sediment Description**		
SS.SSa with SS.SMx.CMx (Variant 2) Sublittoral sand and muddy sands with Circalittoral mixed sediment. CMx, forming waves, dominated the area. Some support for the additional FluHyd allocation in places. Although biotope already allocated in the offshore area, kept separate here due to denser coarse waves rather than coarse sediment patches.	The habitat area was dominated by coarse mixed sediment forming small to approx. 0.5m high coarse gravelly shelly sand waves in places. Large broken shell hash and gravel and pebbles deposits occurred within the troughs between the sand waves. One small boulder seen. The habitat was also interspersed with slightly shelly, slightly muddy rippled sand. Small holes and small burrows were recorded throughout the habitat. **Fauna** The main fauna noted were hydroid/bryozoan turf, including *Flustra*, *Sertularia*, *Abietinaria* and potentially *Thuiaria thuja*. Flat fish, a few starfish and pagurid crabs were evident, along with the round crab *Atelecyclus rotundatus*. *Munida rugosa* was occasionally seen in the coarse sediment. One *Ophiura ophiura* was noted. *Pecten maximus* occurred relatively regularly throughout. Note. *Pecten maximus* noted in higher density in this area.	?*Abietinaria abietina* ?*Thuiaria thuja* *Asterias rubens* *Atelecyclus rotundatus* Bryozoa crust Callionymidae Diatomaceous aggregation *Flustra foliacea* Gadiformes Hydroid/Bryozoan mixed substrate *Luidia ciliaris* *Munida rugosa* *Ophiura ophiura* Paguridae *Pecten maximus* PLEURONECTIFORMES *Sertularia* *Spirobranchus* *Trisopterus lamarkii* *Urticina*	 

Biotope SS.SMx.CMx (Variant 1) Circalittoral mixed sediment. Some support for the additional FluHyd allocation in places.	**Sediment Description** This habitat type was dominated by coarse mixed sediment forming small to approx. 0.5m high coarse gravelly shelly sand waves in places. Large shell hash and gravelly pebbles deposited within the recesses with the occasional cobble. One small boulder seen. **Fauna** The main fauna noted were foliose hydroid/bryozoan turf, including *Flustra*, and *Sertularia*. A few starfish and pagurid crabs were evident, along with *Munida rugosa* which was occasionally seen in the coarse sediment. One *Ophiura ophiura* was noted. *Pecten maximus* occurred rarely.	*Agonus cataphractus* *Alcyonium digitatum* Buccinidae Callionymidae *Flustra foliacea* Hydroid/Bryozoan mixed substrate *Luidia sarsi* *Munida rugosa* *Ophiura ophiura* Paguridae *Pecten maximus* *Sertularia*	 

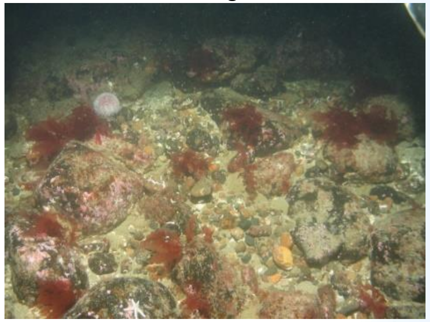
Biotope SS.SMu.CFiMu.SpnMeg (Variant 2) Seapens and burrowing megafauna in circalittoral fine mud Note that in the more southerly areas of the cable route, the burrowed mud habitat supported occasional hydroids, *Tubularia*.	**Sediment Description** This habitat was characterized by a muddy fine sand sediment with numerous burrows, sediment mounds and holes indicating and area of active bioturbation. In some areas, a low lying form was observed comprising a relatively even seabed surface with small burrows, small mounds and holes. While bioturbation activity was evident it was not as deep or dense as other areas. The occasional small boulder, and area of coarser sediment, with a few cobbles, and mixed pebbles and shell hash were recorded in places. **Fauna** Burrowing megafauna evident, including the sea pen *Pennatula phosphorea* and in some areas, *Virgularia mirabilis*. *Nephrops* norvegicus was sporadically seen in the video. Flat fish were also present, and a few starfish were recorded including *Anseropoda placenta*. Pagurid crabs and the occasional Decapod (?*Liocarcinus*) also noted. Gurnards, small gadoid fish and brow crab (*Cancer pagurus)* were also observed. In the low-lying form of the biotope, burrowing megafauna included the seapen *Pennatula phosphorea*. Flat fish and a few starfish were also seen, as well as a few large King scallops. The coarser substrate had denser aggregations of hydroid/bryozoan turf, and a very small amount of *Tubularia indivisa*. Boulders supporting *Metridium senile* were present. Sediment with small polychaete tubes forming a 'mat', believed to be Oweniidae, were occasionally recorded**.**	?*Echinocardium cordatum Anguilla anguilla/Myxine glutinosa* *Anseropoda placenta Asterias rubens* ASTEROIDEA Asteroidea (?*Leptasterias muelleri*) *Astropecten irregularis* Callionymidae *Cancer pagurus* *Chaetopterus* tubes DECAPODA (?*Liocarcinus*) Gadiformes Gobiidae Henricia Hydroid/Bryozoan mixed substrate *Liocarcinus* *Lumpenus lampretaeformis* *M.merlangus* or *T.minutus* Majoidea *Nephrops norvegicus Ophiura ophiura* Paguridae *Pennatula phosphorea* PLEURONECTIFORMES Triglidae *Tubularia indivisa* *Virgularia mirabilis* **low lying and coarser area** *Asterias rubens* Asteroidea (*Asterias* or ?*Leptasterias muelleri*) Callionymidae *Ceramaster/Hippasteria*	  

		Echinus esculentus Hydroid/Bryozoan mixed substrate *Lanice conchilega* *Metridium senile* *Munida rugosa* Paguridae *Pecten maximus* *Pennatula phosphorea* PLEURONECTIFORMES *Porania pulvillus* Tubes in Sediment (Oweniidae) *Tubularia indivisa*	

Biotope SS.SMx.CMx Within SS.SMu.CFiMu.SpnMeg Circalittoral mixed sediment. within Sea pens and burrowing megafauna in circalittoral fine mud There may be some support for the additional FluHyd allocation in places.	**Sediment Description** Low lying, relatively even sandy mud/muddy sand with small burrows, small mounds and holes. Bioturbation evident but not as deep or dense as areas more suited to *Nephrops norvegicus*. Within this area, large sections of coarse mixed sediment with boulders and cobbles occurred. **Fauna** Burrowing megafauna evident in the softer sediment. The coarse section was dominated by hydroid/bryozoan turfs, small amounts of *Tubularia indivisa,* and common *Munida rugosa* under the boulders and cobbles. Occasional *Echinus esculentus* and a few *Pecten maximus* seen. One *Cancer pagurus* seen.	*Cancer pagurus* *Ceramaster/Hippasteria* *Echinus esculentus* *Hydrallmania falcata* Hydroid/Bryozoan mixed substrate *Munida rugosa* *Nemertesia* *ramosa Pecten* *maximus* *Sertularia* Spirobranchus *Tubularia indivisa*	  

Biotope SS.SMx.CMx (Variant 2) Circalittoral mixed sediment. Fauna not considered dense enough to support the additional allocation of FluHyd.	**Sediment Description** Area of hard ground, potentially bedrock in places. Area over-laid with a very coarse mixture of shelly sandy, gravelly pebbly cobble matrix with the occasional boulder. A thin covering of mobile sand of varying depths evident over the hard ground. **Fauna** Fauna largely comprised of coralline algae and bryozoan crusts with sparse outcrops of foliose hydroid/bryozoan turf including *Flustra foliacea* and Plumulariidae, with rare *Tubularia indivisa*. Very small outcrops of *Alcyonium digitatum* were present, and rare *Echinus esculentus*. Lots of *Munida rugosa* were present under the boulders and cobbles, with small crabs such as *Liocarcinus* evident. Occasionally a large edible crab, *Cancer pagurus* was seen and a very occasional *Pecten maximus*. Small starfish were scattered across the area. Debris of fishing ropes present.	*Alcyonium digitatum Asterias rubens* ASTEROIDEA Bryozoa crust *Cancer pagurus* Corallinaceae *Echinus esculentus* *Flustra foliacea* Hydroid/Bryozoan mixed substrate *Liocarcinus* *Metridium senile Munida rugosa* Paguridae *Pecten maximus* Plumulariidae *Sabella* tube *Spirobranchus* *Tubularia indivisa* *Urticina*	 

