BRIMS TIDAL ARRAY

openhydro — a DCNS company

sse

Environmental Statement

Volume 2-A

May 2016

Copies of the Environmental Statement

Additional copies of the Environmental Statement can be provided to third parties, subject to printing costs, details of which are available on request. However, to minimise the use of paper, BTAL requests that where possible, consultees refer to the information in electronic format. DVD copies can be requested from BTAL for a nominal charge at the following address:

Brims Tidal Array Limited
c/o OpenHydro
Greenore Port
Greenore
Co Louth
Ireland

Alternatively, the complete ES can be found at http://www.gov.scot/Topics/marine/Licensing/marine/scoping/BrimsArray

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Acronyms

AA	Appropriate Assessment
AC	Alternating Current
ADBA	Archaeological desk-based assessment
ADCP	Acoustic Doppler Current Profiler
AfL	Agreement for Lease
AIF	Anticipated Impact Footprint
AIS	Automatic Identification System
AoS	Area of Search
ASCOBANS	Agreement on Conservation of Small Cetaceans of the Baltic and North Seas
ATBA	Area to be Avoided
B.P.	Before Present
BATNEEC	Best Available Technology Not Entailing Excessive Costs
BDMPS	Biologically Defined Minimum Population Size
BOCC	Birds of Conservation Concern
BPI	Burial Protection Index
BTAL	Brims Tidal Array Limited
BTO	British Trust for Ornithology
CAP	Common Agricultural Policy
CCGT	Combine Cycle Gas Turbine
CD	Chart Datum
CEMD	Construction Environmental Management Document
CfD	Contract for Difference
CHTDL	Cantick Head Tidal Development Limited
CIA	Cumulative Impact Assessment
CIRIA	Construction Industry Research and Information Association
CITES	Convention on International Trade in Endangered Species
CO_2	Carbon Dioxide

COWRIE	Collaborative Offshore Wind Research into the Environment
CPA	Coastal Protection Act
CRM	Collision Rate Model
CWMTA	Cape Wrath Military Training Area
DBA	Desk-based Assessment
DECC	Department of Energy and Climate Change
DfT	Department for Transport
DIO	Defence Infrastructure Organisation
DP	Dynamic Positioning
DP (vessel)	Dynamic Positioning (vessel)
DTI	Department of Trade and Industry
EC	European Commission
ECoW	Ecological Clerk of Works
EEA	European Environment Agency
EEZ	Exclusive Economic Zone
EGA	Expert Geomorphological Assessment
EIA	Environmental Impact Assessment
EMD	Environmental Management Document
EMEC	European Marine Energy Centre
EMF	Electro-Magnetic Field
EMMP	Environmental Mitigation Monitoring Plan
EMR	Electricity Market Reform
EPS	European Protected Species
ERCoP	Emergency Response Cooperation Plan
ERM	Encounter Rate Model
ES	Environmental Statement
ESAS	European Seabirds at Sea
ETA	Engineering Technology Applications Limited

ETI	Energy Technologies Institute
ETV	Emergency Towing Vehicle
EU	European Union
FAD	Fish Aggregation Device
FAO	Food and Agricultural Organisation
FCS	Favourable Conservation Status
FEPA	Food and Environment Protection Act
FRS	Fisheries Research Services
FSA	Formal Safety Assessment
GBS	Gravity Base Structure
GCR	Geological Conservation Review
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GVA	Gross Value Added
GW	Gigawatt (power)
GWDTE	Ground Water Dependent Terrestrial Ecosystem
HAT	Horizontal Axis Turbine
HDD	Horizontal Directional Drilling
HIE	Highlands and Islands Enterprise
HRA	Habitats Regulations Appraisal
HSE	Health and Safety Executive
HVAC	High Voltage Alternating Current
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for Exploration of the Sea
ICIT	International Centre for Island Technologies
IEEM	Institute of Ecology and Environment Management
IHO	International Hydrographic Organisation

IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
IROPI	Imperative Reasons of Overriding Public Interest
IUCN	International Union for Conservation of Nature
IWC	International Whaling Convention
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LBAP	Local Biodiversity Action Plan
LCCA	Local Coastal Character Areas
LNCS	Local Nature Conservation Site
LSE	Likely Significant Effect
MAIB	Marine Accident Investigation Branch
MBES	Multibeam Echo-Sounder
MCA	Maritime and Coastguard Agency
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MDA	Military Danger Area
MEG	Marine Energy Group
MEHRA	Marine Environmental High Risk Area
MESH	Mapping European Seabed Habitats
MHWS	Mean High Water Springs
MGN	Marine Guidance Notice
MLWS	Mean Low Water Springs
MMEA	Marine Modelling Enabling Action
MMFR	Mean Maximum Foraging Range
MMMP	Marine Mammals Management Plan
MNCR	Marine Nature Conservation Review
MoD	Ministry of Defence

MPAs	Marine Protected Areas
MRESF	Marine Renewable Energy Strategic Framework
MS	Marine Scotland
MSI	Maritime Safety Information
MSL	Mean Sea Level
MS-LOT	Marine Scotland Licensing Operations Team
MU	Management Units
MW	Megawatt (power)
NBN	National Biodiversity Network
NCI	Nature Conservation Importance
NCMPA	Nature Conservation Marine Protected Area
NGET	National Grid Electricity Transmission
NLB	Northern Lighthouse Board
NMR	National Monuments Record
NPF	National Planning Framework
NPPG	National Planning Policy Guidance
NPS	National Policy Statement
NRA	Navigational Risk Assessment
NREAP	National Renewable Energy Action Plan
NSA	National Scenic Area
NSIP	National Significant Infrastructure Projects
NSP	Noise Sensitive Property
NTU	Normal Turbidity Unit
OBRC	Orkney Biodiversity Records Centre
OCT	Open-Centre Turbine
ODBOA	Orkney Dive Boat Owners Association
OFA	Orkney Fisheries Association
OFS	Orkney Fisherman's Society

OIC	Orkney Islands Council
ORCA	Orkney Research Centre for Archaeology
OREI	Offshore Renewable Energy Installations
OS	Ordnance Survey
OSF	Orkney Sustainable Fisheries
PAC	Pre Application Consultation
PAM	Passive Acoustic Monitoring
PAT	Pop-up Archival Tags
PBD	Project Briefing Document
PBR	Potential Biological Removal
PEMP	Project Environmental Management Plan
PFOW	Pentland Firth and Orkney Waters
PHA	Preliminary Hazard Analysis
RAF	Royal Air Force
RCAHMS	Royal Commission on the Ancient and Historical Monuments of Scotland
REE	Roving Eye Enterprises
REZ	Renewable Energy Zone
RIB	Rigid Inflatable Boat
RLG	Regional Locational Guidance
RNLI	Royal National Lifeboat Institution
ROV	Remotely Operated Vehicle
RSPB	Royal Society for the Protection of Birds
RYA	Royal Yachting Association
SAC	Special Area of Conservation
SAMS	Scottish Association of Marine Science
SAR	Search and Rescue
SCADA	Supervisory Control And Data Acquisition
SEA	Strategic Environmental Assessment

SEPA	Scottish Environment Protection Agency
SFF	Scottish Fishermen's Federation
SHEPD	Scottish Hydro Electric Power Distribution
SHE-T	Scottish Hydro Electric Transmission PLC
SLVIA	Seascape, Landscape and Visual Impact Assessment
SMRU	Sea Mammal Research Unit
SMS	Safety Management System
SNH	Scottish Natural Heritage
SOPEP	Shipboard Oil Pollution Emergency Plans
SPA	Special Protection Area
SPFA	Scottish Pelagic Fisherman's Association
SPP	Scottish Planning Policy
SSB	Subsea Base
SSC	Suspended Sediment Concentrations
SSSI	Sites of Special Scientific Interest
STW	Scottish Territorial Waters
T	Tonnes
TCE	The Crown Estate
TEC	Tidal Energy Converters
THC	The Highland Council
TSS	Turbine Support Structure
TWh	Terawatt Hour
UFEN	UK Fisheries Economics Network
UKBAP	UK Biodiversity Action Plan
UNCLOS	United Nations Convention of the Law of the Sea
VMP	Vessel Management Plan
VMS	Vessel Monitoring System
VTS	Vessel Traffic Service

WANE	Wildlife and Natural Environment Licences
WCA	Wildlife and Countryside Act
WDC	Whale and Dolphin Conservation
WHS	World Heritage Site
ZTV	Zone of Theoretical Visibility

Introduction

Chapter 1

1 INTRODUCTION

Brims Tidal Array Limited (BTAL) is proposing to develop a tidal array, known as the Brims Tidal Array Project (the Project), of up to 200 megawatts (MW) of generating capacity within the Pentland Firth.

The key driver for the Project is the development of renewable sources of energy, which is critical for combatting global climate change, and which contributes to improved energy sustainability and security of supply in Scotland.

This document is the Environmental Statement (ES) for the Project and focuses on the offshore aspects of the Project.

1.1 THIS DOCUMENT

This Environmental Statement (ES) presents the results from the Environmental Impact Assessment (EIA) of the Project. The purpose of the document is to bring together, evaluate and present succinctly the findings from a number of dedicated studies carried out as part of the EIA. Information and conclusions on potential significant impacts presented in this document will be taken into consideration by the Licensing Authority, Marine Scotland, and their advisors as part of the determination of the Marine Licence and Section 36 consent applications.

In addition to providing information on the potential impacts associated with the construction, installation, operation and decommissioning of the tidal turbines and supporting infrastructure including turbine support structures (TSS), subsea cable connection hubs, inter-array and export cables, this ES also provides: a detailed description of the Project; highlights the need for the Project; a rationale for the selection of the Project Agreement for Lease (AfL) area and key Project parameters; information on legislation and policy relevant to the Project; and presents a summary of the consultation process carried as part of the EIA. The ES also includes information about and from the Habitats Regulations Appraisal (HRA) and Navigational Risk Assessment (NRA) processes that have also been undertaken for the Project. These additional assessments have been carried out as integral components of the overall EIA process. Results from the HRA and NRA are presented in separate documents (Supporting Document: BTAL, 2015c and Supporting Document: Anatec, 2015 respectively). These documents, together with all supporting documents, are provided as Volume 3 of this ES. Hard copies of all application documentation will be made available at the public locations as advertised in the Public Notice during the public consultation period.

1.2 PROJECT OVERVIEW

The Project is an offshore tidal array which will comprise of up to 200 fully submerged tidal turbines with a maximum total installed capacity of 200MW. Electricity generated by the turbines will be transmitted to shore via a series of inter-array and export cables. An overview of the Project Agreement for Lease (AfL) and cable corridors can be seen in Figure 1.1. The marine cables will be joined to terrestrial cables in a buried transition pit in order for the Project to be connected to the electricity network.

This ES considers the following offshore components of the Project:

- All offshore aspects of the Project including tidal turbines and turbine support structures;
- Electrical infrastructure - inter-array and export cables, and subsea cable connection hubs; and
- Landfall for export cables (up to Mean High Water Springs (MHWS)).

In addition to the components described above, the Project will also consist of the following onshore components:

- Cable landfall above Mean Low Water Springs (MLWS), and transition pit;
- Onshore underground cable route, from the landfall point of the tidal arrays export cables to the substation;
- Temporary works including temporary compound and laydown areas to facilitate the cable landfall works; and
- Possible road access improvements; and
- Onshore substation.

Network reinforcement works will also be required to connect the Project to the electricity transmission network. These will be the responsibility of Scottish Hydro Electric Transmission PLC (SHE-T).

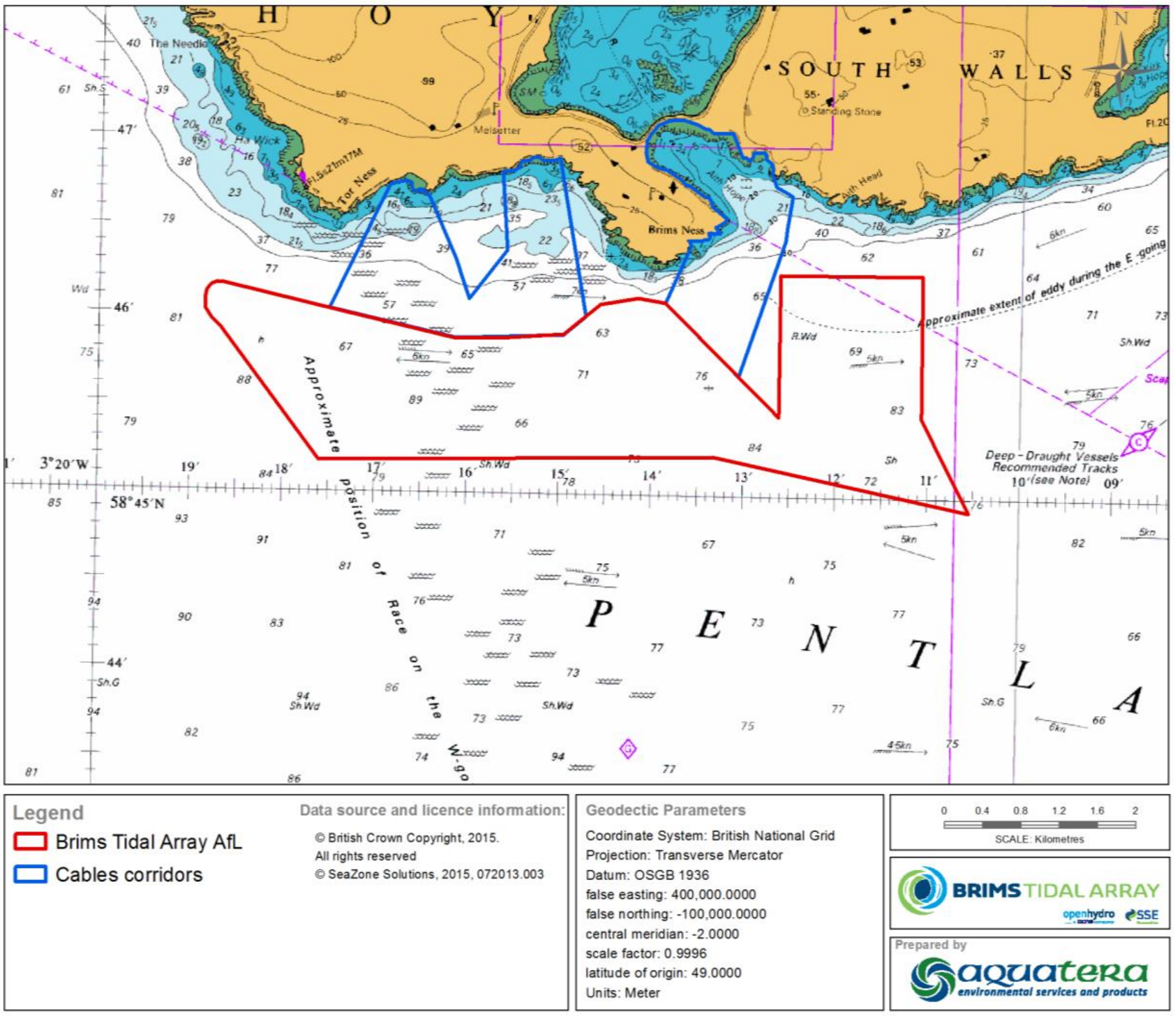

Figure 1.1: Project Agreement for Lease (AfL) and cable corridor areas

1.3 THE APPLICANT

1.3.1 Brims Tidal Array Limited. (BTAL)

Brims Tidal Array Limited (BTAL) is a joint venture partnership between SSE Renewables and OpenHydro Site Development Limited. The sole purpose of BTAL is to progress the development of the tidal array project at Brims Ness. The company was awarded an Agreement for Lease (AfL) for the site by The Crown Estate (TCE) in 2010 which provides it with exclusive rights to investigate the feasibility of developing a commercial scale tidal energy array on the site (see Figure 1.1).

The development of the Project will entail an investment of hundreds of millions of pounds, a significant portion of which will benefit the local Orkney and regional Scottish economies. BTAL is working with local businesses to ensure that they are in a position to take advantage of this opportunity as the Project progresses.

1.3.2 OpenHydro Site Development Limited (OpenHydro)

OpenHydro is an Irish tidal energy technology company whose business is the design and manufacture of tidal turbines for generating renewable energy from tidal streams. Founded in 2004, OpenHydro has developed an innovative turbine capable of producing electricity at competitive prices (see Figure 1.2).