Biotope SS.SMx.CMx with SS.SSa (Variant 3) Circalittoral mixed sediment with Sublittoral sand and muddy sands Fauna not considered dense enough to support the additional allocation of FluHyd. Small areas could potentially be called an impoverished form.	**Sediment Description** This variant habitat type comprised hard ground in places, over- laid with a very coarse mixture of shelly sand, gravel, pebbles and cobble with a few boulders in places. A thin covering of mobile sand of varying thicknesses present overlaying the hard ground. In places, extensive patches of rippled sand occurred, before returning to coarse mixed sediment. In places and particularly further offshore, the sand became coarser and thicker in some areas, forming coarse sand waves with large shell debris within the wave troughs. **Fauna** The coarse ground supported sparse hydroid/bryozoan turf with a few starfish, small amounts of the soft coral *Alcyonium digitatum*, *Tubularia indivisa*, and *Urticina.* Boulders were particularly covered in dense hydroid/bryozoan turf, with large clusters of *Flustra foliacea*. *Munida rugosa* were regularly seen across the area under the coarser sediment. *Pecten maximus* and the occasional *Cancer pagurus* were often seen. In some of the patches of sand, *Lanice conchilega* tubes were present together with smaller tubes believed to be of the family Oweniidae. In the deeper coarser sand waves, sand eels were often recorded.	?*Omalosecosa ramulosa* *Agonus cataphractus* *Alcyonium digitatum* Ammodytidae Bryozoa crust Callionymidae *Cancer pagurus* *Chaetopterus* tubes *Crossaster papposus* DECAPODA (?*Liocarcinus*) *Echinus esculentus* *Flustra foliacea* Gobiidae *Henricia* Hydroid/Bryozoan mixed substrate *Lanice conchilega* *Liocarcinus* *Metridium senile* *Munida rugosa* Paguridae *Pecten maximus* PLEURONECTIFORMES Plumulariidae *Porania pulvillus* PORIFERA *Spirobranchus* Triglidae *Trisopterus esmarkii* Tubes in Sediment (Oweniidae) *Tubularia indivisa* *Urticina*	Lanice and Oweniidae  Coarse mixed sediment  

Biotope Inshore Sand SS.SSa (Variant 3) Sublittoral sand and muddy sands. Bedrock and boulder reef with algae CR.MCR.EcCr.FaAlCr.Pom (sheltered inshore variant) Bedrock and boulder reef CR.MCR.EcCr.FaAlCr.Pom Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock	**Sediment Description** Inshore area a rippled sand with a few holes, with a biofilm evident across the area. From the inshore sand, the area gradually became a bedrock and boulder reef, with a small outcrop of rock with the brown alga *Saccharina latissima* and long foliose red and brown algal fronds. Where the reef became more established, only foliose red algal fronds remained, ?*Delesseria sanguinea*, before the alga cover reduced completely. The area then became a bedrock, boulder and cobble reef, undulating and rising to around 1 to 2.0m approx. in height at its greatest point. A cobble, pebble and gravelly sand matrix evident within the recesses in places. There were small areas where a thin film of sediment was evident on the hard rock surfaces. **Fauna** Only a few flat fish were evident on the inner shore sand area. The areas of bedrock and boulder reef were covered by a brown algal crust with red coralline algae and bryozoan crusts. *Spirobranchus* worm tubes were frequently observed. The urchin *Echinus esculentus* occurred commonly across the area, along with a frequent presence of the soft coral *Alcyonium digitatum*. Small starfish (Asteroidea) were also recorded frequently noticeable, probably *Asterias rubens* but confirmation difficult. *Crossaster papposus* also occurred commonly. *Cancer pagurus* was noted occasionally.	**Sand** ASTEROIDEA PLEURONECTIFORMES Biofilm **Algae additions to reef** *Saccharina latissima* ?*Delesseria sanguinea* Red and brown algal turf - long **Reef** ?*Abietinaria abietina* Hydroid/Bryozoan turfs *Alcyonium digitatum Urticina* *Metridium senile* *Spirobranchus Munida* *rugosa Cancer pagurus* *Gibbula* Bryozoa crust ASTEROIDEA *Marthasterias glacialis* *Crossaster papposus Echinus* *esculentus* Labridae Corallinaceae Encrusting brown algae	Inshore sand with biofilm  Reef with algae  

			Reef 

Biotope SS.SSa (Variant 4) Sublittoral sand and muddy sands.	**Sediment Description** Rippled sand with a few holes, becoming gradually coarser further offshore. Ripples becoming more mixed and larger in form. **Fauna** A few starfish are scattered across the area, with large pagurid crabs, a few flat fish and a few gadoid fish in places. One monkfish seen. As the sand became coarser, sand eel activity became more apparent.	DECAPODA (?*Liocarcinus*) Paguridae *Cancer pagurus* *Astropecten irregularis* ASTEROIDEA *Lophius piscatorius* Ammodytidae Gadiformes Gobiidae PLEURONECTIFORMES	

4 Discussion and Conclusions

Seabed video and photographic stills images are frequently used to ground truth geophysical datasets for the purposes of segmenting areas of seabed into distinct benthic habitat types. Here, the technique has been successfully employed to discriminate between soft sediment, coarse mixed sediment and hard seabed substrate types throughout the export cable corridor and to classify and map these according to the UK biotope classification system.

Overall, there was good agreement between the seabed images and the interpretation of the geophysical data despite these datasets being collected at different times. Soft sediment areas corresponded with low reflectivity acoustic regions while coarser and hard seabed types matched heterogeneous high reflectivity signatures.

Marine Scotland digital national maps (NMPi)[2] and EU SeaMap 2[3] online map data classify the marine sediments between the Moray offshore wind fam and the planned export cable landfall site at Inverboyndie as offshore deep circalittoral sand with deep circalittoral mud and circalittoral and infralittoral coarse sediments occurring closer inshore. Nearshore and coastal habitats are dominated by high and moderate energy rock interspersed by areas of littoral sand and sandy embayments. These classifications align with the subtidal sands and muddy sands, bedrock and boulder reefs, circalittoral mixed sediments and burrowed mud habitats classified during the current study. The different types of seabed habitats identified from the video and stills images were thus readily discriminated within the acoustic data allowing for confident interpolation and attribution of those seabed areas which were not represented by video data.

As explained in the initial benthic ecology survey (see Technical Appendix 4.1A) benthic studies within the Moray Firth have typically focused on the Smith Bank and the Beatrice Field (Eleftheriou *et al*., 2004). The communities studied on the Smith Bank and Beatrice field have shown considerable persistence in the medium term (Eleftheriou *et al*., 2004). This suggests relatively stable environments.

Samples of medium to coarse sands taken just north-east of the Beatrice oilfield for the Jacky oilfield development (Ithaca Energy, 2008) were mostly dominated by *S. bombyx*, *T. pygmaea*, *C. pratenue* and *E. pusillus*. Two stations with high proportions of gravel and pebbles were dominated by epifaunal species such as *G. intermedia* and *L. asellus*.

In their analysis of the North Sea Benthos Project 2000 data, Rees *et al*. 2007 grouped sites in the Moray Firth with those in the central and northern North Sea at depths > 50 m (mean depth of 96 m). These sites were composed of muddy sand and fine sand and had *Myriochele* sp., *A. filiformis* and *Spiophanes* spp. as the dominant fauna (Rees *et al.*, 2007; Reiss *et al.*, 2009).

Beatrice Offshore Wind Ltd (BOWL) undertook a comparable cable route video survey just over 20 km west of the proposed corridor as part of the EIA investigations and development application for the Beatrice Offshore Wind Farm (BOWL, 2012 and 2013). This also found burrowed mud and fine-medium sand with shell fragments. In the offshore area, the burrowed mud habitat, although with a low density of sea pens, was identified as the biotope SS.SMu.CFiMu.SpnMeg - Sea pens and burrowing megafauna in circalittoral. Inshore areas were mainly fine-medium sands and gravels with small patches of cobble reef. This area was considered to be a fairly rich example of the biotope SS.SCS.CCS.PomB *Pomatoceros triqueter* with barnacles, coralline algae and bryozoan crusts on unstable circalittoral cobbles and pebbles. It was noted that the biotope may be considered as being potential Annex I cobble reef (Irving, 2009). The sublittoral area closest to the shore was recorded as being composed very clean fine sand with no visible epifauna.

[2] https://marinescotland.atkinsgeospatial.com/nmpi/
[3] https://www.emodnet-seabedhabitats.eu/access-data/

The OSPAR Threatened and Declining (T&D) habitat 'Sea-pen and burrowing megafauna communities' has been found across the southern half of the Moray Firth. This habitat broadly equates to the burrowed mud MPA search feature. Burrowed mud extends across the southern half of the Moray Firth and as such is likely to intersect with the cable route. The biotope 'Seapens and burrowing megafauna in circalittoral soft mud' SS.SMu.CFiMu.SpnMeg (Connor *et al*., 2004) is considered a component of both the OSPAR T&D and PMF "burrowed mud" habitat features. Furthermore, Greathead *et al.* (2007) have maps showing the location of seapens around Scotland with both *Pennatula phosphorea* and *Virgularia mirabilis* found at various locations in the Moray Firth.

While the habitats and biotopes found within the export cable corridor are generally common at both regional and national scales, the SS.SMu.CFiMu.SpnMeg and CR.MCR.EcCr.FaAlCr.Pom biotopes are nonetheless representative of valued benthic features in Scotland. The SpnMeg biotope was allocated to the majority of offshore areas of the OfTI corridor below the 50 m contour. This biotope is likely to form part of the extensive '*burrowed mud'* habitat known to occur throughout the southern Moray Firth. The FaAlCr.Pom biotope, on the other hand, was comparatively restricted in its distribution, and was found only within the shallow inshore waters close to the landfall site at Inverdoyndie. However, it is likely to be contiguous with the coastal rocky habitats found throughout the southern Moray Firth.

In conclusion, current observations of subtidal mixed coarse sediments and muddy sand sediments appear to match historic records for this area. Two broad habitats and two detailed biotopes have been classified and mapped using acoustic and seabed video data. The two detailed biotopes are indicative of valued seabed features including a Scottish PMF and an Annex I (EC Habitats Directive) habitat. The biotope map and associated GIS layers showing the extents of these biotope boundaries are presented to inform the final CaP and meet the benthic ecological monitoring requirements as described in the PEMP.

5 References

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Beatrice Offshore Wind Ltd (BOWL) 2013. *Beatrice offshore wind farm Environmental Statement Addendum*

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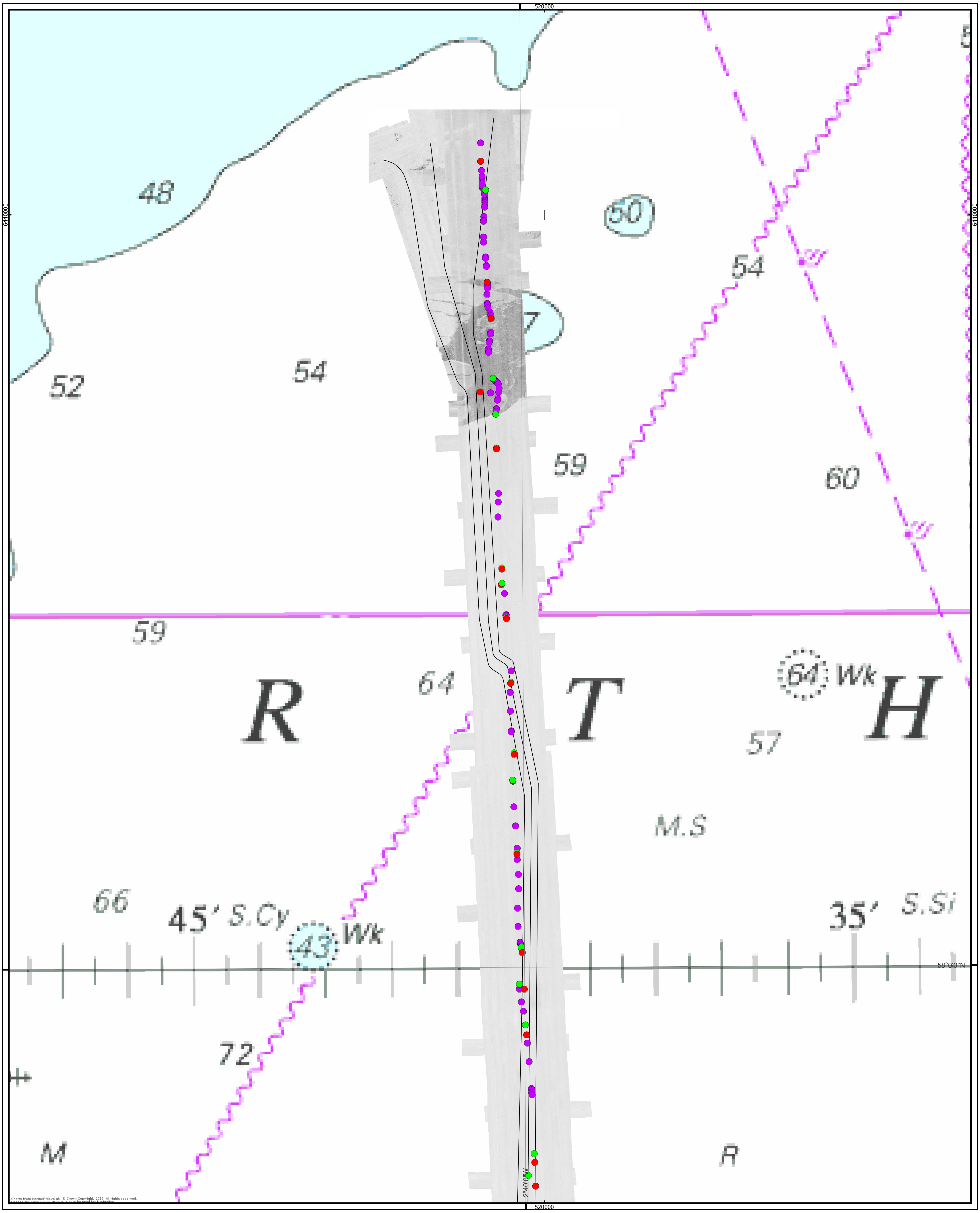
FIGURES