Figure 1.2: 16m Open-Centre Turbine, France

In March 2013, a French industrial company, DCNS, secured a majority shareholding in OpenHydro. DCNS is a world leader in naval defence and an innovative player in energy. DCNS designs, builds and supports submarines and surface naval vessels and provides services for naval shipyards and bases. It also develops solutions in civil nuclear engineering and marine renewable energy.

OpenHydro is uniquely positioned in the tidal energy industry. It has a commercial scale tidal turbine with proven ability to generate electricity, the technical ability to connect successfully to a national grid and a method to deploy turbines quickly, safely and economically on the seabed. OpenHydro's achievements have been recognised through a number of prestigious international awards including, the Green Energy, Rushlight, Ocean Energy, and numerous Engineers Ireland awards. OpenHydro has the longest track record at the European Marine Energy Centre (EMEC) in Orkney. The company completed the installation of the first tidal turbine (see Figure 1.3) at this test facility in 2006 and in 2008 OpenHydro became the world's first company to connect a tidal turbine to the UK national grid. OpenHydro was also the first to successfully demonstrate a fast and economically viable deployment method for the installation of turbines at depth.

Figure 1.3: OpenHydro test platform in EMEC

1.3.3 SSE Renewables Developments (UK) Limited (SSER)

SSE Renewables Developments (UK) Limited (SSER) is a wholly owned subsidiary of the SSE Group and is responsible for the development of renewable energy projects on behalf of the generation part of the company. The overall SSE generation portfolio presently has an installed generation capacity of over 13GW, including almost 3.2GW of renewables, and supplies energy to some 10 million customers across the UK and Republic of Ireland. SSE defines its core purpose as providing the energy people need, in a reliable and sustainable way. SSER is one of the UK's leading offshore renewable energy developers, responsible for 6.6GW of development projects.

1.4 BENEFITS OF TIDAL ENERGY

The proposed tidal energy development will make a significant contribution to the Scottish target for 100% of Scotland's electricity demand to be generated from renewable sources by 2020. In addition to this, Scotland has the opportunity to significantly build on their reputation as world leaders in development and integration of tidal energy, and benefit from the diversity the technology brings to the overall generation portfolio.

Some of the unique benefits of tidal energy include:

- The turbines are located on the seabed and therefore have no visual impact;
- Improves grid management because the electricity produced is entirely predictable for years in advance;
- Has a different generation profile to wind energy which will allow a higher penetration of renewable generation;
- Higher level of diversity of renewable generation type available on the system;
- Relatively small footprint compared to other renewable technologies; and
- Due to the stage of development of the technology, locations where early deployment is successful will result in competitive advantage to local businesses involved in the development and will attract scientific interest.

1.5 BACKGROUND TO THE PROJECT

In November 2008, TCE issued an invitation to tender for site development rights in the Pentland Firth and Orkney Waters (PFOW) strategic area to marine energy developers. On the 16th March 2010, TCE issued an Agreement for Lease (AfL) for a tidal energy array up to 200MW in capacity, located off the south coast of South Walls, to Cantick Head Tidal Development Limited (CHTDL), a joint venture between OpenHydro Site Development Limited (OpenHydro) and SSE Renewables (Holdings) UK Limited (SSER). The AfL allows the holder exclusive rights to investigate the feasibility of developing the Project whilst seeking the necessary development consent(s) from the licensing authorities. Analysis and review of the detailed survey datasets led to the identification of site characteristics at the original Cantick Head AfL that were unsuitable for the development of a tidal energy array. On this basis, CHTDL initiated a consultation exercise with The Crown Estate in 2013 to identify a more suitable location. Following the collection of additional data from further site surveys and a stakeholder consultation process a revision was made to the boundary of the AfL area. As a result of this boundary change, and in order to ensure a name relevant to the Project location, the site name was revised from Cantick Head Tidal Development to Brims Tidal Array. This process is discussed in more detail in Chapter 4 Site Selection and Alternatives.

1.5.1 Project Site Definitions

The following definitions have been used throughout the ES to describe various components of the Project:

Agreement for Lease (AfL) area – this is the area awarded by The Crown Estate to investigate the feasibility of developing a tidal array;

Area of search for export cable corridor – this is an indicative area of search within which the preferred export cable corridor will be located;

Export cable corridor – the export cables will be located within an export cable corridor. The export cable corridor will be located within the wider area of search for the export cable corridor;

Project site – the Project site covers both the AfL area and the area of search for the export cable corridor;

Project study area – this is the area covered as part of the impact assessment for the specific EIA topics. The Project study area varies from topic to topic. A description of the Project study area identified for each EIA topic is provided in each of the impact assessment chapters;

Project survey area – where surveys have been carried out for specific EIA topics, the area covered by the survey is referred to as the Project survey area; and

Indicative turbine layout – for the purpose of the EIA it is assumed that turbines could be located anywhere within the AfL area applying the principles explained in Chapter 5 Project Description. An indicative turbine layout is provided for illustrative purposes (Figure 5.2) and will be refined during the detailed design phase. The total number of turbines installed will depend on the rating of the selected turbine among other factors. The assessment in the technical chapters has taken into account the range of potential layouts which may arise, by applying a worst case approach as explained in Chapter 7 EIA Scope and Methodology.

1.6 CONSENTING STRATEGY

This ES is submitted in support of BTAL's applications for both Marine Licence and Section 36 consents through Marine Scotland, and wish to provide a robust ES which fully satisfies the EIA Regulations for such an application for the offshore components up to MHWS. The offshore components of the Project consists of:

- All offshore aspects of the Project including tidal turbines and turbine support structures;
- Electrical infrastructure - inter-array and export cables, and subsea cable connection hubs; and
- Landfall for export cables (up to MHWS).

The consents applying to the offshore Project are summarised in Table 1.1. As part of the consenting process BTAL is required to prepare and submit an ES in support of the consent applications which documents the results from an EIA of the Project. The EIA legislation that informs the scope of the ES is covered in more detail in Chapter 3 Policy and Legislation.

Table 1.1: The Project consent requirements

Offshore project component	Consent	Duration	Description	Licensing Authority
Tidal turbines, Turbine Support Structures, inter-array cables, connection hubs and export cables to shore (up to MHWS)	Marine Licence under the Marine (Scotland) Act	25 years	Consent under a Marine Licence covers construction and deposit of structures below Mean High Water Springs. This covers the following offshore areas of the Project: Deposit of objects on the seabed, e.g. turbines, cables, connection hubs and TSS; The deposit of objects under the seabed, e.g. cables to shore with HDD boreholes; and, Construction on and under the seabed, e.g. drilling for piling or HDD bores.	Scottish Ministers (through Marine Scotland)
Tidal turbines, inter-array cables, connection hubs, subsea cables and export cables to shore (up to MHWS)	Section 36 consent under the Electricity Act 1989	25 years	Section 36 consent is required for development of offshore generating stations over 1MW within Scottish territorial waters.	Scottish Ministers (through Marine Scotland)

At this stage in the consenting process, as the grid connection point is still to be confirmed, it has not been possible to progress the design of the onshore components in sufficient detail to enable a full EIA to be carried out. Once the grid connection point has been confirmed, design of the onshore components will be completed, and an EIA will be undertaken (see Section 21.5) to support a separate planning application through the OIC, under the Town and Country Planning (Scotland) Act 1997. The onshore components of the Project consists of:

- Cable landfall above MLWS, and transition pit;
- Onshore underground cable route;
- Temporary works including construction compound(s) and laydown areas to facilitate landfall works;
- Possible road access improvements; and
- Onshore substation.

The information currently available on the onshore components of the Project is summarised in Chapter 21 Overview of Onshore Impacts. Once the location of the onshore substation has been confirmed, this information will be used to inform the EIA for the onshore components, which will be carried out in further consultation with relevant stakeholders.

A connection agreement is in place between National Grid and BTAL. This agreement outlines the requirement to establish a new substation on South Hoy or South Walls for the BTAL Project. SHE-T will own and operate this substation, and all infrastructure required to support the onward connection to the wider grid network. The exact location of the substation has not yet been confirmed; however the design of the wider grid upgrade work and the connection works associated with the Project is currently under way (see Section 21.4) and will be subject to a full stakeholder consultation and planning permission process at the appropriate time. The timing for the application process for all onshore components will be informed by the development of the grid connection infrastructure by SHE-T.

1.7 SUPPORTING EIA STUDIES

For some EIA topics supporting studies were carried out to help characterise the baseline environment in more detail and/or inform the impact assessment and determination of impact significance. All methodologies were based on current best practice, and published guidance available at the time, and took into account any advice received through consultation with the Licensing Authority and consultees.

All supporting studies undertaken as part of this EIA are listed in Table 1.2. Specific study scopes and methodologies are described in detail in the relevant technical reports prepared for each of the studies. Further information on specific studies is also included in the relevant impact assessment chapters of this ES. Copies of the relevant technical reports are provided on the DVD that can be found on the inside of the front cover of this ES, in hard copy at the nominated public locations or can be made available upon request.

1.8 STRUCTURE OF THIS ENVIRONMENTAL STATEMENT

This ES document communicates the process and findings of the EIA. The EIA process represents an assessment of the potential impacts of the Project on the environment. It is shaped by the content of the Scoping Report and guided by advice received through the formal Scoping Opinion. The results are presented in Chapters 8 to 24 of this ES. In addition all supporting documents are provided on a DVD located inside the front cover of this ES. The structure of the ES is detailed in Figure 1.4. A full list of EIA contributors, ES supporting studies and supporting documents is provided in Table 1.2. All supporting studies relevant to each EIA topic are also listed at the beginning of each ES chapter. The methodology adopted for the EIA is covered in more detail in Chapter 7 EIA Scope and Methodology.

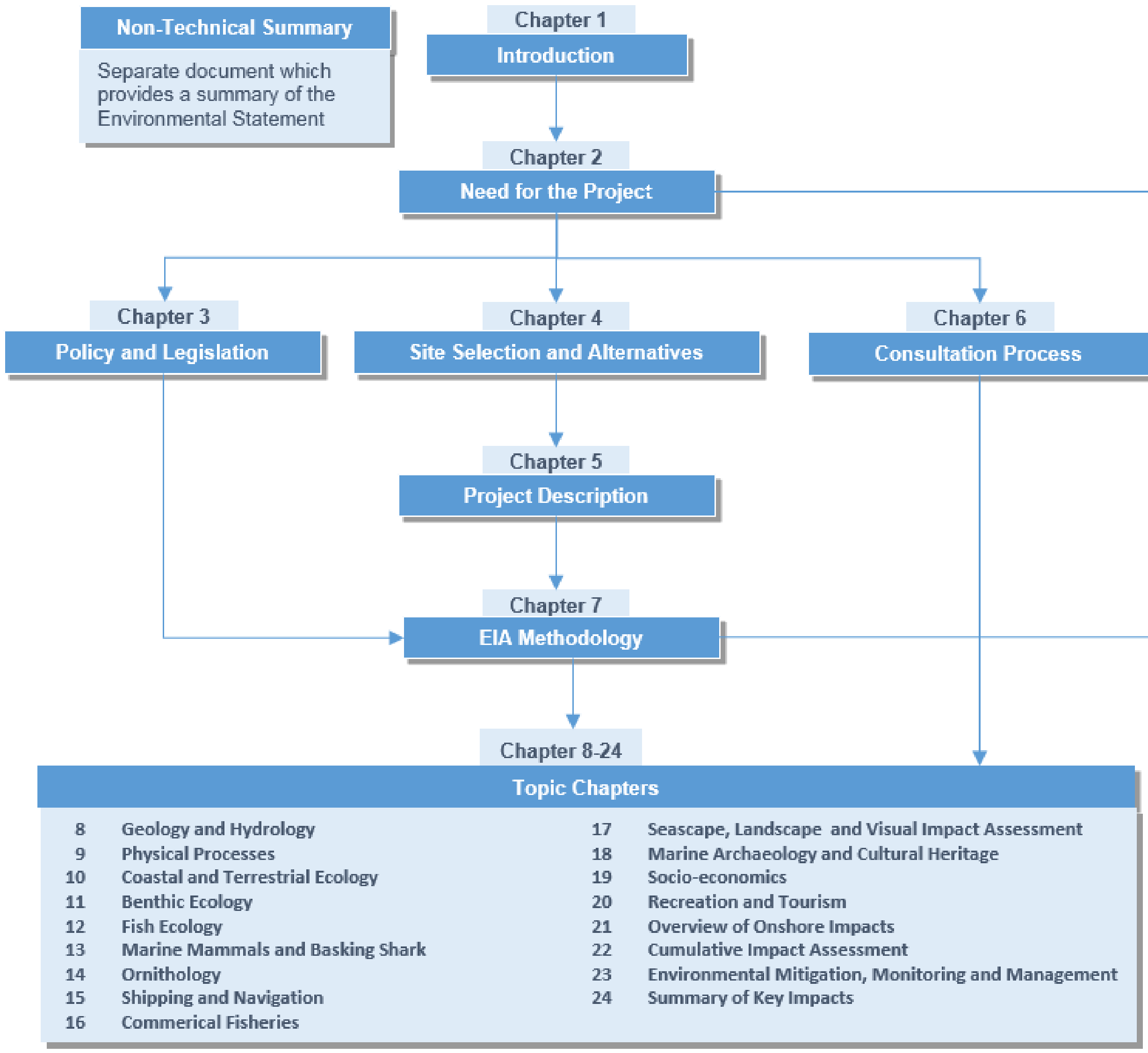

Figure 1.4: EIA structure

1.9 CONTRIBUTORS TO THE EIA

The ES presents the results of a number of assessments carried out by technical authors. The area of expertise of these consultants and their contribution to the ES are detailed in Table 1.2. Table 1.2 also details how supporting studies are referenced within the ES. Supporting documents can be found on the DVD provided with this ES.

Table 1.2: EIA chapters and supporting studies

Chapter	Title	Contributor	Supporting Studies	As Referenced within ES
N/A	Non-Technical Summary		None	
Chapters 1 to 7	Introduction, Need for the Project, Planning and Legislation, Site Selection and Alternatives, Project Description, Consultation Process, EIA Scope and Methodology	BTAL and Aquatera	*Navigation Risk Assessment. Brims Tidal Array. (Technical Note)*	(Supporting Document: Anatec, 2015)
			BRIMS Environmental Scoping Report (August 2013). Brims Tidal Array Ltd (2013)	(Supporting Document: BTAL, 2013)
			Pre Application Consultation Report. Brims Tidal Array Ltd (2015)	(Supporting Document: BTAL, 2015a)
			Information to Inform Habitats Regulations Appraisal (Volume 3). BTAL (2015)	(Supporting Document: BTAL, 2015c)
			Gap Analysis. BTAL (2015e)	(Supporting Document: BTAL, 2015e)
			Project Briefing Document. Cantick Head Tidal Array. Cantick Head Tidal Development Head Ltd (2010)	(Supporting Document: CHTDL, 2010)
			The Brims Tidal Array Scoping Opinion (Final) (April 2014). Marine Scotland-Licensing Operations Team (2014)	(Supporting Document: MS-LOT, 2014)
			Brims Tidal Array, Orkney Geophysical Survey. Volume 2c Results Report. Osiris Projects (2014)	(Supporting Document: Osiris, 2014)
Chapter 8	Geology and Hydrology	Aquatera	*Supplementary Study. Geological, Hydrogeological Baseline Desk Study Brims Tidal Energy. Flett Brown,Dr J (2015)*	(Supporting Document: Flett Brown, 2015)

Chapter	Title	Contributor	Supporting Studies	As Referenced within ES
			May 2014 Benthic Survey Report September 2014. Aquatera (2014)	(Supporting Document: Aquatera, 2014)
			Phase 1 Intertidal Habitat Survey for Brims Tidal Array Sheep Skerry Cable Corridor and Landfall Area of Search. Aquatera (2015)	(Supporting Document: Aquatera, 2015a)
			Sheep Skerry MBES Survey. Brims Tidal Array Project	(Supporting Document: Aquatera, 2015c)
Chapter 9	Physical Processes	RHDHV	*May 2014 Benthic Survey Report September 2014*. Aquatera (2014)	(Supporting Document: Aquatera, 2014)
			Sheep Skerry MBES Survey. Brims Tidal Array Project	(Supporting Document: Aquatera, 2015c)
			Brims Tidal Array, Orkney Geophysical Survey. Volume 2c Results Report: Osiris Projects (2014)	(Supporting Document: Osiris, 2014)
			Baseline Physical Processes Environment. Brims Tidal Array Ltd (2015)	(Supporting Document: BTAL, 2015b)
			Physical Processes Modelling. Royal Haskoning DHV (2015)	(Supporting Document: RHDHV, 2015a)
Chapter 10	Coastal and Terrestrial Ecology	Aquatera	*Brims Tidal Array Ltd Project Extended Phase 1 Habitat Survey*. Royal Haskoning (2012)	(Supporting Document: RHDHV, 2012)
			Brims Tidal Array Ltd Intertidal Survey Report. Royal Haskoning DHV (2014)	(Supporting Document: RHDHV, 2014a)
			Brims Otter Survey. Royal Haskoning DHV (2014)	(Supporting Document: RHDHV, 2014b)

Chapter	Title	Contributor	Supporting Studies	As Referenced within ES
			Cantick Head Bird Survey Report. Aquatera (2012)	(Supporting Document: Aquatera, 2012a)
			Sheep Skerry Breeding Bird Survey Report. Aquatera (2015)	(Supporting Document: Aquatera, 2015d)
			Phase 1 Intertidal Habitat Survey for Brims Tidal Array Sheep Skerry Cable Corridor and Landfall Area of Search. Aquatera (2015)	(Supporting Document: Aquatera, 2015a)
			Phase 1 Habitat Survey and Otter Survey at 'Brims Sheep Skerry'. Crossley, J (2015)	(Supporting Document: Crossley, 2015)
			Cantick Head Wintering Greenland Barnacle Goose Report. Aquatera (2012)	(Supporting Document: Aquatera, 2012b)
Chapter 11	Benthic Ecology	Aquatera	*Brims Tidal Array, Orkney Geophysical Survey. Volume 2c: Results Report. February 2014*. Osiris Projects (2014)	(Supporting Document: Osiris, 2014)
			May 2014 Benthic Survey Report September 2014. Aquatera (2014)	(Supporting Document: Aquatera, 2014)
			Sheep Skerry MBES Survey. Brims Tidal Array Project. Aquatera (2015)	(Supporting Document: Aquatera, 2015c)
			Sheep Skerry Benthic Survey Report July 2015. Aquatera (2015)	(Supporting Document: Aquatera, 2015b)
Chapter 12	Fish Ecology	Xodus	*May 2014 Benthic Survey Report September 2014*. Aquatera (2014)	(Supporting Document: Aquatera, 2014)
			Collision Risk Modelling – Atlantic Salmon. Xodus (2016)	(Supporting Document: Xodus, 2016)
			Sheep Skerry Benthic Survey Report July 2015.	(Supporting Document: Aquatera, 2015b)

Chapter	Title	Contributor	Supporting Studies	As Referenced within ES
			Aquatera (2015)	
			Brims Underwater Noise Assessment Report. Xodus (2015)	(Supporting Document: Xodus, 2015)
Chapter 13	Marine Mammals	RHDHV	*Brims Tidal Array. Marine Mammal and Basking Shark Boat Based Visual Survey Data Analysis*. Royal Haskoning DHV (2014)	(Supporting Document: RHDHV, 2014c)
			Analysis of Towed Hydrophone Data Collected at Costa Head, Westray South and Cantick Head Sites Between January and August 2012. MER (2013)	(Supporting Document: MER, 2013)
			Brims Underwater Noise Assessment Report. Xodus (2015)	(Supporting Document: Xodus, 2015)
Chapter 14	Ornithology	NRP	*Brims Tidal Array Seabirds Technical Report*. Natural Research Projects (2015)	(Supporting Document: NRP, 2015a)
			Brims Tidal Array Ltd Collision Risk to Diving Seabirds. Natural Research Projects (2015)	(Supporting Document: NRP, 2015b)
			Distance Sampling Analyses of ESAS Survey Results for the Brims Tidal Array Project. Caloo Ecological Services (2015)	(Supporting Document: Caloo 2015)
Chapter 15	Shipping and Navigation	Anatec	*Traffic Survey During Geophys Work. SSE Renewables (Technical Note).* Anatec (2012)	(Supporting Document: Anatec, 2012)
			Summary of PHA AIS Survey Data. Brims Tidal Array (Appendix B). Anatec (2013)	(Supporting Document: Anatec, 2013)
			Maritime Traffic Survey – Winter 2013. Brims Tidal Array (Technical Note). Anatec (2014)	(Supporting Document: Anatec, 2014a)
			Maritime Traffic Survey – Summer 2014. Brims Tidal Array (Technical Note). Anatec (2014)	(Supporting Document: Anatec, 2014b)

Chapter	Title	Contributor	Supporting Studies	As Referenced within ES
			Navigation Risk Assessment. Brims Tidal Array _ (Technical Note). Anatec (2015)	(Supporting Document: Anatec, 2015)
Chapter 16	Commercial Fisheries	Xodus	*Navigation Risk Assessment. Brims Tidal Array _ (Technical Note).* Anatec (2015)	(Supporting Document: Anatec, 2015)
			Maritime Traffic Survey – Winter 2013. Brims Tidal Array (Technical Note). Anatec (2014)	(Supporting Document: Anatec, 2014a)
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			May 2014 Benthic Survey Report September 2014. Aquatera (2014)	(Supporting Document: Aquatera, 2014)
			Sheep Skerry Benthic Survey Report July 2015. Aquatera (2015)	(Supporting Document: Aquatera, 2015b)
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			SLVIA Baseline and Technical supporting document. Aquatera (2015)	(Supporting Document: Aquatera, 2015e)
Chapter 18	Marine Archaeology and Cultural Heritage	ORCA	*Brims Tidal Array, Orkney Geophysical Survey. Volume 2c: Results Report. February 2014*. Osiris Projects (2014)	(Supporting Document: Osiris 2014)
			Marine Historic Environment Technical Baseline Report. ORCA Marine and SULA Diving (2014)	(Supporting Document: ORCA Marine and SULA Diving, 2014)
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			BRIMS Environmental Scoping Report (August 2013). Brims Tidal Array Ltd (2013)	(Supporting Document: BTAL, 2013)

Chapter	Title	Contributor	Supporting Studies	As Referenced within ES
			The Brims Tidal Array Scoping Opinion (Final) (April 2014). Marine Scotland (2014)	(Supporting Document: MS-LOT, 2014)
Chapter 19	Socio-economics	Aquatera	*Navigation Risk Assessment. Brims Tidal Array _ (Technical Note).* Anatec (2015)	(Supporting Document: Anatec, 2015)
Chapter 20	Recreation and Tourism	Aquatera	*Navigation Risk Assessment. Brims Tidal Array _ (Technical Note).* Anatec (2015)	(Supporting Document: Anatec, 2015)
Chapter 21	Overview of Onshore Impacts	BTAL	Not Applicable	Not Applicable
Chapter 22	Cumulative Impact Assessment	Aquatera	*Brims Underwater Noise Assessment Report*. Xodus (2015)	(Supporting Document: Xodus, 2015)
Chapter 23	Environmental Mitigation, Monitoring and Management	Aquatera	Not Applicable	Not Applicable
Chapter 24	Summary of Key Impacts	Aquatera	Not Applicable	Not Applicable

Need for the Project

Chapter 2

2 NEED FOR THE PROJECT

2.1 INTRODUCTION

This chapter sets the context for climate change and renewable energy including key legislative and policy drivers, identifies what these mean for Scotland, and describes the role the Brims Tidal Array Project (the Project), will play in enabling Scotland to deliver its commitments to developing renewable energy sources.

The key driver for the Project is the development of renewable sources of energy, which is critical for combatting global climate change, and which contributes to improved energy sustainability and security of supply in Scotland.

Climate change and the effect of climate change on the environment have been high on the political agenda since the adoption of the Kyoto Agreement back in 1997. Since then, the European Union (EU) and UK Government have taken significant steps to tackle climate change through the introduction of various Directives, regulations, plans and policies. These set out long-term aims and objectives, and provide a legal framework for tackling climate change that have resulted in the enforcement of a number of targets for reducing carbon dioxide (CO_2) emissions and increasing the amount of energy produced from renewable sources of energy including wind, wave and tidal power.

2.2 CLIMATE CHANGE AND THE ROLE OF RENEWABLE ENERGY

Climate change is described as "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2013).

There is increasing acceptance that excessive burning of fossil fuels and the resultant CO_2 gas emissions into the atmosphere has had, and is continuing to have, a major impact on the world's climate. CO_2 is one of four long-lived greenhouse gases (GHGs) which are naturally occurring gases and which trap heat radiating out from earth in the atmosphere. The trapping of heat in the earth's atmosphere is described as the greenhouse effect and is the natural process which maintains temperatures on earth and stabilises the earth's climate. However, a build-up of these gases leads to increased amounts of heat being trapped in the atmosphere with a resulting acceleration of the warming of the earth.

It is now understood that this accelerated warming has significant impacts on the earth's climate as a result of increased global air and ocean temperatures. It is predicted that a continuation of global emissions of greenhouse gases like carbon dioxide at current levels could result in average global temperatures rising by up to 6°C by the end of this century (IPCC, 2007). In addition to decreases in the average annual cover of snow and ice (IPCC, 2007) the consequence of these temperature increases will be significant with a rise in the frequency of extreme weather events like floods and drought resulting in increased global instability, conflict, public health-related deaths and migration of people to levels beyond any recent experience (DECC, 2011b). Within the UK it is considered that heat waves, droughts, and floods would also become more prevalent (DECC, 2011b).

Climate change also poses a significant economic threat. The Stern Report (Stern, 2006) investigated the economic implications of not addressing climate change and concluded that with no action, the overall costs and risk will be equivalent to losing at least 5% of global gross domestic product (GDP) each year. Taking a wide range of risks and impacts into account, global GDP could be 20% lower than it might otherwise be (Stern, 2006).

A more recent review undertaken by the UK Government outlined the possible risks and impacts associated with climate change for a number of business sectors. Amongst the potential risks were supply chain disruption and increases in energy requirements (HM Government, 2012).

In order to prevent the most severe impacts of climate change, it has now been calculated that global warming needs to be limited to 2ºC above the pre-industrial temperature (DECC, 2011b). This is just 1.2°C above today's level. To stay within this ceiling, mitigation actions are required that substantially reduce greenhouse gas emissions before 2020 (EEA, 2014; DECC, 2011b).

The prevention of climate change may not be possible. However, society and the economy can be protected from its impacts through the development of low carbon energy alternatives. Action needs to be taken to address this issue, energy sources are required that are naturally occurring and inexhaustible, which do not generate CO_2.

2.3 ENERGY SUPPLY

In addition to combatting the impact that carbon emissions from fossil fuel consumption has on the environment, the development of renewable energy sources is also essential for reducing the UK and Scotland's increasing dependency on energy from imported fossil fuels.

Across the UK primary energy production has fallen year on year since 1999. Primary energy production fell by 6.7% from 2012 to 2013, following a decline of 11.7% the previous year and a record fall of 13.2% from 2010 to 2011. There were falls in both oil and gas production caused by long-term decline and maintenance activity on the UK Continental Shelf. Production has now fallen below half of the 1999 levels, an average annual rate of decline of over 7%. In 2004 the UK became a net importer of energy from fossil fuels, in 2012 this dependency increased to 43%. In 2013 the UK imported more coal, manufactured fuels, crude oil, electricity and gas than it exported; this year also saw the UK become an importer of petroleum for the first time since 1984 (DECC, 2013a; DECC, 2014).

The UK and Scotland reliance on imported energy from fossil fuels is considered an unsustainable energy model which places financial and demand risks on the UK through increased global competition for energy resources and an increasing UK population.

2.4 THE KEY DRIVERS FOR RENEWABLE ENERGY

DECC (2012) sets out the need for renewable energy: "For a whole variety of reasons. It will help us get off the fossil fuel hook and reduce our greenhouse gas emissions. If we meet our target of delivering 15% renewables by 2020 it will reduce our overall fossil fuel demand by around 10%. Our gas imports will reduce by 20-30% against what they would have been in 2020. More renewable energy will also bring outstanding opportunities to create jobs and we will become more energy secure".

The key drivers for moving towards providing energy from renewable sources include:

- Tackling climate change;
- Provision of a secure energy supply;
- Developing new infrastructure; and
- Provide economic opportunities.

2.5 ENERGY POLICY AND LEGISLATION

In order to combat climate change significant steps are being taken both globally and at a national level within the UK. These steps are defined through a series of protocols, policy statements and papers that are delivered through various pieces of legislation such as Directives, Acts and Regulations. This is covered in more detail in Chapter 3 Policy and Legislation.

2.6 NEED FOR RENEWABLE ENERGY

The UK is a signatory to the EU Renewable Energy Directive, which includes a UK target of 15% of energy from renewable sources by 2020. 30% of this energy is expected to have to come from renewable electricity generation. Scotland's potential to produce marine renewable electricity is vast, with the total wave and tidal resource in Scotland estimated at 14GW and 7.5GW respectively (Scottish Government, 2011). In September 2008, the Scottish Government published its future approach to energy policy. This recognises that marine renewable energy has a part to play in future energy supply and as part of its strategy to reduce greenhouse gases and tackle global warming.

In 2011 the Scottish Government raised its renewable energy target from 80% to 100% equivalent of Scottish electricity consumption to come from renewable energy sources by 2020. A new target of at least 30% overall energy demand from renewables by 2020 is also committed to in the 2020 Routemap for Renewable Energy in Scotland (Scottish Government, 2011).

Therefore, with such ambitious electricity targets to be achieved from renewable sources and a wealth of wave and tidal resource, energy developments in Scotland's seas will continue to contribute to meeting the Government's renewable energy policy and targets. The 200MW Project would make a significant contribution to these targets.

2.7 NEED TO TACKLE CLIMATE CHANGE

The National Renewable Energy Action Plan (NREAP) sets out how the United Kingdom plans to reach its targets for renewable energy, based on targets identified in the UK Renewable Energy Strategy 2009. These targets include the generation of 15% of UK energy from renewables by 2020, based on 30% renewable electricity, 12% renewable heat and 10% renewable transport (UK Government, 2009).

The Climate Change (Scotland) Act 2009 introduced binding targets on the Scottish Government to reduce net Scottish greenhouse gas emissions by 80% by 2050 from 1990 levels; with an interim target of 42% by 2020. The Scottish Governments' Renewables Action Plan, published in July 2009 and most recently updated in March of 2011, reiterates the targets set in 2007. Support for renewables development, including tidal, is contained in National Planning Framework (NPF) 3 and Scottish Planning Policy (SPP).

The Renewables Obligation Order for Scotland (2002) obliges licenced electricity suppliers to source an increasing proportion of electricity from renewable sources. The current proportion for 2015 is 15.4% and the scheme extends to 2037.

Electricity Market Reform (EMR) proposes to provide a market framework that will facilitate the cost effective delivery of secure supplies of low carbon energy. The EMR will serve to promote investment in green energy infrastructure.

Therefore, adequate reduction of greenhouse gases is still an important target to be achieved by the Scottish Government, with the initial 2007 target re-iterated in 2011 and identified in their Renewables Action Plan. The development of renewable energy devices such as the tidal turbine proposed as part of the Project will assist in achieving such targets by providing 'green energy', reducing the use of finite fossil fuels as well as ensuring Scotland (and the UK) meet international commitments to reduce greenhouse gases under the Kyoto Protocol.

2.8 NEED TO SECURE ENERGY SUPPLY

In addition to combatting the impact that carbon emissions from fossil fuel consumption has on the environment, the development of renewable energy sources is also essential for reducing the UK and Scotland's increasing dependency on energy from imported fossil fuels.

The UK and Scotland's reliance on imported energy from fossil fuels is considered an unsustainable energy model which places financial and demand risks on the UK through increased global competition for energy resources and an increasing UK population. Projects such as the 200MW Brims Tidal Array will help reduce such a reliance on imported energy from fossil fuels in Scotland and the UK. Electricity generated from renewable sources in the UK in 2014 increased by 21% on a year earlier, and accounted for 19.1% of total UK electricity generation, up from 14.8% in 2013. Total renewables, as measured by the 2009 EU Renewables Directive, accounted for 7% of energy consumption in 2014, up from 5.6% in 2013 (DECC, 2015).

2.9 NEED TO MAXIMISE ECONOMIC OPPORTUNITIES

The cost associated with acting on combating climate change through such measures as increased renewable energy production are considered to be significantly lower than not acting. The Stern Report (Stern, 2006) estimates the cost of acting to reduce emissions to a level consistent with avoiding dangerous climate change would be 1 – 2% of GDP by 2050 whereas the cost of doing nothing to tackle climate change will be between 5 – 20% of GDP (Stern, 2006). In the year 2011 to 2012, low carbon and environmental goods and services were worth an estimated £3.4 trillion (Department for Business, Innovation and Skills, 2013).