MORAY EAST
OFFSHORE WINDFARM

KEY

- Still Camera Location

Video Transect

- Start of Line
- End of Line
- Primary Export Cable Route

Geodetic Parameters: WGS84 UTM Zone 30N

Horizontal Scale: 1:50,000 A3 Chart

0 500 1,000 1,500 Meters

Produced: TN
Reviewed: JB
Approved: PE

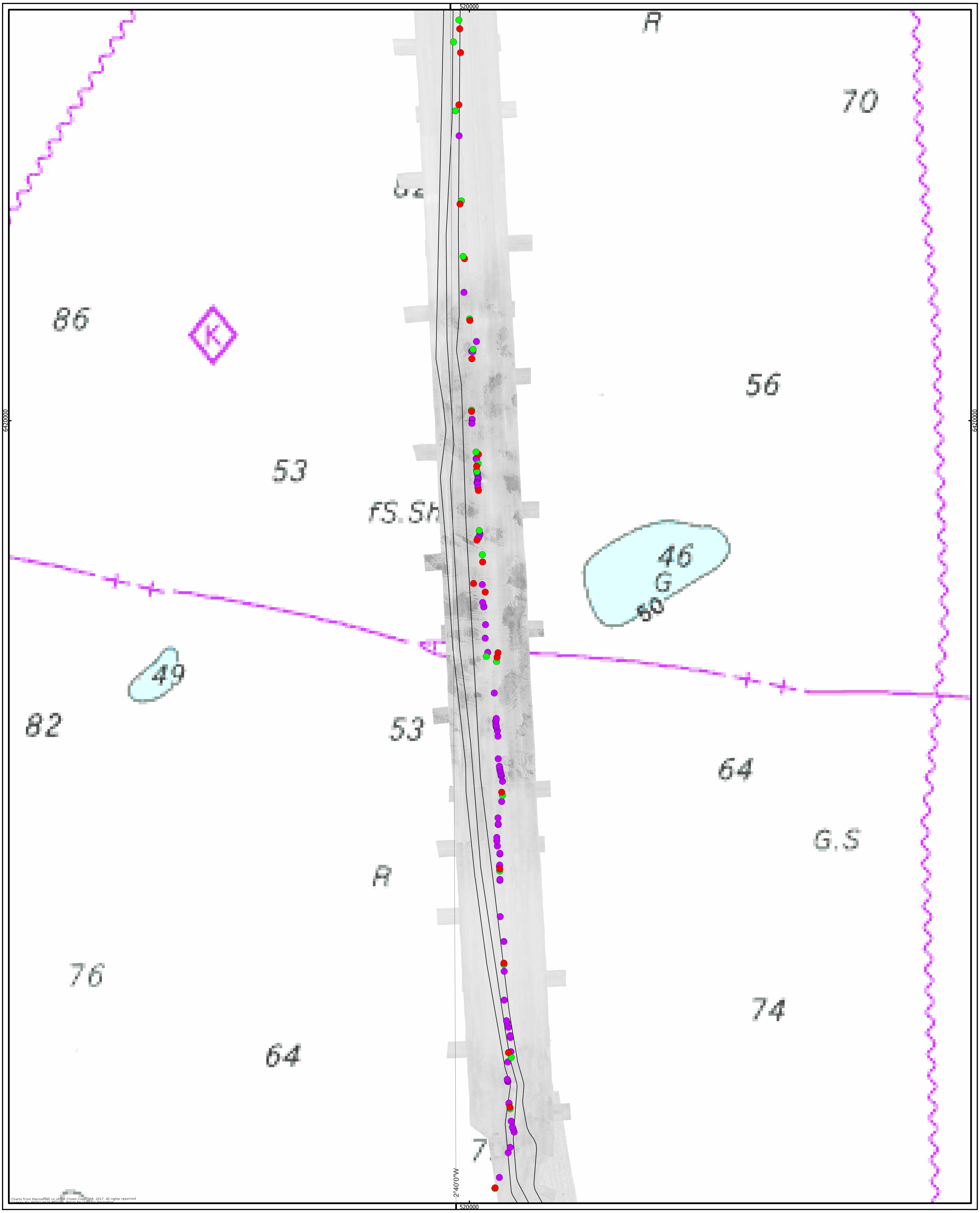
Date: 11/09/2018 | Revision: A

REF: 8460001-AAA0000-AAA-AAA-001

Figure 2-1 Sidescan Sonar Mosaic

Chart: 3 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

KEY

- Still Camera Location

Video Transect

- Start of Line
- End of Line
- Primary Export Cable Route

Geodetic Parameters: WGS84 UTM Zone 30N

Horizontal Scale: 1:50,000 A3 Chart

0 500 1,000 1,500 Meters

N

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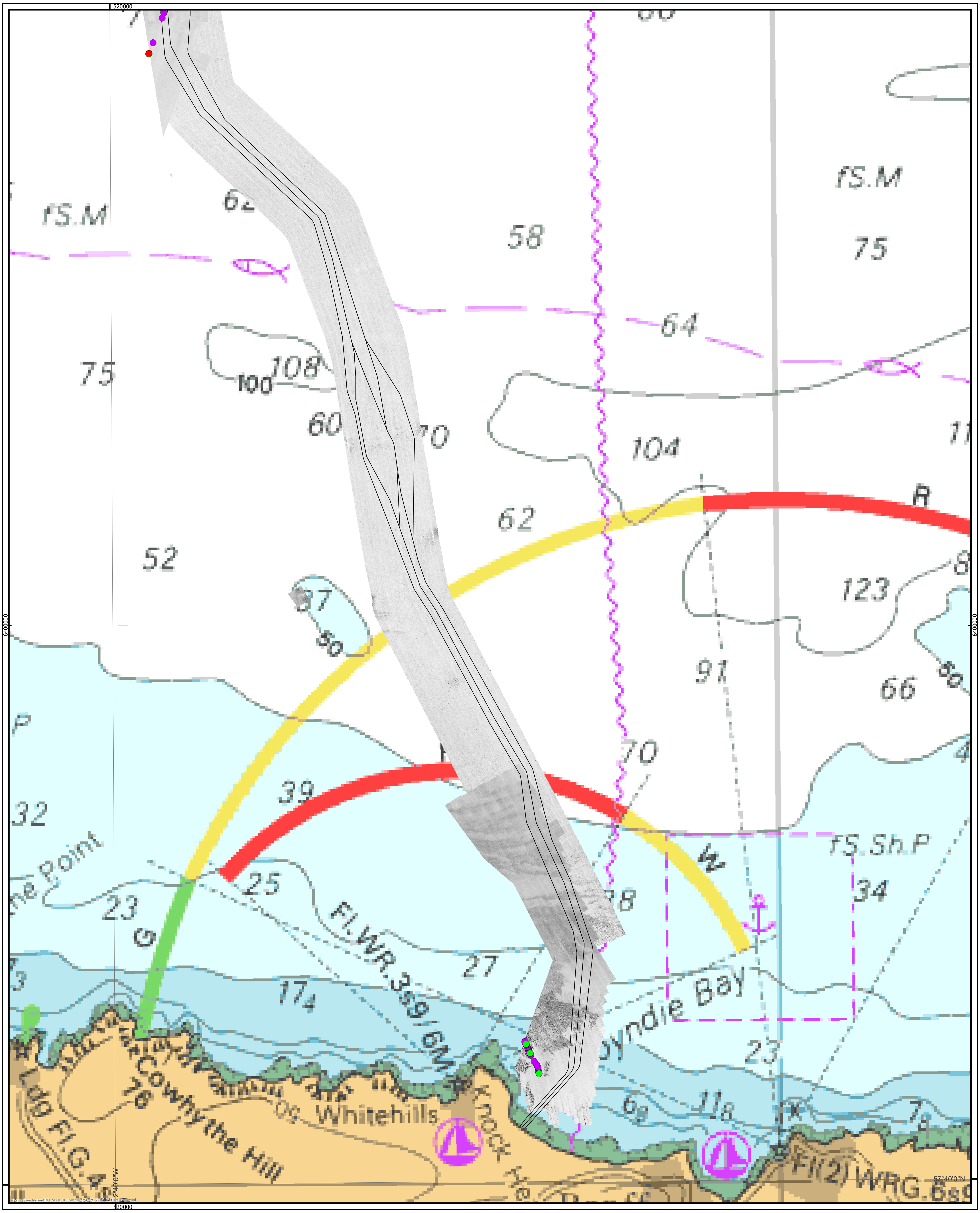
Date: 11/09/2018 | Revision: A

REF: 8460001-AAA0000-AAA-AAA-001

Figure 2-1 Sidescan Sonar Mosaic

Chart: 2 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST OFFSHORE WINDFARM