The energy industries in the UK play a central role in the economy. In 2014, the energy industries contributed 2.8% GDP and directly employed over 162,000 people (5.9% of industrial employment) (DECC, 2015). In addition the number of people employed through low carbon and environmental goods and services in the UK was 937,923 in 2012 and for the same year the value of the sector was estimated at £121.8 billion (Department for Business, Innovation and Skills, 2013). It is estimated that employment levels could rise to more than a million people by 2020 if the UK is able to maximise the opportunity presented by being a world leader in low carbon technologies.

Acting on climate change will stimulate innovation, new technologies and provide further employment opportunities in 'green industries' and will be a key commitment within the UK's Low Carbon Transition Plan to help make the UK a centre of green industry by supporting the development and use of clean technologies (HM Government, 2009).

Chapter 19 Socio-economics provides potential workforce estimates for the different stages as follows Table 2.1.

Table 2.1: Employment estimates for the Project

Stage	Construction and Installation Jobs	Operations and Maintenance Jobs
1	180	17
2	1020	98

To give an understanding of the value to the economy of the Project, standard practice is to estimate the increases Gross Value Added (GVA) that the Project will bring to the area. The GVA calculations for the Project are based on the percentages used for the workforce estimates (Table 2.2 and Table 2.3).

Table 2.2: GVA estimates for different Capex investments

CAPEX Estimates	Capex per MW	Project Stage 1	Project Stage 2
	Industry average	30MW	170MW
Minimum	£4m	£120m	£680m
Median	£5.5m	£165m	£935m
Maximum	£7m	£210M	£1,190M

Table 2.3: Local content estimates using the median figures

GVA Estimates				
Stage	MW	GVA	Construction and Installation	Totals locally
1	30	£165m	30%	£49.5m
2	170	£935m	30%	£280.5m

2.10 NEW INFRASTRUCTURE

On a national scale Scotland has a range of ports and construction facilities that could host the construction activity and benefit from the operation and maintenance activities of the Project.

The construction and operation of any marine energy development is likely to have a number of benefits to the local supply chain, local services and infrastructure as well as social benefits such as:

- Job opportunities;
- Improved infrastructure;
- Improved services;
- Business opportunities in local supply chain; and
- Better communications.

Chapter 19 Socio-economics provides more detail on the local and regional benefits that can arise from the Project of a tidal array of this size.

2.11 CARBON OFFSET

One of the key objectives of the Project and similar renewable energy projects is to reduce greenhouse gas (GHG) emissions by displacing the generation of electricity from fossil fuels e.g. electricity from gas-fired combined cycle gas turbine (CCGT) power stations.

As a reliable and predictable source of clean renewable energy, tidal energy offers significant potential in terms of carbon offsetting. Energy production from tidal resources is not affected by weather conditions and, with water being 830 times denser than air, for the same electricity output tidal turbines can be much smaller than equivalent wind turbines.

In February 2013, Renewable UK published a paper on Wave and Tidal Energy in the UK; Conquering Challenges and Generating Growth (Renewable UK, 2013). This paper suggests that, in the UK, 18TWh/year (terawatt hours per year) of tidal stream energy resources are assessed as being economically recoverable with current technologies. To set this in context, this is approximately 5% of the current UK annual electricity demand (350TWh/year). The paper also notes that, based on DECC's calculated carbon saving of 0.43kg of CO_2 per kWh for wave and tidal electricity generating assets, there is potential for the deployment of 100MW to displace 131,850 tonnes (T) of CO_2 per year.

Therefore carbon savings for this Project are:

- 30MW – 39,555T CO_2 equivalent;
- 170MW – 224,145T CO_2 equivalent; and
- Resulting in a total savings for the 200MW is 263,700 CO_2 equivalent.

As one of the first commercial scale tidal energy array projects to be installed in Scotland, knowledge and experience gained from this Project is essential for informing the continuing growth and development of the tidal energy industry. This growth will help to reduce Scotland's carbon emissions and will make a significant contribution towards achieving the targets for energy generation from renewable sources set out in the 2011 Renewable Energy Roadmap (DECC, 2011a). The Project will provide valuable support to the local Orkney and wider Scottish economies by creating new jobs, new infrastructure and by enhancing sustainable development of the region.

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Policy and Legislation

Chapter 3

3 POLICY AND LEGISLATION

3.1 INTRODUCTION

This chapter provides an overview of international, national and local policy and associated legislation relevant to the Brims Tidal Array Project (the Project) and the assessment of potential environmental impacts. The chapter outlines how the Project contributes towards achieving key policy targets and legislative requirements. A summary of legislation and policy is detailed within Figure 3.1.

3.2 INTERNATIONAL AND EUROPEAN UNION RENEWABLE ENERGY COMMITTMENTS

This Project will help enable international and European Union renewable energy commitments to be met.

3.2.1 Kyoto Protocol and the Doha Amendment

The Kyoto Protocol is an international agreement that was adopted in 1997 through the United Nations Framework Convention on Climate Change. There are currently 192 Parties to the Kyoto Protocol. Its Parties commit to emission reduction targets. It was entered into force in 2005 with the first commitment period running from 2008 to 2012. In 2012, the Doha Amendment to the Kyoto Protocol was adopted. This Amendment includes new commitments as well as a revised list of greenhouse gases. In the first commitment period, the European Community committed to reduce greenhouse gases by 5% compared to the levels recorded in 1990. The second commitment period runs from 2013 to 2020. During the second commitment period, the reduction in greenhouse gases target was increased to 18%.

3.2.2 EU Climate and Energy Package

The Climate and Energy Package is a set of legally binding legislation to ensure the European Union meets 20-20-20 climate and energy targets for 2020 which include 20% reduction in EU greenhouse gas emissions from 1990 levels, 20% improvement in energy efficiency and 20% energy consumption from renewable energy sources.

3.2.3 European Union Renewable Energy Directive 2001/77/EC - the Directive on the Promotion of the use of Energy from Renewable Sources

European Directive 2001/77/EC (Amended by Directive 2006/108/EC and Directive 2009/28/EC); Renewable Energy: the promotion of electricity from renewable energy sources was introduced in 2001. It was designed to promote the development of renewable energy sources in the internal electricity market. It set an original target for renewables of a 12% contribution to electricity production. This was enlarged to a 21% contribution to electricity production by 2020.

In Article three, Annex 1 the Directive states that each Member State should have mandatory national overall targets and measure for the use of energy from renewable sources. In the UK, there is a target to achieve 15% of energy consumption from renewable sources by 2020. Renewable electricity generation is anticipated to contribute 30% of this energy target. Scotland’s potential to produce marine renewable electricity is vast, with the total theoretical wave and tidal energy resource in Scotland estimated by The Crown Estate (2012) at 46TWh/year (18GW) and 32TWh/year (11GW) respectively.

Article four states that each Member State should adopt a national renewable energy action plan. This plan should set out the Member States' national targets for the share of energy from renewable sources consumed in transport, electricity, heating and cooling in 2020.

Year	International Agreements	European Directives	UK Legislation and Regulations	Scottish Commitments	
1997	Kyoto Protocol				Commitment by EU + 37 other countries to reduce GHG emissions by 5% compared to 1990 levels by 2012 and 18% by 2020.
2007		EU Climate Change Energy package			Package of legally binding legislation for meeting the EU's 20-20-20 climate and energy targets for 2020 which include 20% reduction in GHG emissions, 20% energy efficiency and 20% energy consumption from renewable sources.
2008			UK Climate Change Act 2008		Makes legal requirement for UK Government to cut carbon emission by 80% compared to 1990 levels by 2050.
2009		EU Renewable Energy Directive (2009/28/EC)			Sets out legally binding targets for all Member States to achieve the 20-20-20 targets set out in 2007.
			UK Renewable Energy Strategy 2009		Set out how UK Government will achieve its goal of generating 15% of UK energy from renewables by 2020 based on 30% renewable electricity, 12% renewable heat and 10% renewable transport.
				The Climate Change (Scotland) Act 2009	Introduces binding targets on the Scottish Government to reduce net Scottish greenhouse gas emissions by 80% by 2050 from 1990 levels; with an interim target of 42% by 2020
				Marine and Coastal Access Act 2009	The Marine and Coastal Access Act 2009 (MCAA) puts in place a system for management and protection of the marine and coastal environment. The Scottish Government has devolved power for marine planning and conservation in the offshore region (12 to 200 nm) under the MCAA.
2010			National Renewable Energy Action Plan (NREAP) 2010		Prepared in accordance with the EU Renewable Energy Directive. Sets out how UK plans to reach individual targets for renewable energy based on targets identified in the UK Renewable Energy Strategy 2009.
				Marine (Scotland) Act 2010	Marine (Scotland) Act 2010 provides a framework for the sustainable management of Scotland's seas with measures for marine planning, licensing and conservation. Key aim is to streamline and simplify the licensing and consenting process for offshore renewable projects.
2011		EC Roadmap for a Low Carbon Economy in 2050			Long-term policy plan which sets out a cost effective pathway for achieving a competitive low carbon economy in 2050.
			UK Renewable Energy Roadmap 2011		Sets out further actions for achieving UK 2020 targets. Progress against the UK Roadmap is reported annually.
				The Scottish Government's (2011) Renewables Action Plan	Published in July 2009 and updated in March of 2011 as the Routemap for Renewable Energy in Scotland, reiterates these targets set by the Climate Change (Scotland) Act 2009
2013				Draft Sectoral Marine Plans 2013	Sectoral Marine Plans are in development alongside Regional Locational Guidance (RLG) to facilitate the development of offshore wind, wave and tidal energy in Scottish waters.
2014		EU 2030 Framework for Climate and Energy Policies			Framework for creating a low carbon economy 2050. Central to the framework is target to reduce EU domestic GHG emissions by 40 % compared to 1990 levels by 2030.
2015				National Marine Plan 2015	Identifies certain key objectives for management of the marine environment and in particular recognises the role offshore renewables could play in promoting economic growth

Figure 3.1: Key international and national legislation and policy for marine renewables

In September 2008, the Scottish Government published its future approach to energy policy which recognises that marine renewable energy has a role in future energy supply as part of its strategy to increase energy security, diversify the energy mix and reduce greenhouse gases to tackle climate change (The Scottish Government, 2008).

The Scottish Government target for renewable electricity generation is 100% gross annual consumption by 2020 (Scottish Government, 2013). Therefore with such ambitious electricity targets to be achieved from renewable energy sources and a considerable wave and tidal resource in Scotland, marine energy projects such as this Project have the potential to make a significant contribution to meeting the Government's renewable energy targets and maintaining 100% renewable power generation as demand continues to increase beyond 2020.

3.2.4 EC Roadmap for a Low Carbon Economy 2011

The 2011 European Commission roadmap represents long-term policy plan which sets out a cost effective pathway for moving to a competitive low carbon economy by 2050 (European Commission, 2011).

3.2.5 EU 2030 Framework for Climate and Energy Policies

This 2030 policy framework aims to make the European Union's economy and energy system more competitive, secure and sustainable through the setting of a target of at least 27% for renewable energy and energy savings by 2030 (European Council, 2014).

3.3 NATIONAL RENEWABLE ENERGY COMMITMENTS

This Project will help enable national renewable energy commitments to be met.

3.3.1 National Renewable Energy Action Plan (NREAP) 2010 and UK Renewable Energy Strategy 2009

Prepared in accordance with Article 4 of the EU Renewable Energy Directive 2009/28/EC, the National Renewable Energy Action Plan (UK Government, 2009) sets out how the United Kingdom plans to reach its targets for renewable energy, based on targets identified in the UK Renewable Energy Strategy 2009. These targets include the generation of 15% of UK energy from renewables by 2020, based on the 30% renewable electricity, 12% renewable heat and 10% renewable transport.

3.3.2 The Climate Change (Scotland) Act 2009 and the Scottish Governments Renewables Action Plan 2011

The Climate Change (Scotland) Act introduces binding targets on the Scottish Government to reduce net Scottish greenhouse gas emissions by 80% by 2050 from 1990 levels; with an interim target of 42% by 2020. The Scottish Government's (2011) Renewables Action Plan, published in July 2009 and updated in March of 2011 as the Roadmap for Renewable Energy in Scotland, reiterates these targets set in 2009. It also sets out a target for 100% electricity consumption in Scotland to come from renewable sources by 2020. Support for renewable energy developments, including tidal, is contained in National Planning Framework (NPF) 3 and Scottish Planning Policy (SPP).

The deployment and operation of tidal energy devices will assist in achieving binding emissions reduction targets by providing a low carbon and renewable energy resource, reducing reliance on finite fossil fuels and ensuring Scotland and the UK meet international commitments to reduce greenhouse gases under the Kyoto Protocol.

3.4 MARINE PLANNING REQUIREMENTS

3.4.1 Marine and Coastal Access Act 2009

The Marine and Coastal Access Act 2009 (MCAA) puts in place a system for management and protection of the marine and coastal environment and therefore ensures clean, healthy, productive and biologically diverse oceans and seas. The MCAA is also designed to streamline the marine planning system. The Scottish Government has devolved power for marine planning and conservation in the offshore region (12 to 200nm) under the MCAA.

3.4.2 Marine (Scotland) Act 2010

The Marine (Scotland) Act 2010 has introduced a marine planning regime for Scotland's marine area. The Scottish Government has the responsibility for marine planning within both Scottish territorial waters (STW) (0 -12nm), and within the Scottish Renewable Energy Zone (REZ) (12 – 200nm).The Marine (Scotland) Act 2010 provides a framework for the sustainable management of Scotland's seas with measures for marine planning, licensing and conservation. One of its key aims is to streamline and simplify the licensing and consenting process for offshore renewable projects.

Projects have historically been required to seek licences and planning consent under several pieces of legislation before the development can proceed. However, with the introduction of the Act, co-ordinated applications for planning consent and associated licences (under the Electricity Act, the Coastal Protection Act, and the Food and Environment Protection Act) can now be made via a single point of contact, Marine Scotland Licensing Operations Team (MS-LOT), as part of a unified consenting and licensing process.

3.4.3 Section 36 Electricity Act 1989

Any applications for power stations over a certain capacity must be made to Scottish ministers under Section 36 of the Electricity Act 1989. This capacity is over 1MW within UK territorial waters and above 50MW and up to 100MW in the UK Renewable Energy Zone (REZ).

3.4.4 National, Regional and Sectoral Marine Plans

Under the Marine (Scotland) Act 2010, new statutory marine planning systems were brought into place to manage resources in the Scottish marine environment. In addition to this, the Scottish Government worked with the UK Government, the Welsh Assembly, and the Northern Ireland Executive in order to adopt a UK-wide Marine Policy Statement. This was agreed in March 2011. It sets the policy context within which administrations will develop regional and national marine plans. It will be used to influence authorisation and enforcement decisions across the UK.

In March 2015, the Scottish Government published its National Marine Plan (Scottish Government, 2015) which covers both Scottish territorial waters and the Scottish renewable energy zone. The Plan identifies certain key objectives for management of the marine environment and in particular recognises the role offshore renewables could play in promoting economic growth and tackling climate change.

The establishment of Regional Marine Plans will enable planning decisions to be made at a local level. A pilot marine spatial plan for the Pentland Firth and Orkney Waters (PFOW) strategic area was undertaken and outlined different users in the PFOW area, how such activities may cause interaction and recommendations for avoiding conflict. Such planning systems will enable the integration of marine renewable energies into the marine environment and contribute towards Government targets to achieve 100% of Scottish electricity consumption from renewable energy sources by 2020.

Sectoral Marine Plans are in development alongside Regional Locational Guidance (RLG) to facilitate the development of offshore wind, wave and tidal energy in Scottish waters. These plans will explore how marine energy can contribute to meeting Government renewable electricity targets and in achieving a low carbon economy. The Tidal RLG (Scottish Government, 2012) contains information relating to future search areas for tidal energy, such as the PFOW which has been identified as having a significant energy resource, and considers the technical, environmental and socio-economic issues associated with the offshore renewable energy regions of Scotland.

The Scottish Government's Strategic Environmental Assessment (SEA) on Marine Renewables in 2007 (Scottish Government, 2007) concluded that the deployment of new technology, particularly marine renewable devices, would carry a degree of uncertainty regarding potential associated environmental impacts. As a result, a risk-based 'Survey, Deploy and Monitor Policy' has been adopted in principle to enable efficient, sustainable deployment of wave and tidal energy devices.

Therefore, marine planning policy in UK waters will facilitate the integration of renewable energy developments within the marine environment. Currently, regional marine plans are still in draft formation but identify the key role offshore renewable energy will play in increasing economic growth and reducing the effects of climate change.

3.4.5 Marine Protected Areas

Under the Marine (Scotland) Act the Scottish Government has tasked Marine Scotland, Scottish Natural Heritage (SNH), JNCC, Scottish Environment Protection Agency (SEPA) and Historic Scotland to designate particular features of conservation interest and develop a network of Marine Protected Areas (MPAs) within Scottish territorial waters. These will include Nature Conservation MPAs, designated for nationally important marine wildlife, habitats, geology and undersea landforms; demonstration/research MPAs, to demonstrate or research sustainable methods of marine management or exploitation; and Historic MPAs for features of historic/cultural importance such as shipwrecks and submerged landscapes (JNCC, 2014). The Nature Conservation MPAs designated for habitats and species will together with existing Natura sites and other conservation designations form a network of MPAs. At present thirty MPAs have been designated in Scotland and proposed management measures for these sites are undergoing public consultation (Scottish Government, 2014). None of these proposed sites cover or are adjacent to the Project site.

3.5 TERRESTRIAL REQUIREMENTS

Planning permission will be required from Orkney Islands Council (OIC) through the Town and Country Planning (Scotland) Act 1997 for the cable landfall area and the onshore cable corridor. As discussed in Section 1.6 Consenting Strategy the onshore components associated with the proposed development are not considered within this ES as these components will be covered within a future onshore Environmental Statement, if applicable, which will accompany the relevant planning and consent applications.

3.5.1 Town and Country Planning (Scotland) Act 1997

Onshore works from Mean Low Water Spring (MLWS) will be consented by the onshore planning authority under the Town and Country Planning (Scotland) Act 1997.

This ES contains components of the Project up to the Mean High Water Spring tide (MHWS). With associated overlap with the Section 36 and Marine Licence where applicable.

The Orkney Local Development Plan, adopted in April 2014, sets out the vision and strategy for the development of land in Orkney over the subsequent 10-20 years (OIC, 2014). Determination of a development proposal will be made 'in accordance with the Plan unless material considerations indicate otherwise' under Section 25 of The Town and Country Planning (Scotland) Act 1997.

In principle, Policy SD6 of the Plan states that upgrades and infrastructure for marine renewable energy developments will be supported by OIC provided that an appropriate assessment is made and mitigation measures are put in place to ensure that the proposal does not have any significant effects. Supplementary guidance is still to be developed by OIC with regard to the appropriate location, siting and design considerations of onshore infrastructure requirements for marine renewables.

3.6 ENVIRONMENTAL IMPACT ASSESSMENT REQUIREMENTS

This ES has been produced in accordance with EIA legislative requirements listed below.

3.6.1 The EU Environmental Impact Assessment Directive (Council Directive 2014/52/EU)

The EIA Directive (Council Directive 85/337/EEC as amended by Council Directive 97/11/EC, 2003/35/EC and 2009/31/EC and 2014/52/EU) defines the limits by which a project may fall under the category of Mandatory EIA (Annex I), or may be at discretion of Member States (Annex II). It was first brought into force in 1985 but has since undergone a number of amendments. The latest amendment in 2014 was designed to simplify the rules of environmental assessment and to reduce the administrative burden. There is more focus on resource efficiency, climate change and disaster prevention. Timeframes have been introduced for the different stages of environmental assessment in attempt to speed up the process of decision making.

The purpose of the EIA Directive is to ensure that the relevant authority has sufficient information on the possible significant effects on the environment in order to make informed decisions on granting consent.

Another requirement of the EIA Directive, and of the EC Habitats Directive 92/43/EEC, is to assess cumulative effects of a project. EIA regulations have been enacted into law in relation to various consents and permits which required cumulative or in-combination effects to be taken into account. A Cumulative Impact Assessment has been carried out for this Project (Chapter 22 Cumulative Impact Assessment).

3.6.2 The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended)

The Electricity Works Regulations implement the European EIA Directive and outline the requirement for assessment of the effects of certain public and private projects on the environment. Such projects include the construction, extension and operation of a power station or overhead electricity lines under Sections 36 and 37 of the Electricity Act (1989).

As the Project is over 1MW and requires Section 36 Consent, it is considered to be a Schedule 2 development under The Electricity Works (EIA) (Scotland) Regulations 2000 (as amended); defined as:

> *"a generating station, the construction of which (or the operation of which) will require a Section 36 consent but which is not a Schedule 1 development".*

To ensure full compliance with the regulations, BTAL has undertaken an Environmental Impact Assessment and produced this Environmental Statement (ES) to accompany its Section 36 Consent application.

Under Regulation 7, BTAL requested a 'Scoping Opinion' from Scottish Ministers, before submitting an application for a Section 36 consent under the Act, to state in writing what information should be provided in the ES. Marine Scotland, acting on behalf of Scottish Ministers, is required to consult and obtain the views of the Consultative Bodies (the local Planning Authorities, SNH and SEPA and other organisations (as deemed necessary). Feedback received from stakeholders (Supporting Document: MS-LOT, 2014) is used to inform the content of the EIA, determining the key issues and impacts to be assessed.

3.6.3 The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended)

The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) transpose some of the requirements of the EIA Directive 85/337/EC (as amended) in terms of Marine Licences. The EIA procedures apply to certain works undertaken in the marine environment including activities which require a Marine Licence under the Marine (Scotland) Act 2010. The regulations apply to regulated activities including deposits in the sea, works to ensure navigational safety, and harbour works.

3.7 OTHER LEGISLATIVE REQUIREMENTS

3.7.1 Pre Application Consultation

Pre Application Consultation (PAC) is a statutory requirement under the Marine Licensing (Pre Application Consultation) (Scotland) Regulations 2013 for the construction of a renewable energy structure in or over the sea or on or under the seabed, where the total area in which the structure is to be located exceeds 10,000 square metres (Marine Scotland, 2014). Applicants must engage with the public and third sector organisations in advance of a formal application being made. The applicant must hold a public consultation event and produce a pre-application report. The process allows for feedback from these consultations to inform the nature of the application.

BTAL have carried out consultation throughout screening and scoping and in preparation of the ES and are continuing with ongoing consultation throughout the application process (See Chapter 6 Consultation Process).

3.7.2 Conservation (Natural Habitats) Regulations 1994 (as Amended)

Under the Conservation (Natural Habitats, & C.) Regulations 1994 (as amended by the Conservation of Habitats and Species Regulations 2010 as amended by The Conservation of Habitats and Species (Amendment) Regulations 2012 ,S.I. 2010/490, amended by S.I. 2011/603 and 625 and 2012/637), and the Offshore Marine Conservation (Natural Habitats, & C.) (Amendment) Regulations 2010), where a development is proposed in or near to a Natura 2000 site, or in an area recognised as an important site for marine species which are a feature of a Natura 2000 site, the competent authority determine, and inform the developer as early as possible, on the requirement to undertake an Appropriate Assessment (AA) prior to granting the relevant consents and licences for development. A Habitats Regulations Appraisal (HRA) is required for the Project (See Chapter 6 Consultation Process; Supporting Document: BTAL, 2015c).

3.7.3 European Protected Species (EPS)

For any European Protected Species (EPS), Regulation 39 of the Conservation (Natural Habitats, & c.) Regulations 1994 makes it an offence to deliberately or recklessly capture, kill, injure, harass or disturb any such animal. An EPS Licence is required for any activity that might result in disturbance to EPS. In the case of the Project any requirement for an EPS Licence would be on advice from SNH to Marine Scotland as the Licensing Authority.

3.7.4 Energy Act (2004) (Safety Zones)

If a development requires planning consent under Section 36 of the Electricity Act (1989), it may also require a safety zone to be applied. Section 95 and Schedule 16 of the Energy Act (2004) states that there must be a safety zones placed around or adjacent to offshore renewable energy installations (OREI). This applies to territorial waters of England, Scotland and Wales and the UK REZ. A safety zone must be applied for and is subject to consultation. A safety zone can be applied for any one phase of the life of an OREI (Construction, maintenance, decommission etc.) but it is more likely that a developer will apply for a combined safety zone to cover construction and major maintenance. This safety zone, once approved, will be reviewed periodically by BTAL with the relevant Licensing Authority and the Maritime and Coastguard Agency.

3.7.5 Energy Act (2004) (Decommissioning)

Sections 105 to 114 of the Energy Act (2004) state that offshore installations must submit a detailed decommissioning programme for approval to the Department of Energy and Climate Change (DECC). This ensures that the decommissioning plan is in agreement with UK legislation (Coast Protection Act 1949, the Food and Environment Protection Act 1985, the Water Resources Act 1991 and others) as well as international obligations. The Act states that decommissioning solutions should be found that meet these requirements as well as acting in line with the principles of sustainable development.

Table 3.1 summarises the consents necessary for the Project.

Table 3.1: Summary of necessary consents for offshore development

Nature of Consent	Legislation	Licensing Authority	Description
Section 36 Consent	Electricity Act 1989	Scottish Ministers (administered by Marine Scotland)	Required for both stages of the Project, the installation of inter-array cables and subsea cables to landfall area.
Marine Licence	Marine (Scotland) Act 2010	Marine Scotland	Required for marine project components up to Mean High Water Spring tide zone (MHWS), under Part 4 of the Marine (Scotland) Act 2010. Licence required for all deposits on the seabed such as the placement of an array, export cable, or substation and includes the removal of materials such as for seabed preparation.
Seabed Lease	Crown Estate Act 1961	The Crown Estate Commissioners	Seabed rights may be granted for development following receipt of other statutory consents and fulfilment of conditions specified in the AfL area.
Harbour Works Licences	Orkney County Council Act 1974	OIC Marine Services	May be required for works within or in approaches to the statutory Harbour Authority Area, and where the authority has Works Licensing Powers (ability to regulate right of navigation and fishing within area).
Safety zones	Section 95 of the Energy Act 2004	DECC	Application for Safety Zones during construction and operational activities.
Habitats Regulations Appraisal (HRA) for Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)	The Conservation of Habitats and Species Regulations 2010 (as amended) and The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007/1842 (as amended)	Marine Scotland and SNH	Required where there is potential connectivity with a Natura site and its qualifying features and the proposed development i.e. whether the proposal is likely to have a significant effect (Likely Significant Effect) on the site either individually or in-combination with other plans or projects; and whether an appropriate assessment of the implications (of the proposal) for the site in view of that site's conservation objectives is required.

Nature of Consent	Legislation	Licensing Authority	Description
European Protected Species (EPS)/ Wildlife and Natural Environment (WANE) Licences	Habitats Directive (92/43/EEC); The Conservation and Habitats Regulations 2010; Offshore Marine Regulations 2007 (as amended); Wildlife and Countryside Act (1981) (as amended); Wildlife and Natural Environment (Scotland) Act 2011 (WANE).	Marine Scotland on behalf of Scottish Ministers and on advice from SNH/JNCC	Licences may be required where any activity relating to the Project might result in a disturbance of protected species. Marine Scotland are responsible for issuing EPS/WANE licences for cetaceans and basking sharks, while SNH are responsible for issuing licences for otters, bats and nesting birds.
Approved Decommissioning Programme	Sections 105 to 114 of the Energy Act 2004	DECC	Offshore installations must submit a detailed decommissioning programme for approval to DECC.

3.8 REFERENCES

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Site Selection and Alternatives

Chapter 4

4 SITE SELECTION AND ALTERNATIVES

4.1 INTRODUCTION

This chapter of the Environmental Statement (ES) includes a description of the alternative sites and approaches considered for the Brims Tidal Array Project (the Project), and an explanation of the basis for the selection of the preferred Project.

4.2 SITE SELECTION

The key steps involved in selecting an appropriate site for development can be summarised as follows:

- Site selection;
- Site characterisation; and
- Detailed design.

The following sections outline the processes BTAL undertook to select a suitable site and further characterise the site to inform project design and the impact assessment. This is the step prior to detailed design which occurs post consent determination when turbine specifications, offshore architecture and array layout, for example, are confirmed in advance of installation.

In seeking a suitable site for the development of a tidal energy project one of the fundamental drivers is the location of the tidal resource suitable for exploitation by tidal energy technology. Tidal resource is by its nature more spatially constrained compared to other offshore renewable energy resources such as offshore wind and wave, and therefore project location must be carefully considered to ensure the successful development of a tidal stream energy project. The UK Marine Energy Atlas (ABPmer, 2008) and The Tidal Current Resource and Economics report commissioned by The Carbon Trust in 2011 (Carbon Trust, 2011) identified the Pentland Firth and Orkney Waters as a key potential tidal energy resource that could be suitable for commercial scale development. This is consistent with the findings of the Scottish Marine Renewables Strategic Environmental Assessment (SEA) commissioned by the Scottish Government in 2007 (Scottish Government, 2007) which identified the Pentland Firth as a tidal energy resource hotspot.

4.3 INITIAL SITE SELECTION

In 2004 a report prepared by the Marine Energy Group (MEG) (FREDS, 2004) identified that up to 10% of Scotland's electricity generation (about 1,300 megawatts, MW) could come from wave and tidal stream power by 2020. As such, this would contribute significantly to the Scottish Executive's target of 40% of electricity generated in Scotland to be from renewable sources by 2020.

The Scottish Executive commissioned this Strategic Environmental Assessment (SEA) to examine the environmental effects from the development of wave and tidal power and to use the results to inform the preparation and delivery of the Scottish Executive's strategy for the development of marine energy (Scottish Government, 2007). The key objectives of the SEA were as follows:

- To assess, at the strategic level, the effects on the environment of meeting or exceeding the Marine Energy Group's estimate of 1,300MW of marine renewable energy capacity around Scotland by 2020;

- To advise and support the Scottish Executive in the development and implementation of its strategy for marine renewable energy and to inform future development of planning guidance for marine developers;
- To inform the Project-level decision-making process for all stakeholders (to include the Licensing Authority and developers); and
- To facilitate focused investment into the marine renewable energy sector in Scotland.

Following completion of the SEA in 2008, The Crown Estate issued an invitation to tender for development rights for tidal energy projects in the Pentland Firth and Orkney Waters Leasing Round (PFOW) to marine energy developers. Figure 4.1 illustrates the PFOW lease area that was presented to developers for consideration. The Pentland Firth and Orkney Waters area was the first to be made available for commercial scale development of wave and tidal energy in Scotland and the whole of the UK by The Crown Estate with a total capacity of 1,600MW.

Consultants were engaged in 2008 and 2009 to undertake regional scale assessments of the PFOW to assist with the identification of suitable locations for which to submit a tender under The Crown Estate's programme. A number of key criteria and constraints were included in this initial assessment including:

1. Technical Constraints Mapping;
2. Environmental Constraints Mapping;
3. Tidal Resource Assessment; and
4. Evaluation of Grid Connection Options.

High level information from these assessments and how they informed identification of potential sites is provided below.