KEY

- Still Camera Location

Video Transect

- Start of Line
- End of Line
- Primary Export Cable Route

Geodetic Parameters: WGS84 UTM Zone 30N

Horizontal Scale: 1:50,000 A3 Chart

0 500 1,000 1,500 Meters

Produced: TN
Reviewed: JB
Approved: PE

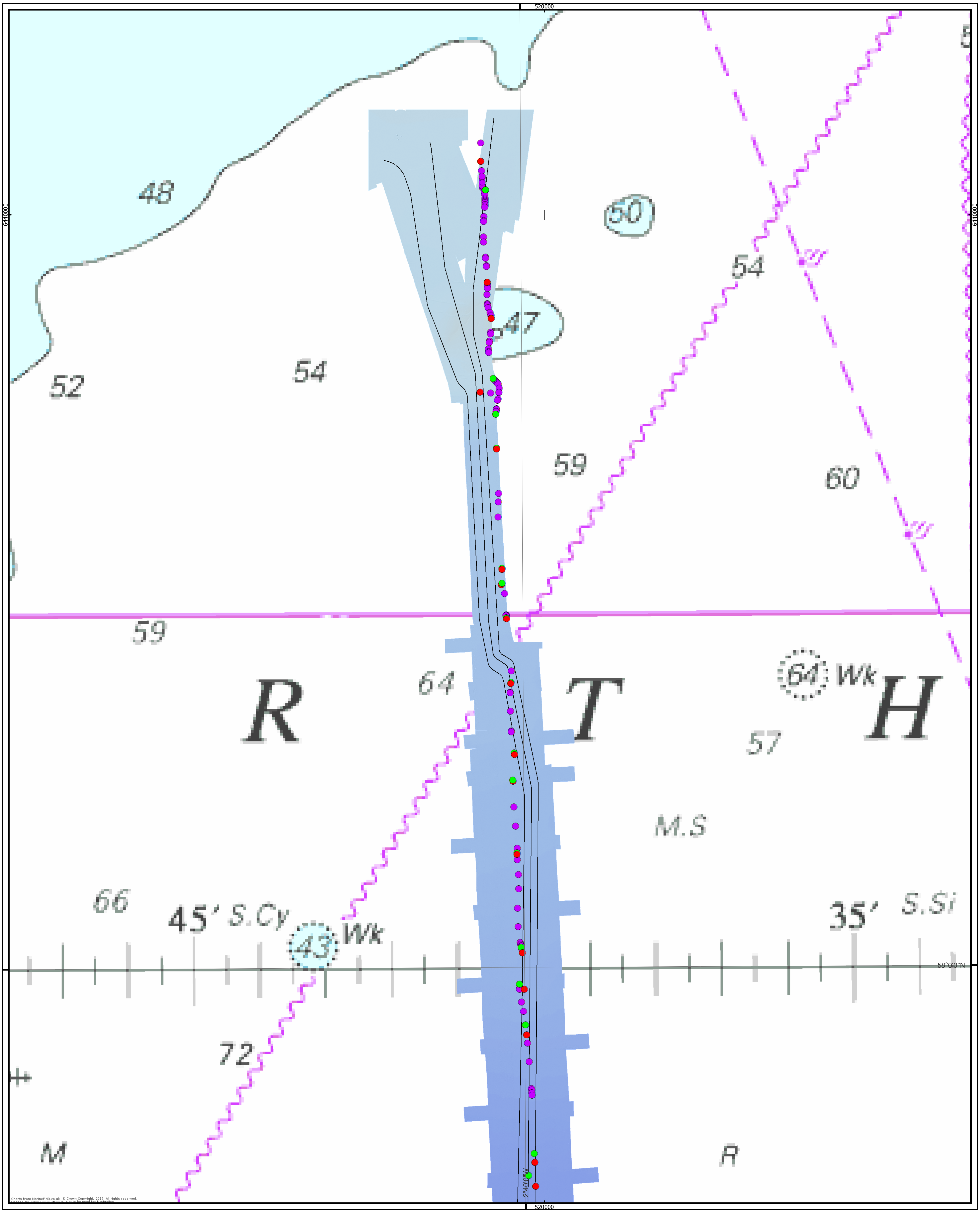
Date: 11/09/2018 | Revision: A

REF: 8460001-AAA0000-AAA-AAA-001

Figure 2-1 Sidescan Sonar Mosaic

Chart: 1 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters

KEY

- Still Camera Location

Video Transect

- Start of Line
- End of Line
- Primary Export Cable Route

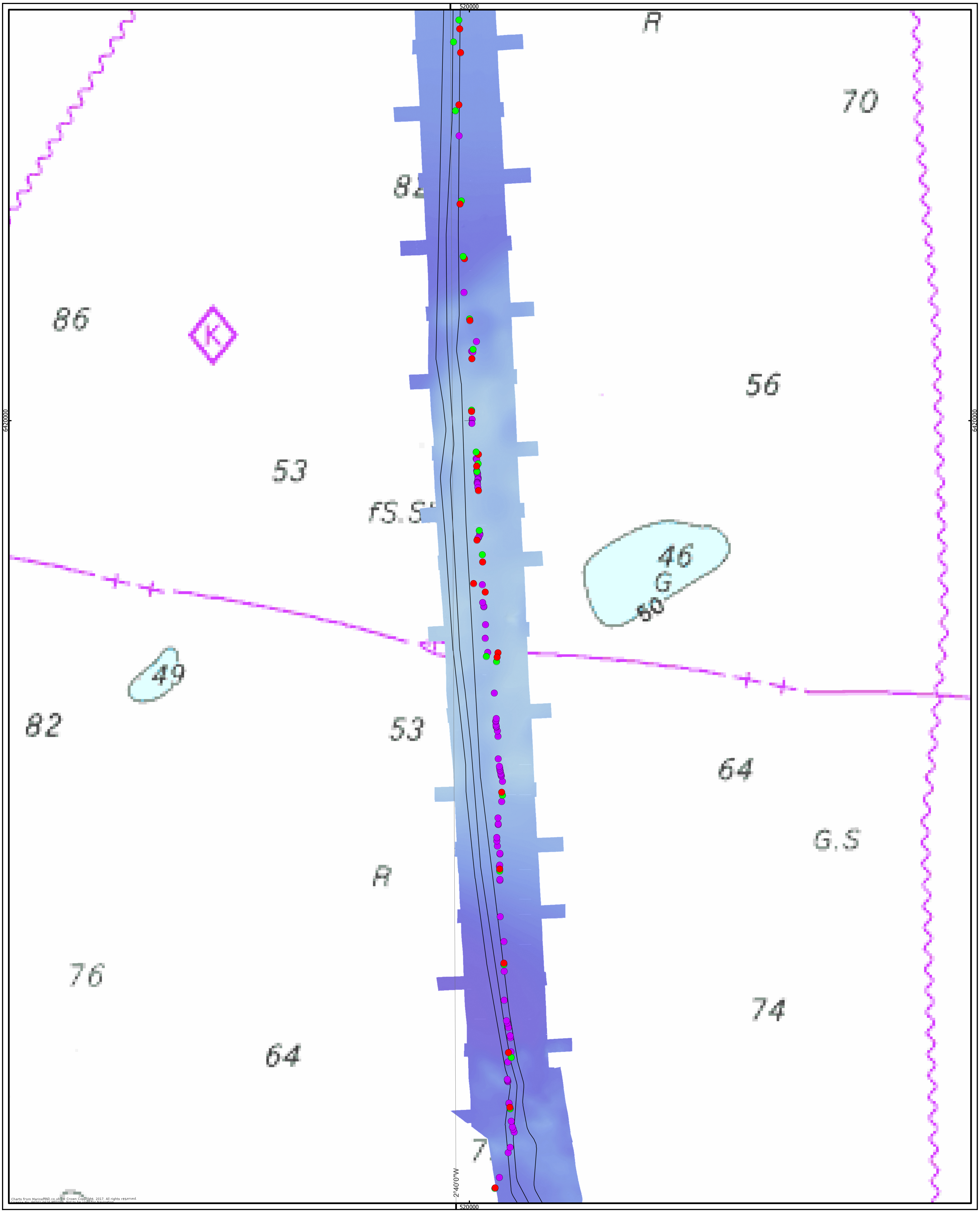
Water Depth [m below MSL]
High : 106.5
Low : -1.3

Produced: TN
Reviewed: JB
Approved: PE

Date: 11/09/2018 | Revision: A
REF: 8460001-AAA0000-AAA-AAA-002

Figure 2-2 Bathymetry
Chart: 3 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters
N

KEY

- Still Camera Location

Video Transect

- Start of Line
- End of Line
- Primary Export Cable Route

Water Depth [m below MSL]
High : 106.5
Low : -1.3

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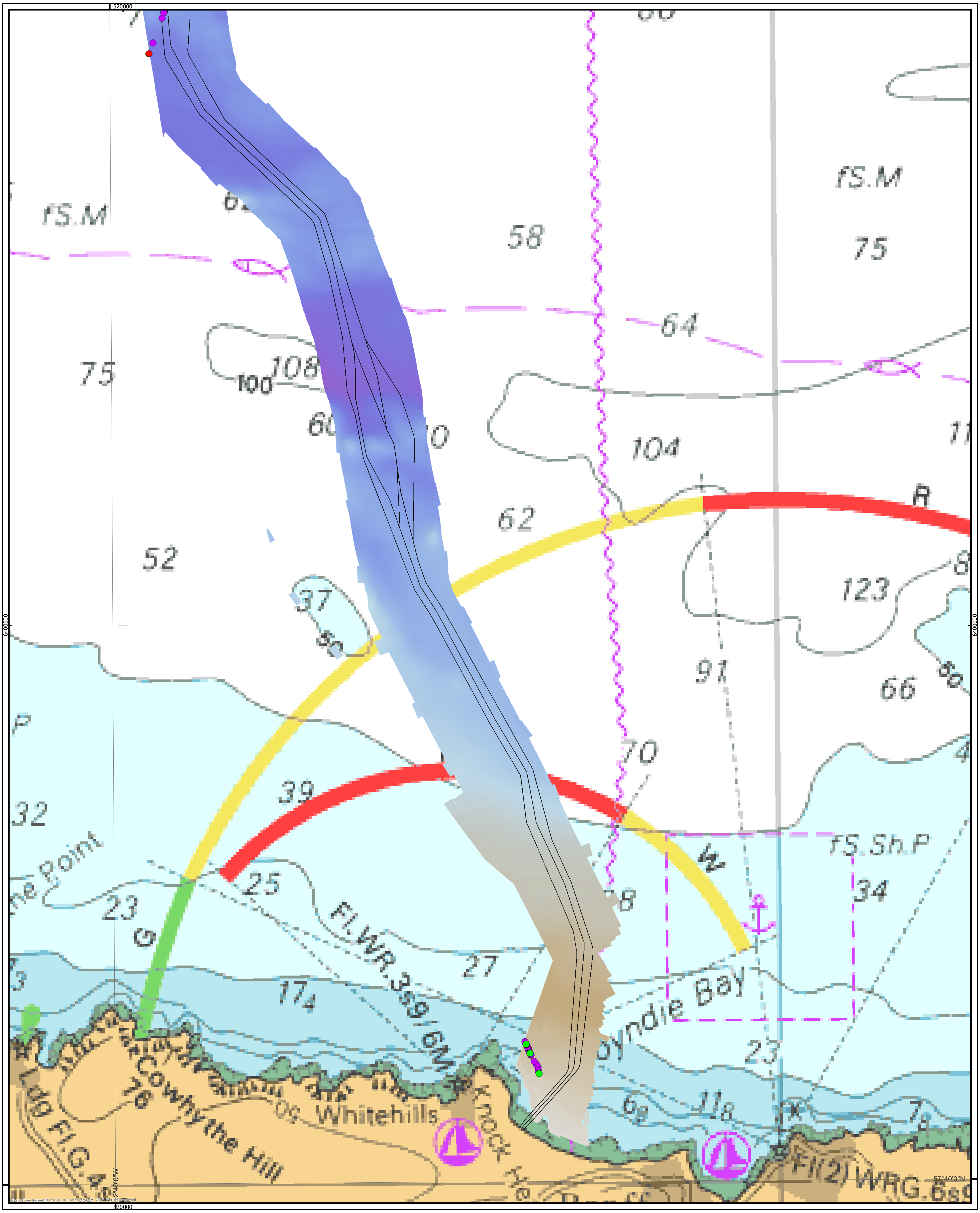
Date: 11/09/2018	Revision: A
REF: 8460001-AAA0000-AAA-AAA-002	

Figure 2-2 Bathymetry
Chart: 2 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters

KEY

Still Camera Location
Video Transect
Start of Line
End of Line
Primary Export Cable Route

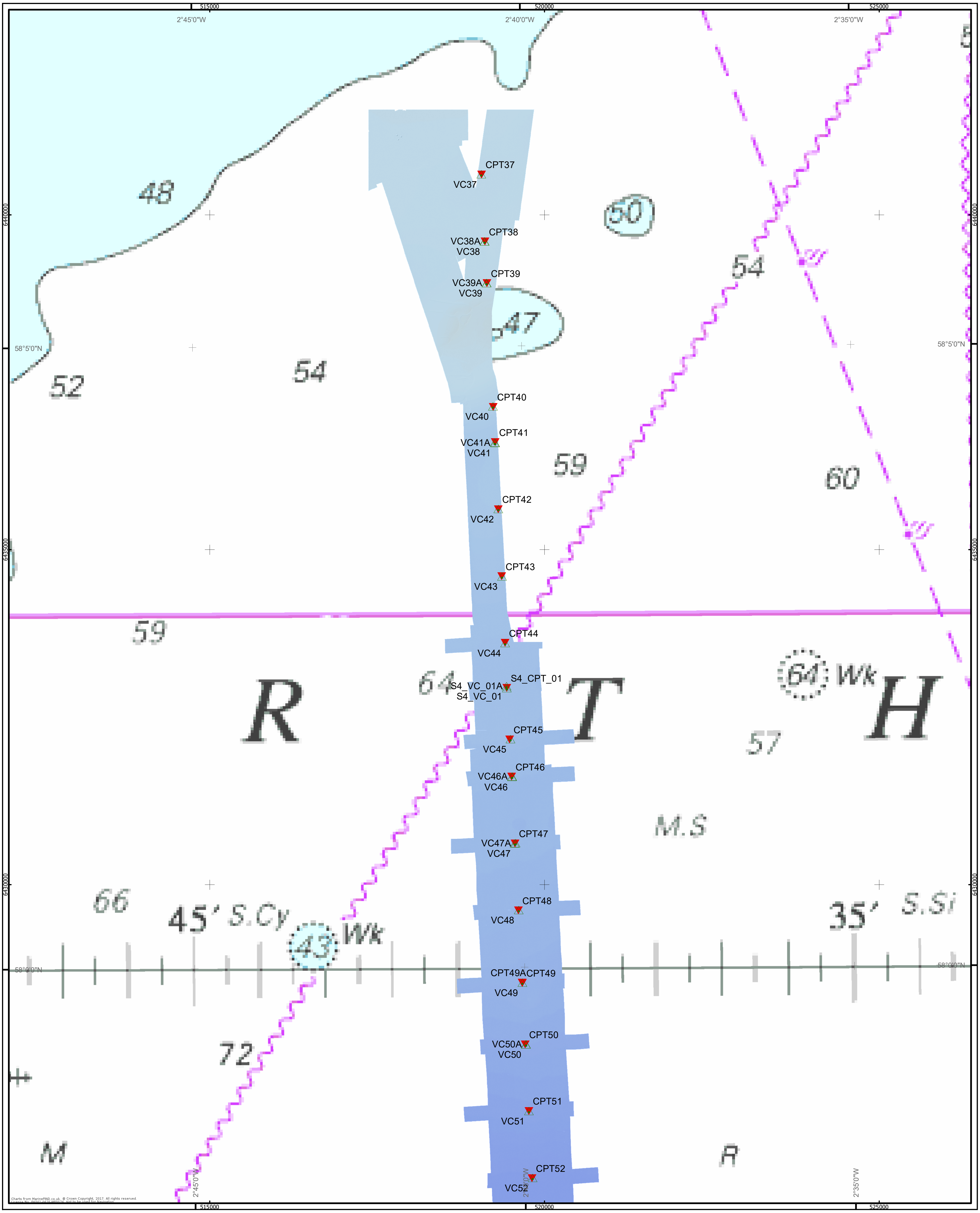
Water Depth [m below MSL]
High : 106.5
Low : -1.3

Produced: TN
Reviewed: JB
Approved: PE

Date: 11/09/2018
Revision: A
REF: 8460001-AAA0000-AAA-AAA-002

Figure 2-2 Bathymetry
Chart: 1 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N

Horizontal Scale: 1:50,000 A3 Chart

0 500 1,000 1,500 Meters

N

KEY

- Vibrocore
- Cone Penetration Test
- Primary Export Cable Route

Water Depth [m below MSL]

High : 106.5

Low : -1.3

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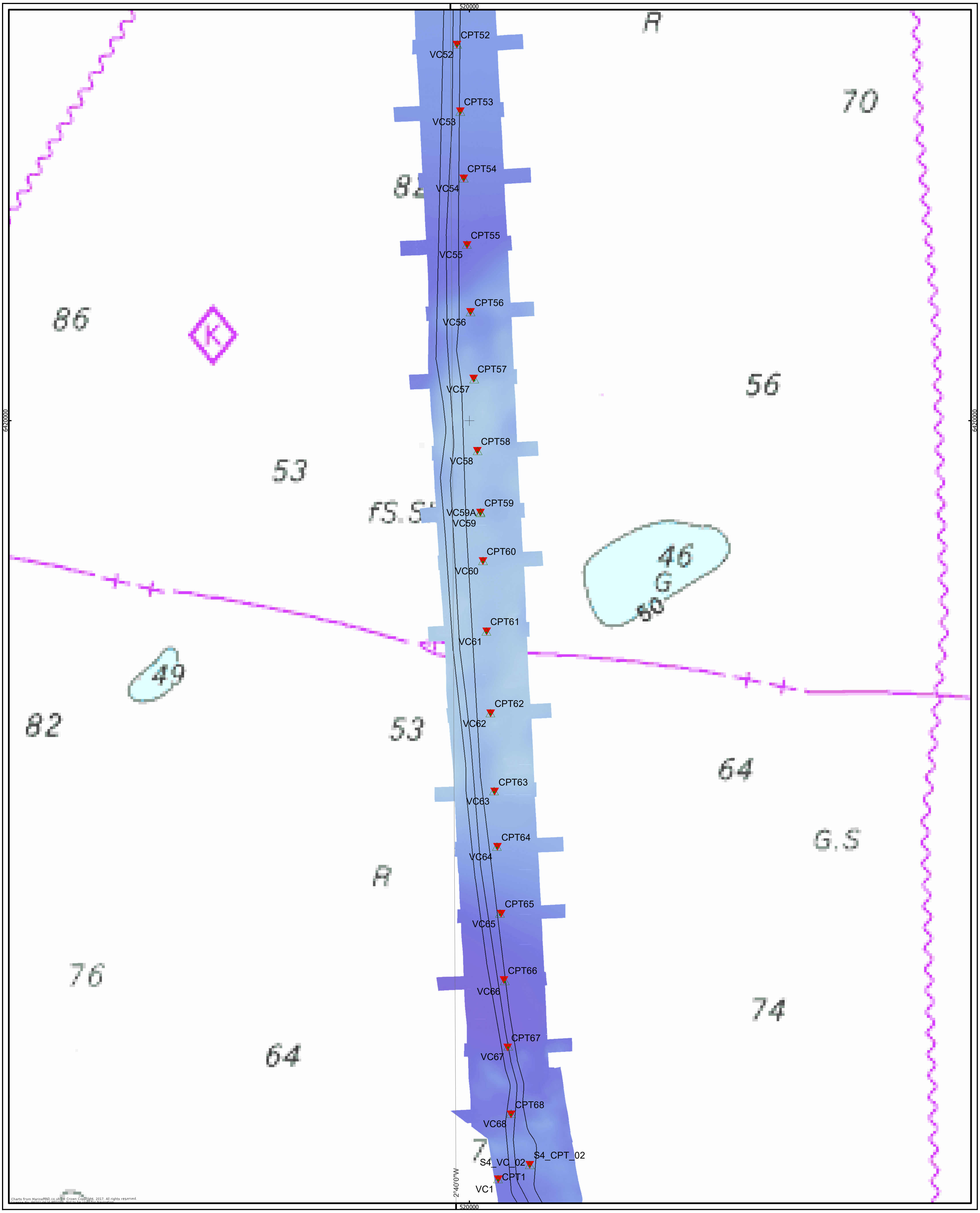
REF: 8460001-AAA0000-AAA-AAA-004

Figure 2-3 Geotechnical Locations

Chart: 3 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters
N

KEY

- Vibrocore
- Cone Penetration Test
- Primary Export Cable Route

Water Depth [m below MSL]
High : 106.5
Low : -1.3

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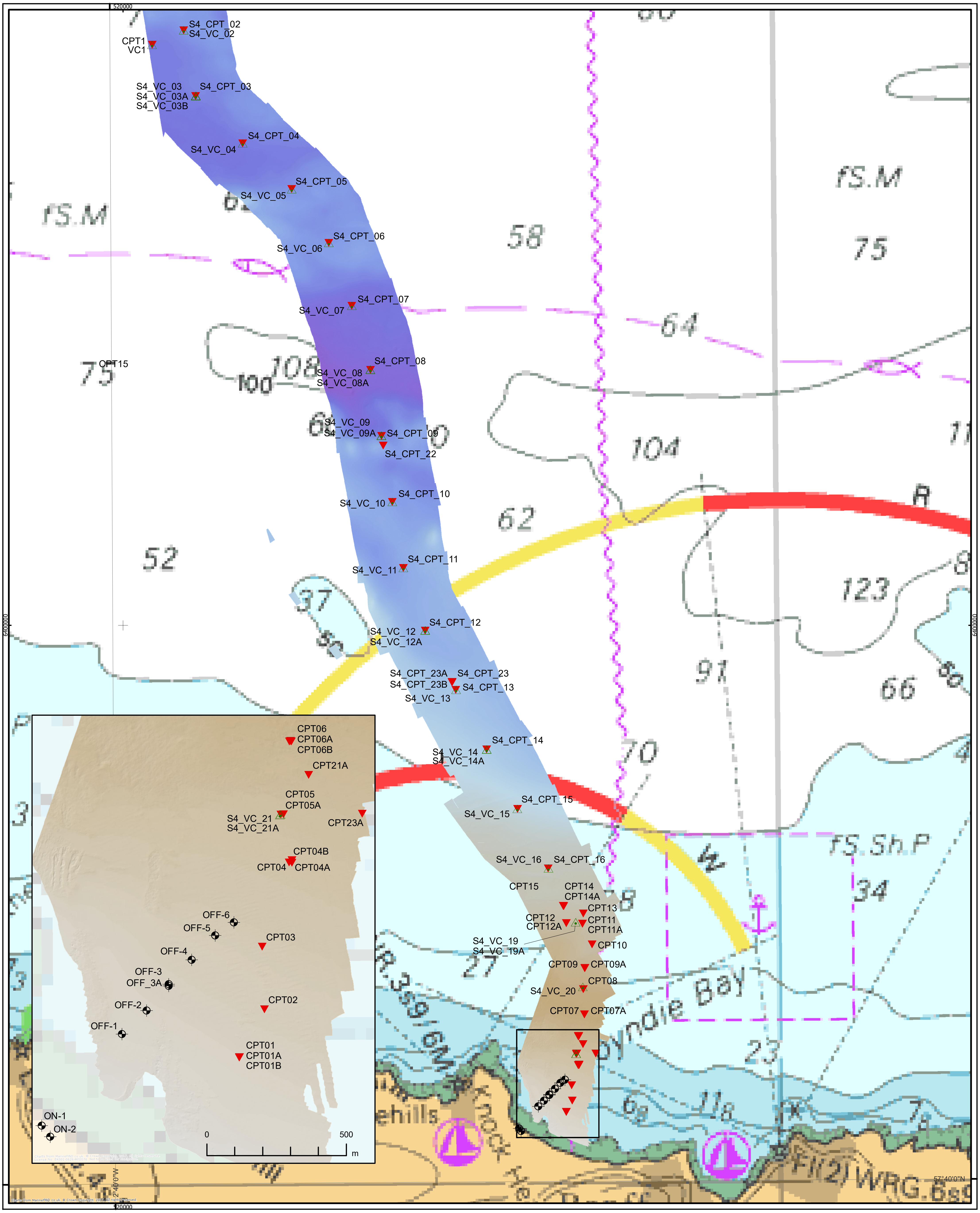
Date: 02/10/2018	Revision: A