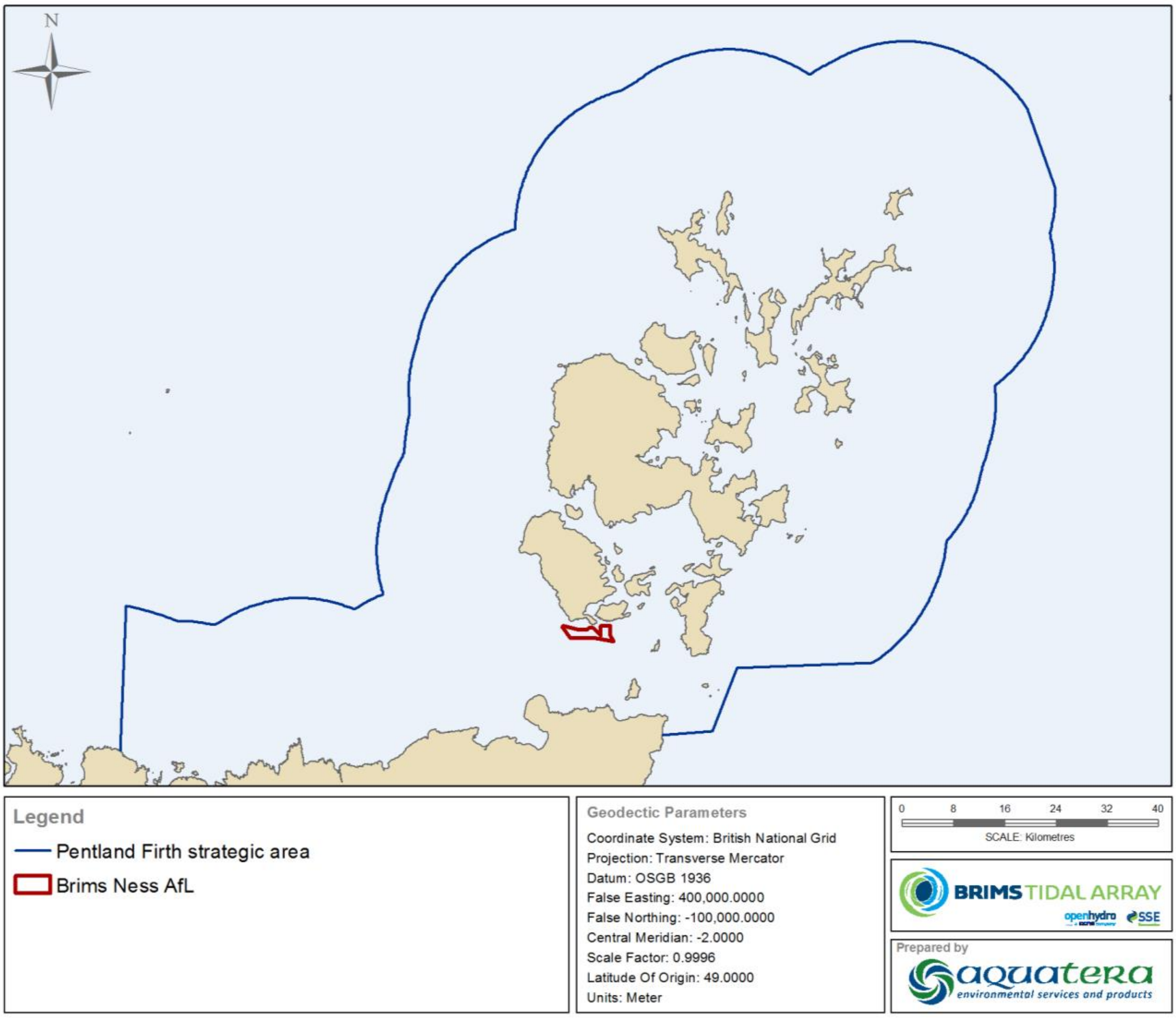


Figure 4.1: The Pentland Firth and Orkney Waters Strategic Area

4.3.1 Technical Constraints Mapping

The technical constraints considered during the site selection process included site bathymetry for the offshore infrastructure, and a large number of constraints associated with locating a substation (in turn leading to constraints in the location of the offshore components of the Project).

Halcrow Group Limited were commissioned in 2009 to increase the understanding of the likely ground conditions to be encountered at the site, the availability and quality of existing information and the residual levels of uncertainty about the geophysical and geotechnical conditions in the area of interest (Halcrow, 2009). Figure 4.2 illustrates the 3D ground model for the PFOW area.

This desk study report reviewed the existing geological and geotechnical data and used these data to develop a regional ground model to:

- Characterise the ground conditions and potential geotechnical constraints;
- Review the suitability of ground conditions for facilities infrastructure, given current data availability and related data uncertainty; and
- Provide recommendations for appropriate levels of geophysical and geotechnical data acquisition to resolve key data uncertainties.

In addition to this assessment, a review of available geophysical data was carried out by the developer. This review identified areas that were too shallow or too deep to support the deployment of tidal turbines. These sites were scoped out of the selection process as a result.

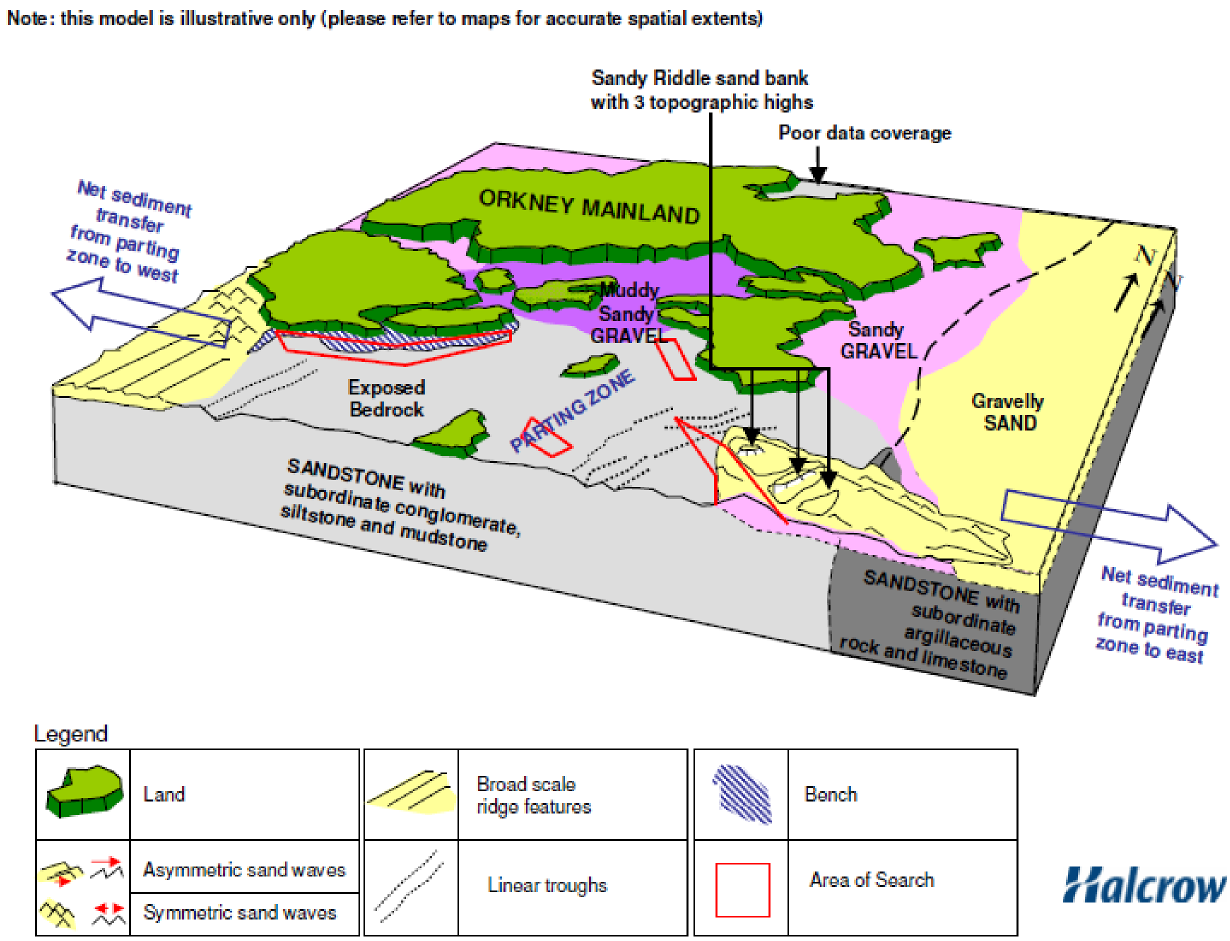


Figure 4.2: Detailed 3D ground model for deep tidal sites (Pentland Firth), (Halcrow, 2009)

4.3.2 Environmental Constraints Mapping

Xodus Aurora and Aquatera completed a regional constraints mapping exercise looking at the PFOW in February 2009 (Xodus Aurora, 2009). Constraints considered and mapped included:

- Designated sites (Special Area of Conservation (SAC), Special Protection Area (SPA), RAMSAR, National Scenic Area (NSA), World Heritage Site (WHS));
- Seabed habitats;
- Marine mammal areas (seals and cetaceans);
- Military activity areas;
- Spoil grounds;
- Material Assets;
- Fisheries and mariculture interests/sites; and
- Navigational constraints.

Figure 4.4 illustrates the regional constraints mapping for the southern Orkney Isles.

This environmental study was essential for identifying the key environmental issues relevant to any potential development and assisted in determining the existing environmental conditions and constraints, all of which were taken into consideration during the site selection process. The study also demonstrated the level of investigation required to enable an assessment of the likely significant impacts of the proposed development.

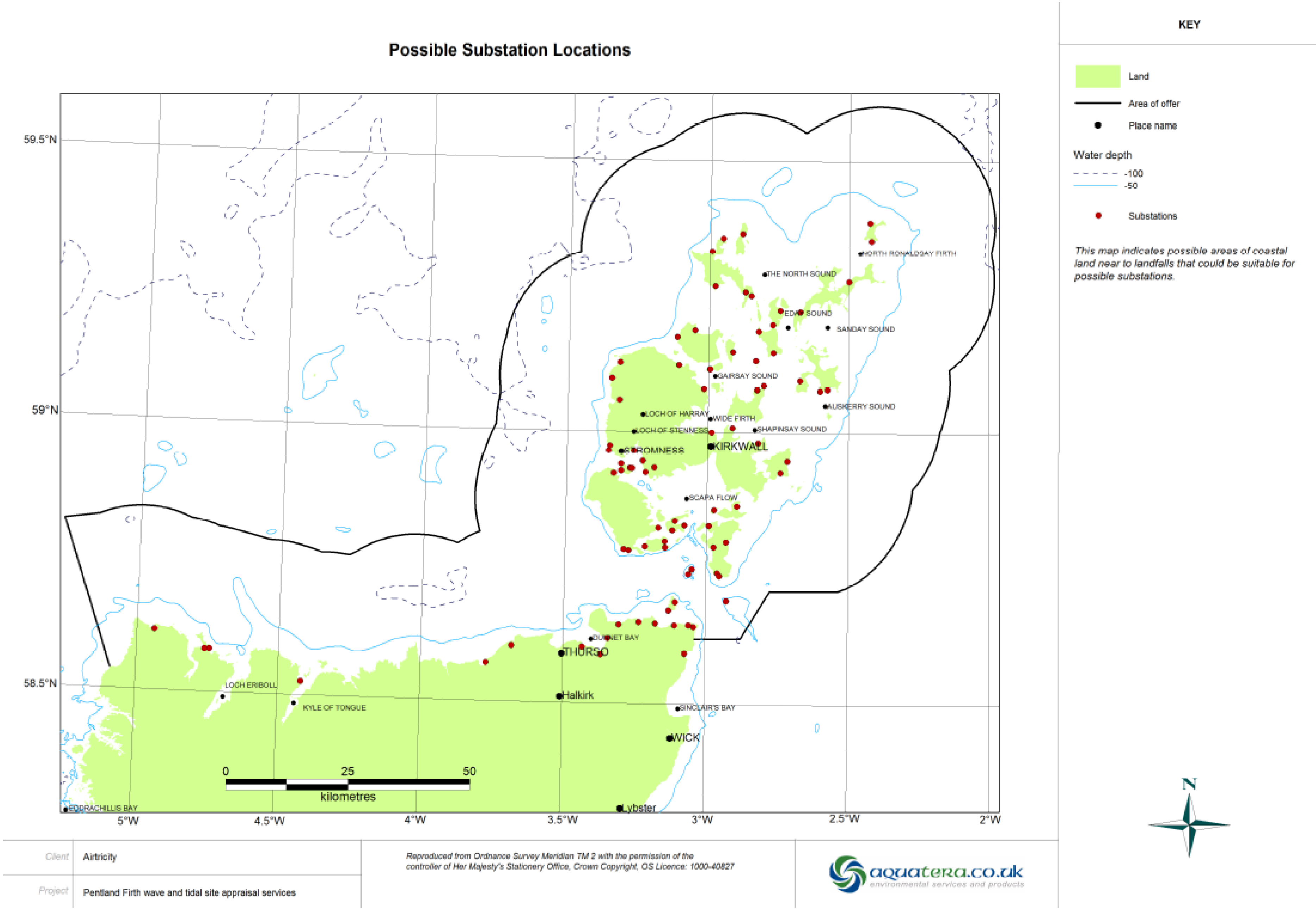


Figure 4.3: Review of possible substation locations (Aquatera, 2009)

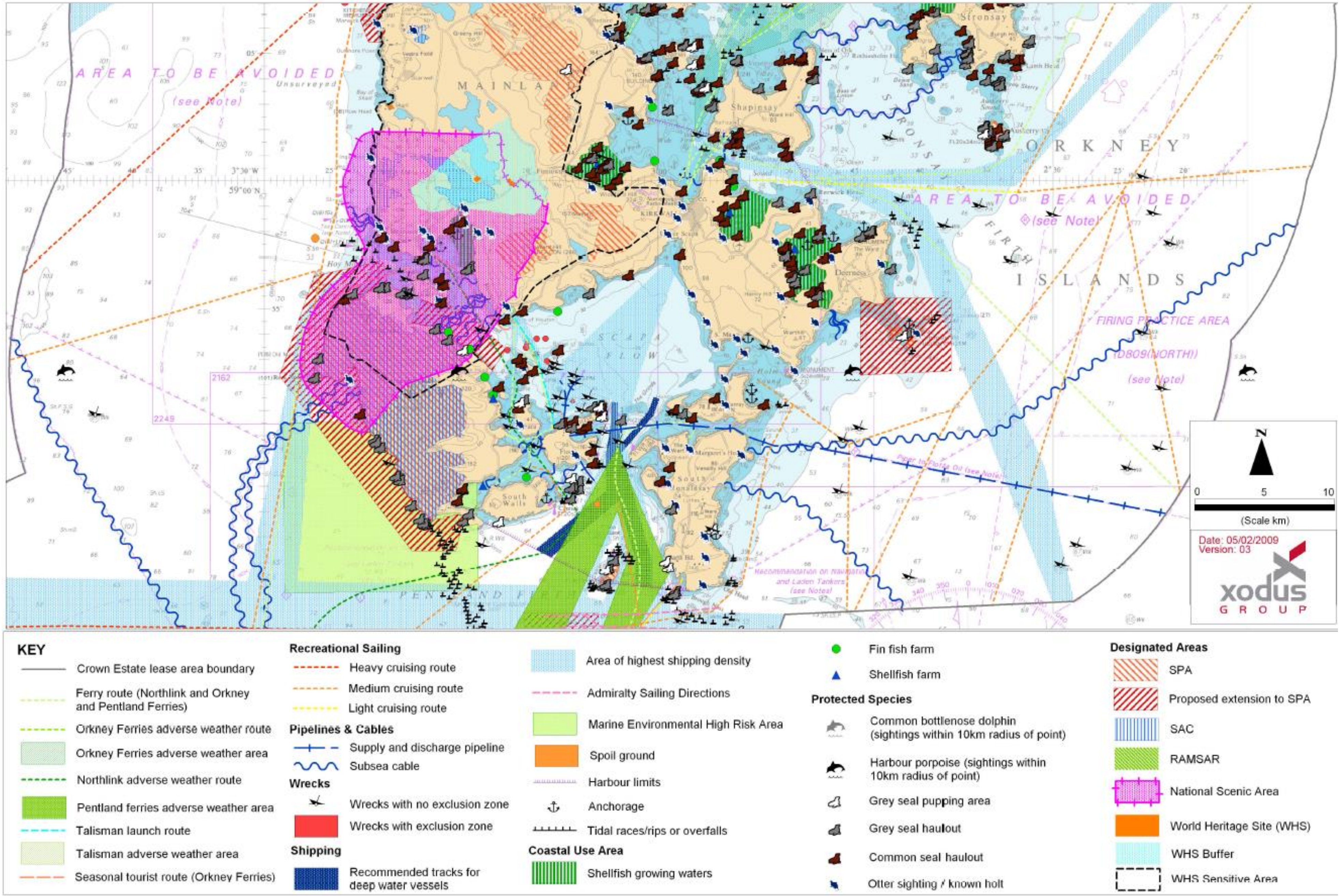


Figure 4.4: Regional constraints mapping (Xodus Aurora, 2009)

4.3.3 Tidal Resource Assessment

Black and Veatch undertook a modelling exercise to assess the tidal stream resource in the Orkney Islands in May 2009 (Black & Veatch, 2009). The Black and Veatch model was run to simulate a period of 42 days to cover a typical lunar cycle from a typical year (neither extreme weather conditions nor extreme astronomical cycle encountered) in order to get the best estimate of the mean power density over the area modelled. The results, illustrated in Figure 4.6, highlighted areas of potential interest for tidal energy extraction with regard to raw resource and bathymetry.