REF: 8460001-AAA0000-AAA-AAA-004

Figure 2-3 Geotechnical Locations

Chart: 2 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

KEY

- Vibrocore
- Cone Penetration Test
- Borehole
- Primary Export Cable Route

Water Depth [m below MSL]
High : 106.5
Low : -1.3

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Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters

Produced: TN
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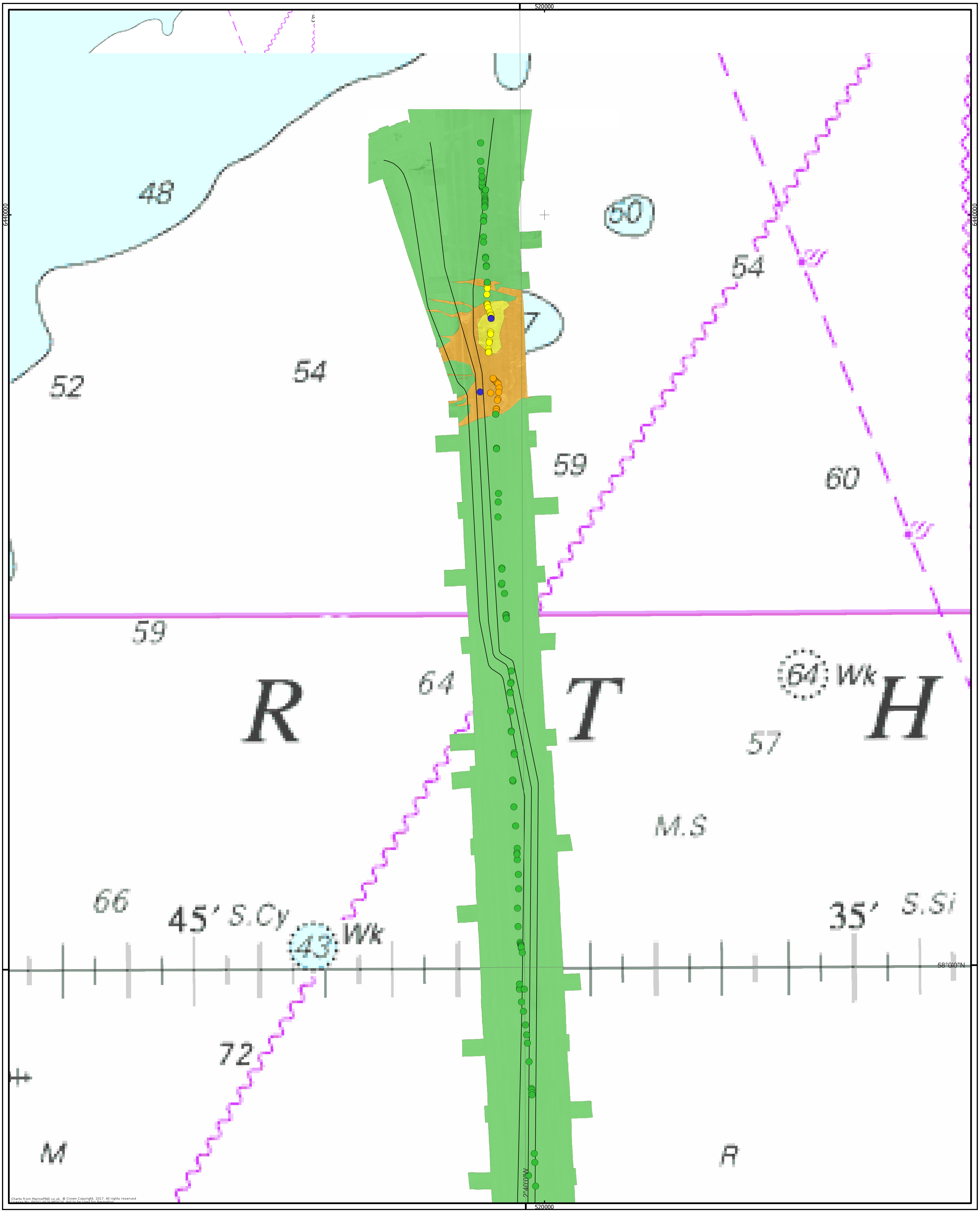
Approved: PE

Date: 02/10/2018 | Revision: A
REF: 8460001-AAA0000-AAA-AAA-004

Figure 2-3 Geotechnical Locations

Chart: 1 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N

Horizontal Scale: 1:50,000 A3 Chart

0 500 1,000 1,500 Meters

N

KEY

Primary Export Cable Route

Biotopes

- CR.MCR.EcCr.FaAlCr.Pom (potential Annex I stony and rocky reef)
- SS.SMu.CFiMu.SpnMeg (component of burrowed mud PMF habitat)
- SS.SMx.CMx
- SS.SMx.CMx with SSa
- SS.SSa

Produced: TN
Reviewed: JB
Approved: PE

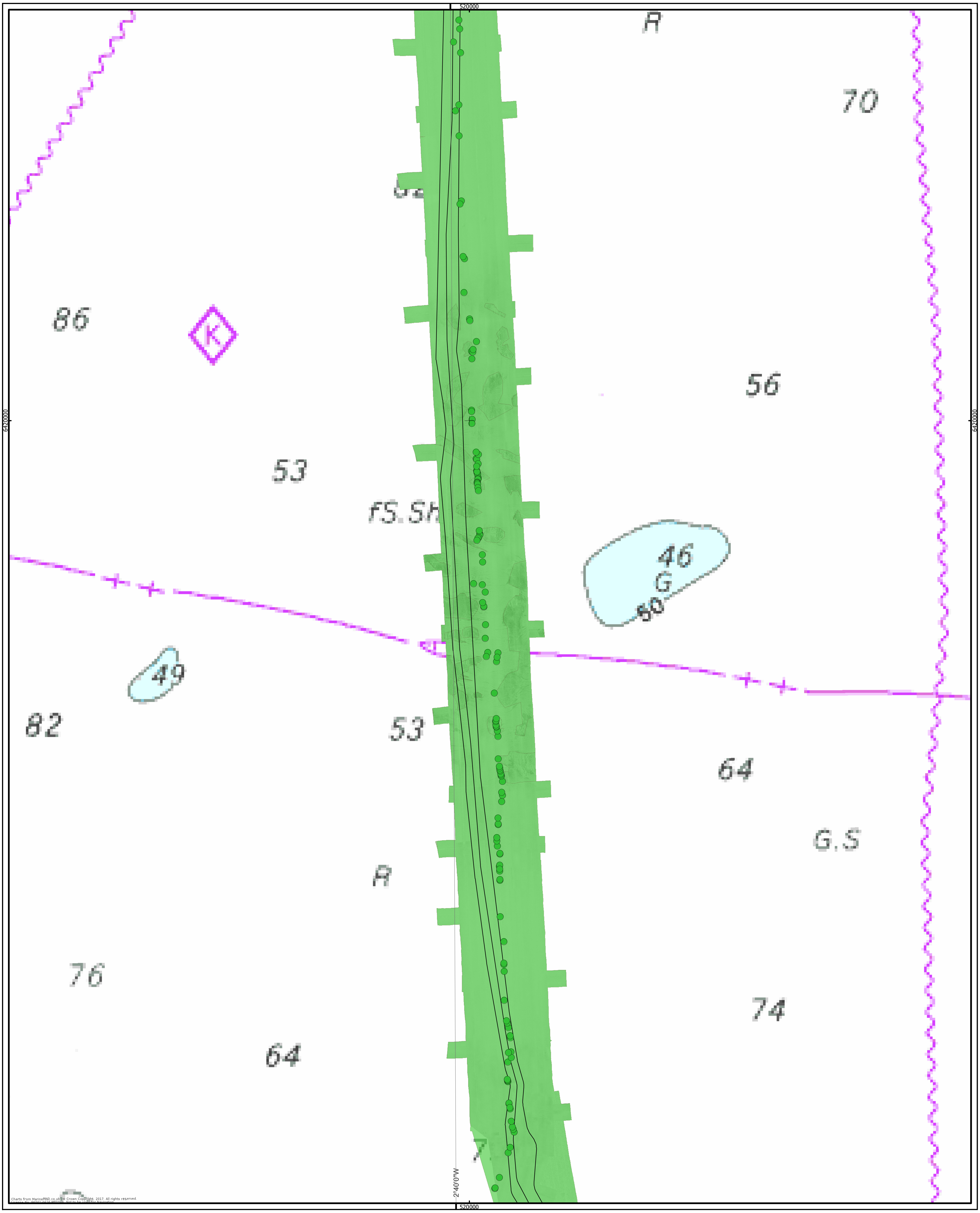
Date: 11/09/2018 | Revision: A

REF: 8460001-AAA0000-AAA-AAA-003

Figure 3-1 Biotopes

Chart: 3 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters
N

KEY

— Primary Export Cable Route

Biotopes

- CR.MCR.EcCr.FaAlCr.Pom (potential Annex I stony and rocky reef)
- SS.SMu.CFiMu.SpnMeg (component of burrowed mud PMF habitat)
- SS.SMx.CMx
- SS.SMx.CMx with SSa
- SS.SSa