4.3.4 Evaluation of Grid Connection Options

Aquatera was commissioned in 2008 to provide a review of potential locations for grid infrastructure and interconnecting routes based on various constraining factors (Aquatera, 2009). Constraints considered as part of this review included:

- Possible converter station locations;
- Possible substation locations;
- Possible cable landfall locations;
- Possible directional drilling locations;
- Possible landward cable routes;
- Routes from substations to converter stations;
- Possible tidal generation points;
- Possible routes from tidal generation points to substations;
- Possible seaward cable routes; and
- Port facilities for Installation and Operation and Maintenance.

Figure 4.3 illustrates the potential substation locations that were considered as part of this review.

Following this, Senergy was commissioned in 2009 to carry out a desktop study based on forecast power flows, generation, demand and planned infrastructure (Senergy, 2009). The primary aims of this study were to:

- Identify any available capacity in the existing Scottish Hydro Electricity Power Distribution Limited (SHEPD) 33kV network;
- Identify any available grid capacity and a likely connection strategy for commercial scale projects in the Pentland Firth strategic area; and
- Identify and evaluate grid connection options recommend a preferred grid connection solution.

4.3.5 Preferred Site Identified

Based on the data collected during the studies discussed above, an area off South Walls, near Cantick Head, illustrated in Figure 4.5, was identified as a location which was potentially suitable for the construction of a commercial scale tidal project. In particular the water depth and tidal resource, relatively flat ground conditions and lack of significant environmental constraints were key factors in support of this location. Subsequently, a bid package was submitted to the Crown Estate for the development of a tidal array at the Cantick Head site under the Crown Estate's Agreement PFOW licensing process.

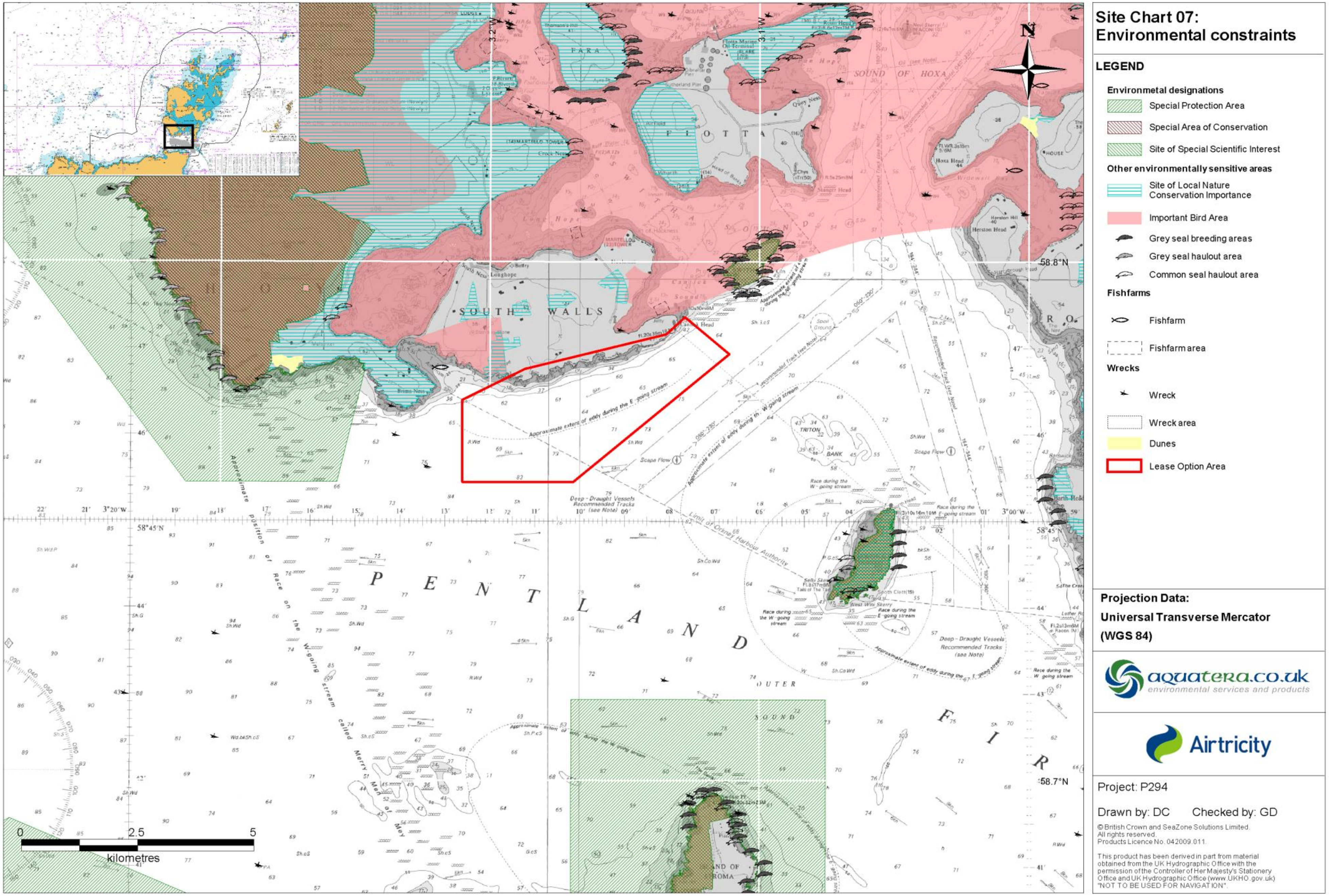


Figure 4.5: Cantick Head site included in TCE leasing round

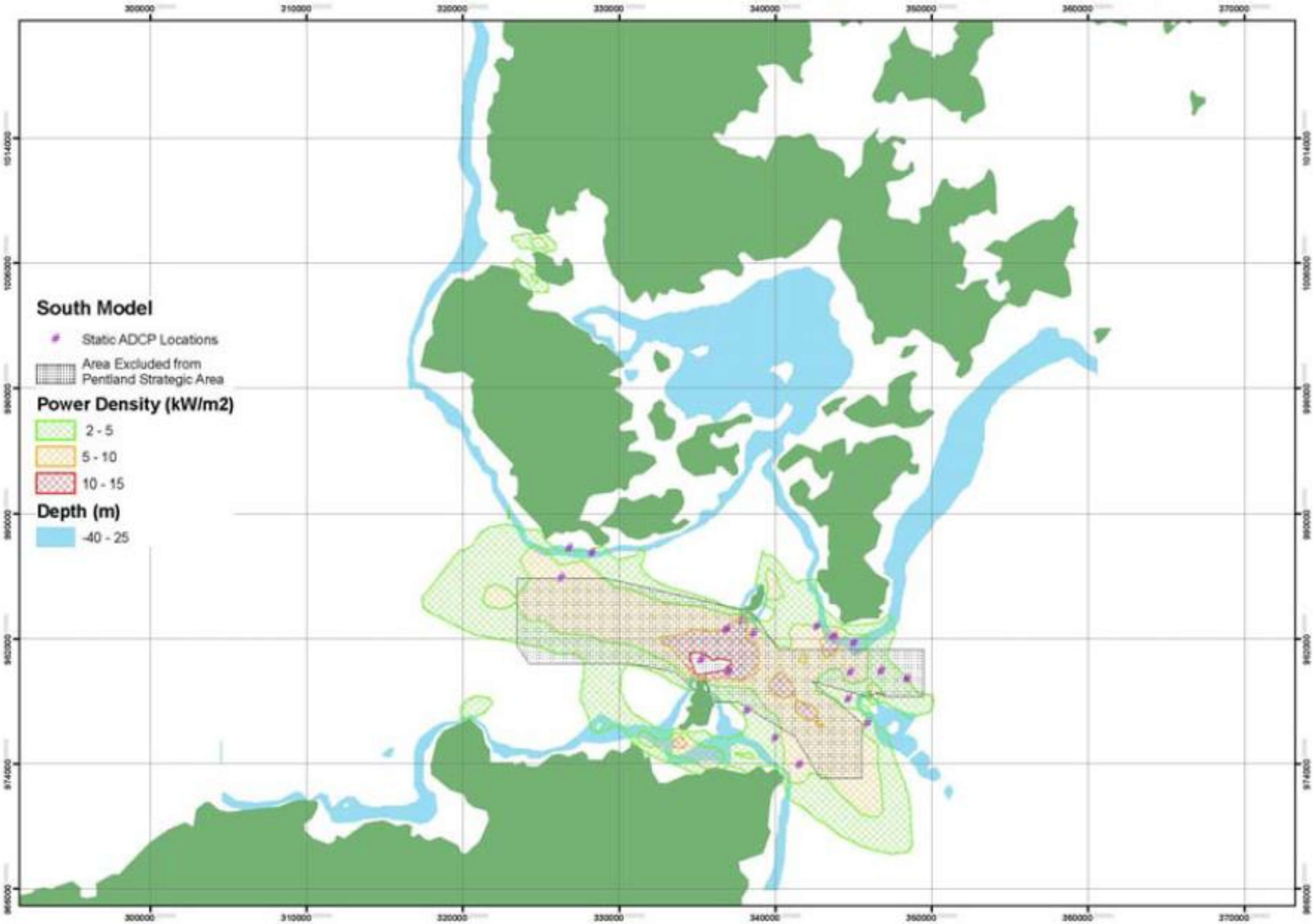
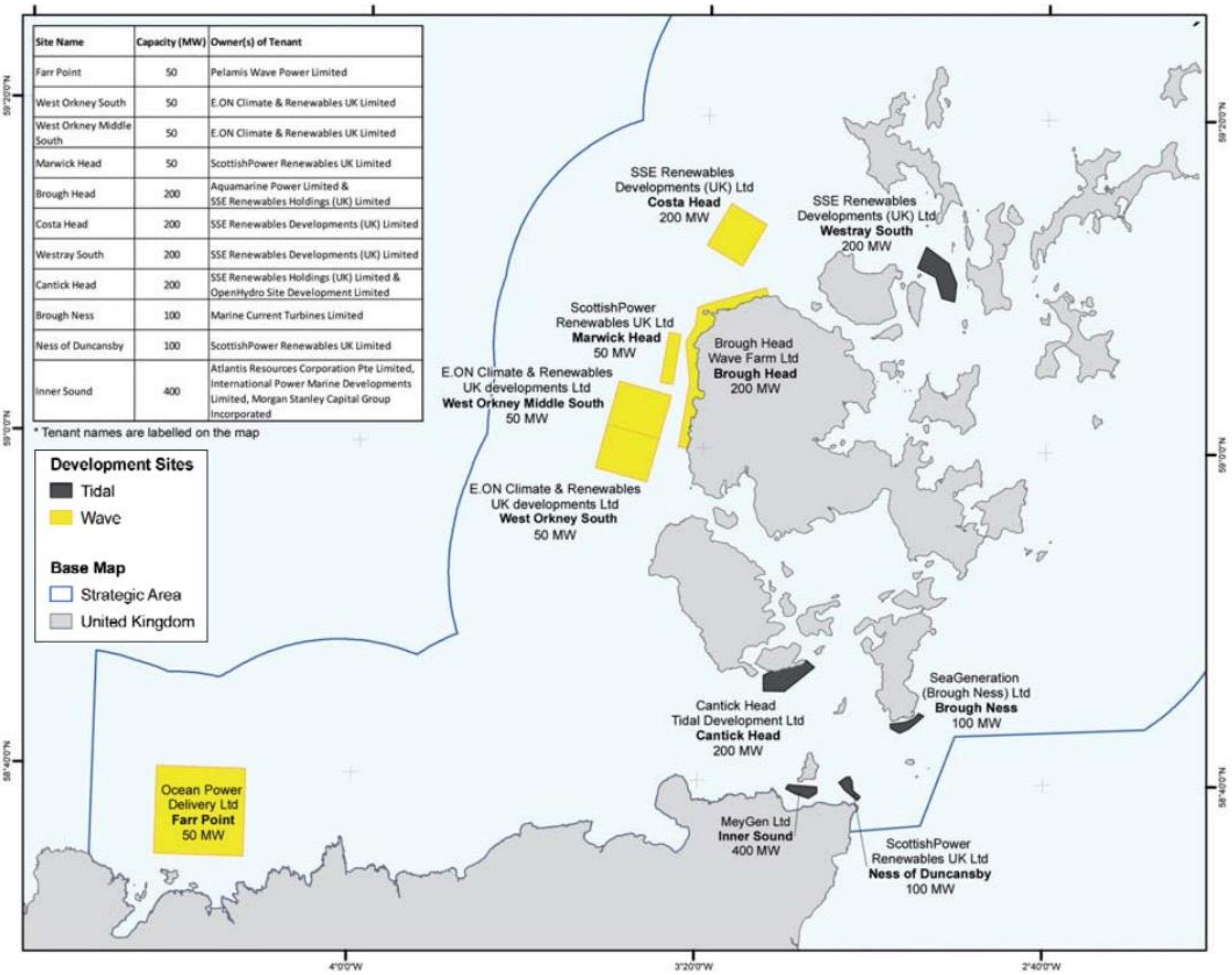


Figure 4.6: Model results: Power density and bathymetry

4.3.6 The Crown Estate Award

On the 16th March 2010, The Crown Estate issued an AfL for a tidal energy array with a capacity of up to 200MW, located off the south coast of South Walls, to Cantick Head Tidal Developments Limited (CHTDL), a joint venture between OpenHydro Tidal Technology Limited and SSE Renewables Limited (shown in Figure 4.7).



Site Name	Capacity (MW)	Owner(s) of Tenant
Farr Point	50	Pelamis Wave Power Limited
West Orkney South	50	E.ON Climate & Renewables UK Limited
West Orkney Middle South	50	E.ON Climate & Renewables UK Limited
Marwick Head	50	ScottishPower Renewables UK Limited
Brough Head	200	Aquamarine Power Limited & SSE Renewables Holdings (UK) Limited
Costa Head	200	SSE Renewables Developments (UK) Limited
Westray South	200	SSE Renewables Developments (UK) Limited
Cantick Head	200	SSE Renewables Holdings (UK) Limited & OpenHydro Site Development Limited
Brough Ness	100	Marine Current Turbines Limited
Ness of Duncansby	100	ScottishPower Renewables UK Limited
Inner Sound	400	Atlantis Resources Corporation Pte Limited, International Power Marine Developments Limited, Morgan Stanley Capital Group Incorporated

Figure 4.7: Pentland Firth and Orkney waters Round 1 development sites

4.4 DETAILED SITE INVESTIGATIONS

Having secured the AfL in 2010, CHTDL initiated a programme of baseline characterisation surveys including bird and marine mammal surveys, seabed-mounted ADCP deployments to collect detailed tidal resource data, an offshore geophysical survey to collect detailed information on seabed sediments, slope and water depths, ROV camera surveys of benthic habitats and a Navigation Risk Assessment (NRA). This facilitated the acquisition of key data to begin to understand the key characteristics of the site that would inform the concept design phase.

The Acoustic Doppler Current Profiler (ADCP) data was used to inform a detailed tidal resource model to characterise the resource in more detail. Complex flows and eddies were found to be impacting the amount of energy that could be extracted from the resource at the site, raising concerns over the nature of the tidal regime within the AfL and its potential for development. The surveys suggested that a more economically developable resource lay west of the original site, off South Hoy.

Further analysis and review of the resource model gave rise to further concerns with the original site, including:

- The average energy at the site is lower than predicted by the initial (Black and Veatch) numerical model;
- There are significant complex non-linear current flows at this site which would increase loadings on turbines deployed at this location; and
- There is substantial short-term turbulence in the tidal current flows, again contributing to high turbine loads.

On this basis, and following feedback from further site surveys (including an additional 6 ADCP deployments) and stakeholder consultation, CHTDL initiated a consultation exercise with The Crown Estate. In 2013, a revision was made to the boundary of the AfL area, whereby 80% of the original AfL area was moved to the west, with the remaining 20% overlapping with the original site. As a result of this boundary change, and to reflect the move of the site to the west, the Project was renamed to Brims Tidal Array. Figure 4.8 illustrates the change in AfL locations described above.