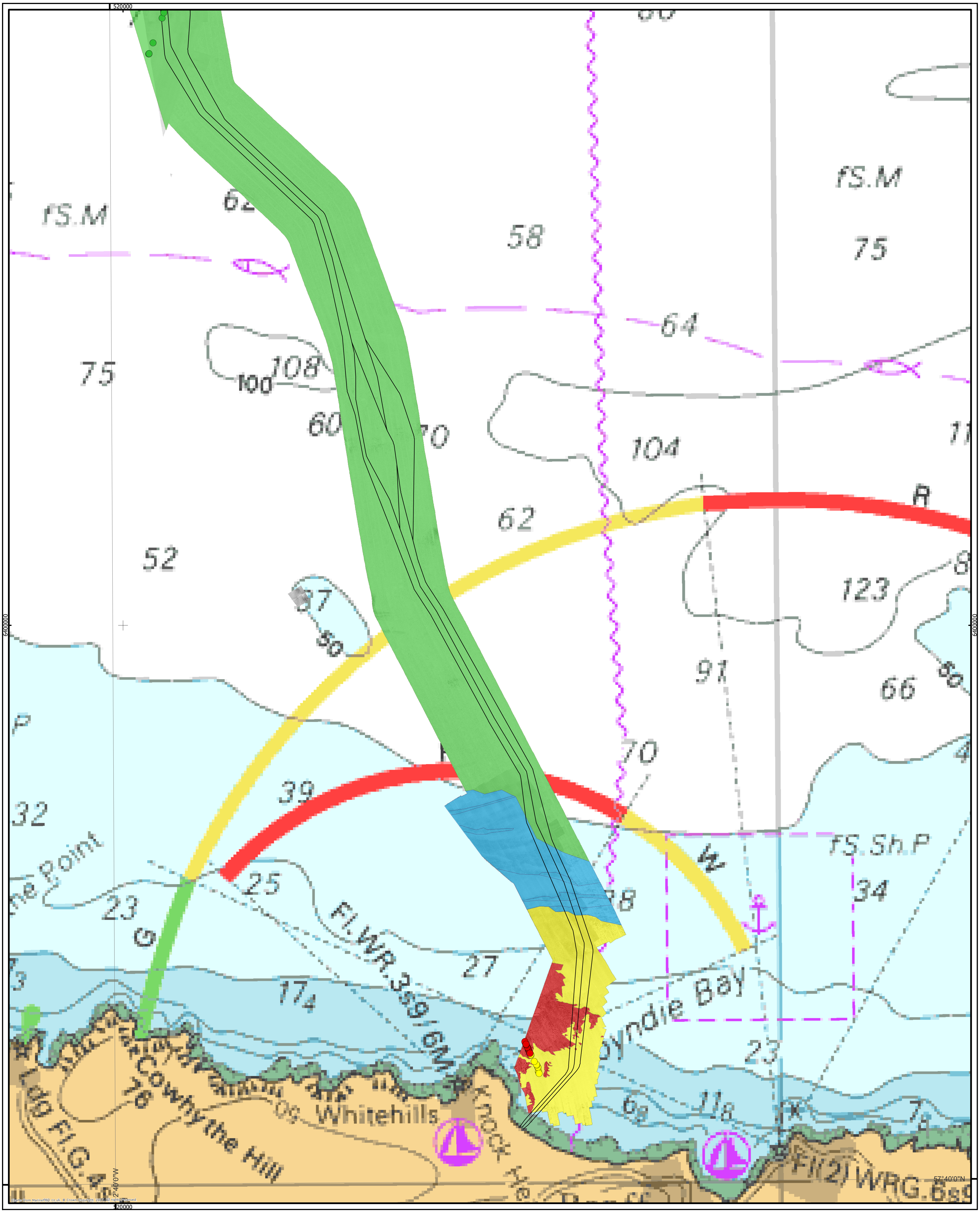
Produced: TN
Reviewed: JB
Approved: PE

Date: 11/09/2018	Revision: A
REF: 8460001-AAA0000-AAA-AAA-003	

Figure 3-1 Biotopes

Chart: 2 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:50,000 A3 Chart
0 500 1,000 1,500 Meters

KEY

—— Primary Export Cable Route

Biotopes

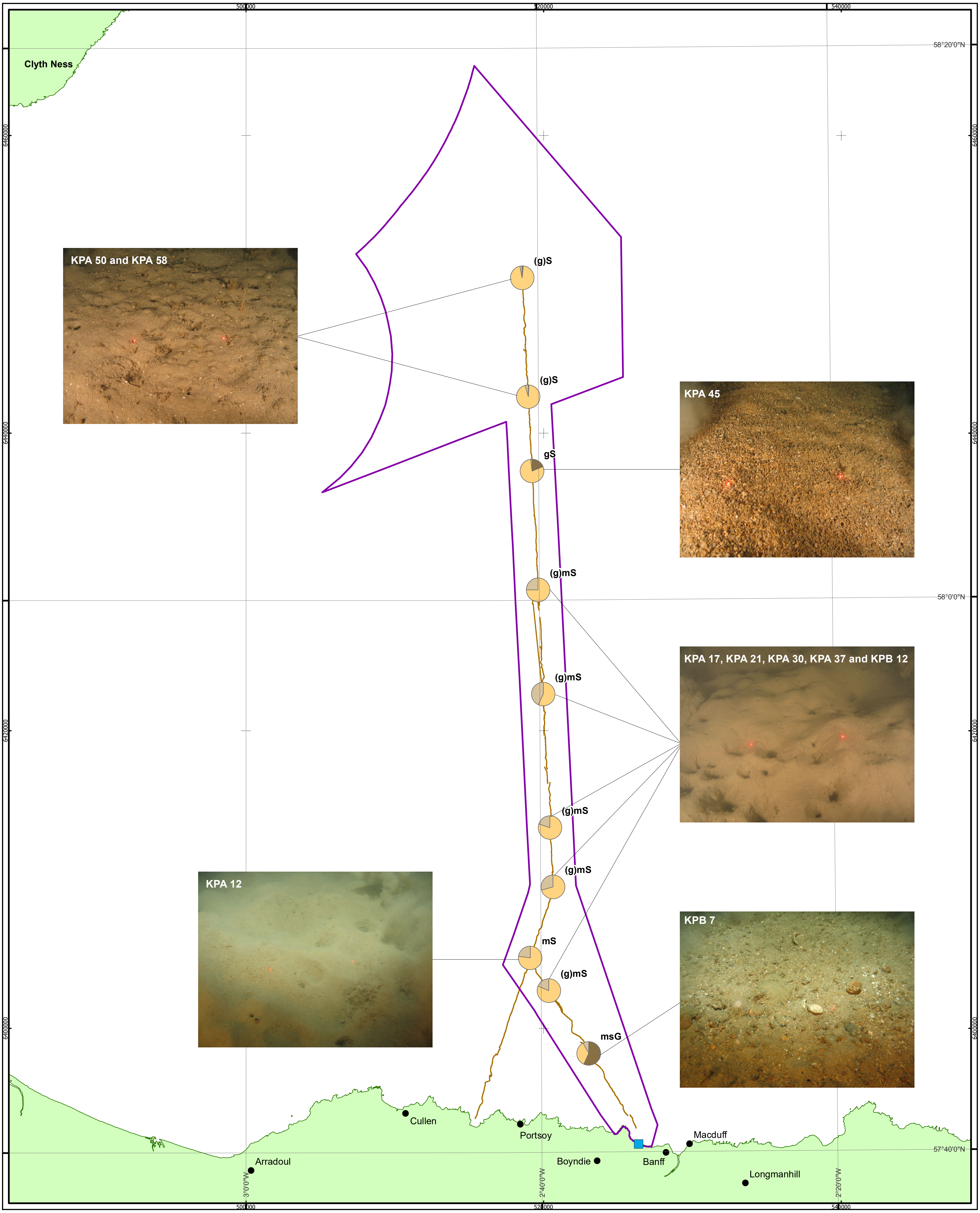
- CR.MCR.EcCr.FaAlCr.Pom (potential Annex I stony and rocky reef)
- SS.SMu.CFiMu.SpnMeg (component of burrowed mud PMF habitat)
- SS.SMx.CMx
- SS.SMx.CMx with SSa
- SS.SSa

Produced: TN
Reviewed: JB
Approved: PE

Date: 11/09/2018 | Revision: A
REF: 8460001-AAA0000-AAA-AAA-003

Figure 3-1 Biotopes
Chart: 1 of 3

Moray Offshore Windfarm (East) Ltd



MORAY EAST
OFFSHORE WINDFARM

Geodetic Parameters: WGS84 UTM Zone 30N
Horizontal Scale: 1:225,000 A3 Chart
0 2,000 4,000 Meters
N

KEY

- Consenting Area
- Cable Route Landing Site
- Video Transect

Principal Sediment Components (%)

- Gravel
- Sand
- Mud

Sediment Classification according to Folk, 1954.

Produced: TN
Reviewed: JB
Approved: PE

Date: 10/09/2018 | Revision: B

REF: 8460001-AAA0000-AAA-AAA-004

Figure 3-2 Distribution of Principal Sediment Components

Moray Offshore Windfarm (East) Ltd

MORAY EAST
OFFSHORE WINDFARM

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