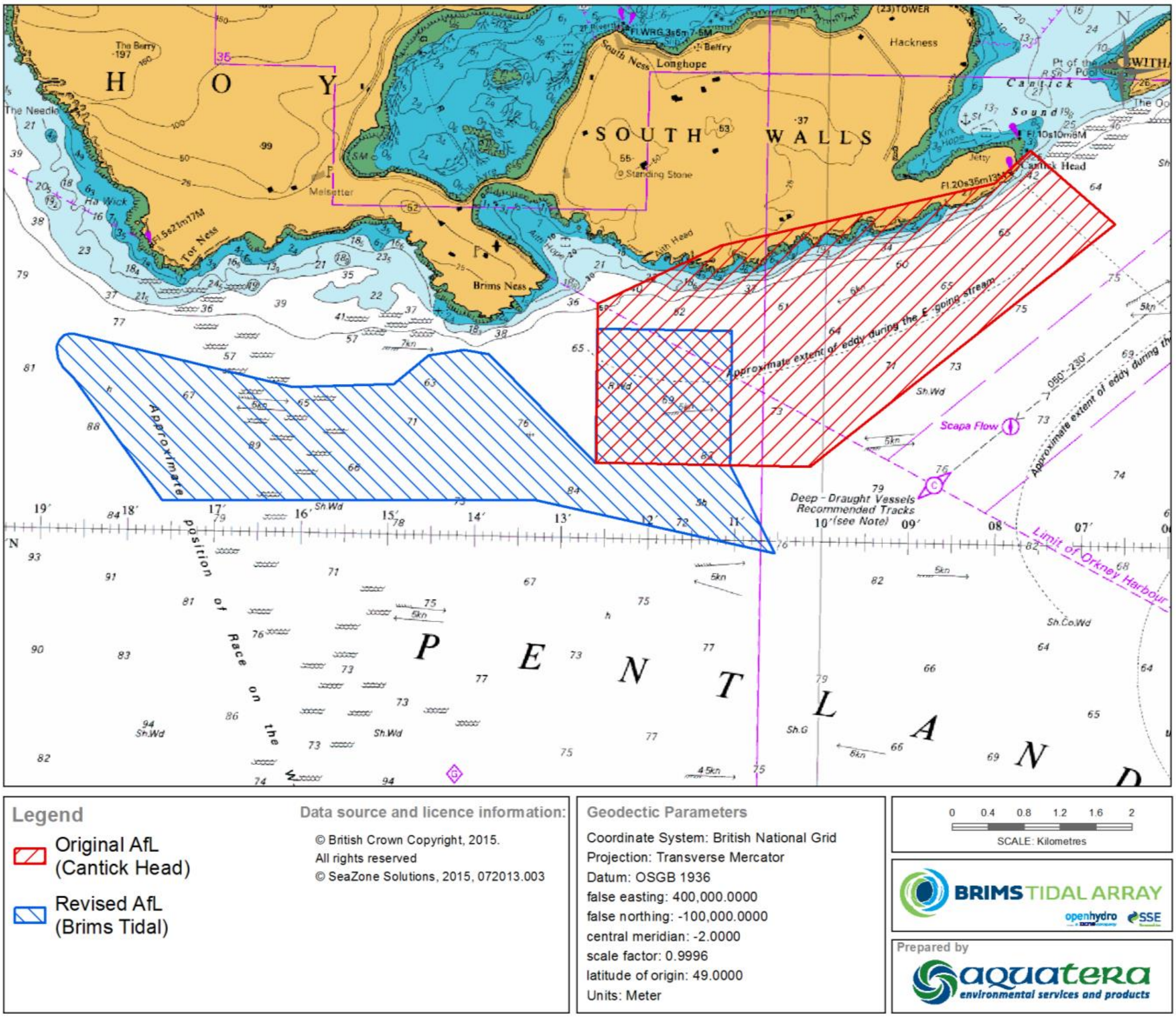


Figure 4.8: Boundary change from original AfL to revised location further west

The final location of the AfL and associated cable corridors which was brought forward for further baseline characterisation and the basis of the current application is illustrated in Figure 4.9.

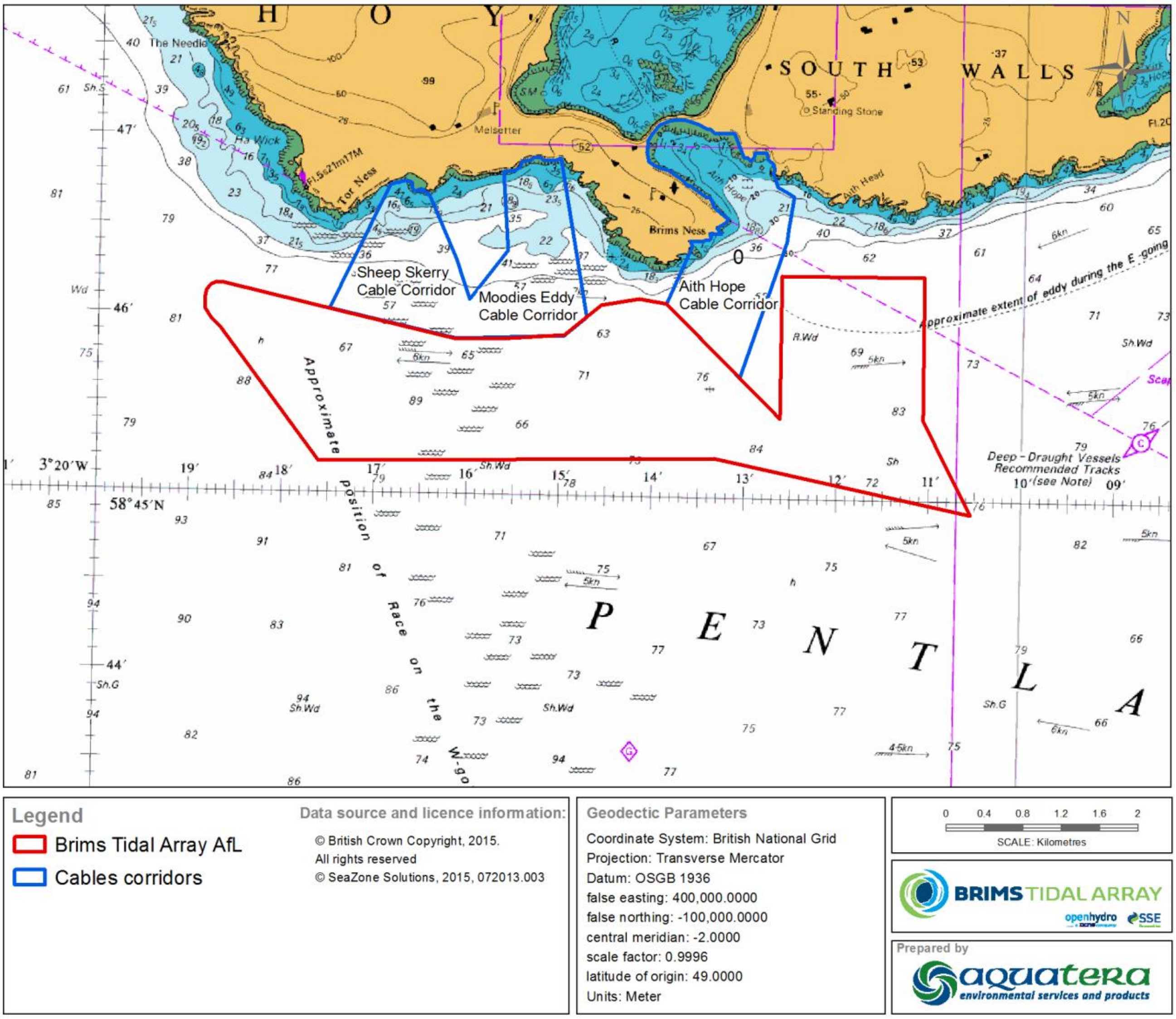


Figure 4.9: Project Agreement for Lease (AfL) and cable corridor areas (Sheep Skerry, Moodies Eddy and Aith Hope)

4.5 PROJECT DESIGN

Once the final AfL and cable corridor locations were confirmed, BTAL began the exercise of detailed environmental baseline data acquisition which has continued throughout the duration of the development phase including further ground investigation work and resource monitoring. This provided the information required for the derivation of tidal array loading specifications, layout designs, accessibility studies and energy yield predictions. This also provided key baseline data which has been used to inform the EIA for this application.

Options for locating the offshore components of the Project have been considered and engineering solutions developed. Each component is discussed below, including details of the options that are covered by the Project design envelope in Chapter 5 Project Description.

4.5.1 Tidal Array

The final location of the turbines within the AfL area will be determined following the detailed engineering design process and will consider a number of factors including:

- Energy capture;
- Seabed conditions;
- Turbulence;
- Metocean conditions;
- Turbine technology; and
- Location and stability of export cables.

The ADCP deployment programme allowed detailed analysis of the tidal flows and**,** when combined with geophysical data**,** enabled the design team to prepare an indicative turbine array layout. Data gathered from the ADCP deployments allowed BTAL to carry out a full assessment of Metocean parameters at the site for the planning phase of the Project. This process included the measurement and modelling of tidal currents, waves, wind speeds and storm surges generated from the data gathered from the ADCP deployments. This approach ensures that the load specifications for both the turbine and foundation arrangements proposed for the Project properly account for all environmental conditions.

BTAL commissioned Numerics Warehouse to carry out numerical modelling to characterise the environment in the region of the lease area. SSE also carried out numerical modelling on behalf of the Project, allowing confirmation of the accuracy of both sets of results relative to the previously collected ADCP data. The main purpose of the modelling work was to confirm energy yield predictions across the extent of the site. Input of long-term ADCP measurements into this model will be used to inform the final array layout design. This model also provided data that could be used as part of the coastal processes assessment for the Project.

Osiris Projects were commissioned between August 2012 and September 2013 by Brims Tidal Array Limited (BTAL), to carry out geophysical surveys of the Brims AfL area (Supporting Document: Osiris, 2014). The main objectives of the surveys were as follows:

- To undertake site surveys to support the technical, environmental and economic appraisal of the Project site including grid connection corridors; and
- To provide sufficient data to allow the identification of locations suitable for the deployment of turbines, as well as cable route options.

The scope of work for the geophysical survey was to acquire the following datasets:

- Bathymetry;
- Side scan sonar;
- Magnetometer; and
- Sub-bottom profile.

During consultation with navigational stakeholders, in particular the Orkney Harbour Authority, it was highlighted to the Project team that a small number of turbine locations in the south east corner of the indicative array layout would be located within the approaches to the shipping lane leading into and out of the Scapa Flow. Although not a navigational issue during operation, due to the clearance above the turbine which allowed safe navigation for vessels, it was agreed that, in order to prevent disruption to shipping during the construction phase of the Project, this section of the Project site would not be developed.

A further multibeam survey of the Sheep Skerry cable corridor was carried out by Roving Eye and Triscom in 2015 to characterise the seabed and its suitability as a cable corridor as well as acquiring the necessary baseline data to inform the impact assessment. The results of this survey are presented in (Supporting Document: Aquatera, 2015c).

Further information on other physical and biological characterisation of the site can be found in the individual chapters 8 to 20.

4.5.2 Offshore Electrical Architecture

The offshore electrical cable architecture for the Project will be determined during detailed design and is dependent on a number of factors including:

- The grid connection requirements of the local system operators;
- Array size and layout i.e. rated output of selected turbine and inter-array cable configuration;
- Options to use subsea hubs and/or bundling of cables;
- Seabed conditions; and
- Cable landfall options.

The need to reduce electrical losses due to long sections of offshore cable, coupled with suitable topography to facilitate cable landfall, were two of the key factors determining cable route options. Consideration was also given to known environmental constraints and suitable seabed conditions. Engineering Technology Applications Limited (ETA) was commissioned in 2014 to commence an offshore array architecture study to provide information about the grid connection infrastructure for the Project and to inform the environmental impact assessments of the Project. The study provided information about the array options, inter-array cable ratings, export cables (or shore landing cable), including number, size and rating of cable, offshore infrastructure requirements, including connections, and current production/development status of infrastructure proposed.

Chapter 5 Project Description provides more detail on the offshore architecture proposed for the Project.

4.5.3 Cable Corridors and Landfall

Cable corridors to Aith Hope and Moodies Eddy were initially identified in 2011 via a geotechnical survey which sought to identify suitable landfall locations where an export cable could be landed for onward connection onshore. BTAL appointed Aquatera in 2015 to carry out a further geological study as part of a geotechnical evaluation of potential landfall locations in the Project site. The objective of the landfall evaluation study was to record the geotechnical features and morphology of the coast to assess the suitability of each landfall site, using a typical open-cut trench cable 'beach' landing, horizontal directional drilling (HDD) method, or other landfall construction techniques.

A third potential cable route corridor and landfall was identified as part of the Aquatera survey. Sheep Skerry (Melsetter Links), west of the onshore boundary offers an alternative suitable landfall location to bring offshore cables from the AfL area to shore. Offshore and onshore surveys were completed in July 2015 to provide the baseline for inclusion in the overall assessment. The addition of this cable route does not impact upon the boundary of the Agreement for Lease area.

The coastline in the vicinity of the Project is generally very rugged with steep cliffs. The landfall study investigated all potential landfall sites located along Hoy and South Walls including:

- Site 1 – Sheep Skerry;
- Site 2 – Moodies Eddy; and
- Site 3 – Aith Hope.

The criteria used to evaluate each landfall location included the following:

- General topographic description of the beach and nearby land;
- Notes on the current land use, including the vegetation type, farming practices, recreational use, etc.;
- Beach morphology (e.g. sandy, gravelly, rocky; bays/inlets, etc.);
- Coastal processes (e.g. general surf description, tidal marks, storm marks, etc.);
- Geology and soil (or surficial deposits) surrounding the beach;
- Geotechnical conditions (e.g. shallow soil profile, rock structure, etc.), including beach and land hazards (e.g. slope instability, ground water discharge, erosion, etc.); and
- Access to site for construction plant and set-up.

Results from the study found the three proposed sites to be suitable for either Open cut trench or HDD landfall construction techniques.

Selection of a final cable landfall will depend on both the onshore infrastructure requirements, including substation location and grid connection point, and results from the detailed design of the offshore array architecture study. Further information on the onshore components is included in Chapter 5 Project Description and Chapter 21 Overview of Onshore Impacts.

4.6 ASSESSMENT OF ALTERNATIVE TIDAL TECHNOLOGIES

There are a number of tidal turbine manufacturers that are currently testing prototype turbines. BTAL has worked with a number of these turbine manufacturers during the design process to identify turbines that would be suitable for the Project. The assessment started by looking at all available technologies that could be suitable for the Project location. A number of these technology options included surface-piercing elements. Following consultation with statutory stakeholders, technologies with surface-piercing elements were excluded from the design envelope thus limiting the range of environmental impacts. Further detail on the refinement of the design envelope can be found in Chapter 6 Consultation

Process. All remaining options are incorporated within the overall design envelope described in Chapter 5 of this ES. The preferred turbine technology under consideration for the Project is the OpenHydro Open-Centre Turbine.

The purpose of the design envelope is to define a series of realistic design parameters that encompass all possible technological, engineering and design options that will be considered for the Project. The realistic design parameters must encompass all technology options and potential environmental impacts in sufficient detail to allow for a robust EIA. This ensures that the maximum potential benefits and adverse effects of the Project have been fully assessed whilst preserving sufficient design flexibility. The design envelope approach also allows for alternatives to be considered and documented as part of the impact assessment. By using a design envelope approach for turbine parameters, the procurement process and detailed design of turbines remains flexible and can make use of technology improvements, whilst retaining a competitive market procurement position and optimising Project economics. In order to ensure that the design envelope is sufficiently flexible to account for a number of possible turbine options BTAL has reviewed the various turbine option parameters to allow for increased Project design flexibility whilst giving sufficient detail to allow the EIA to be conducted.

All of the turbines will be able to capture energy from the flood and ebb tide by either using a yaw system to turn the turbine or nacelle, or by having pitching or bidirectional blades. Electricity generated by the turbines will be converted and transformed in offshore units, and then transmitted to shore via subsea cables before transmission to the national grid. Further information on offshore electrical infrastructure is provided in Chapter 5. A final decision on the tidal turbine technology used for the Project will be made post consent award and will be based on which technology proves to be the most technically and economically viable option for the site.

4.7 PROJECT DESIGN PROCESS - ONSHORE

As outlined in Chapter 1 Introduction, the location and design of the onshore components of the Project will depend on the substation location (to be confirmed) and will be subject to a separate environmental impact assessment and planning application. Chapter 21 provides further information on the onshore components and the work carried out to date to define the onshore area of search.

4.8 REFERENCES

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Project Description

Chapter 5

5 PROJECT DESCRIPTION

5.1 INTRODUCTION

This chapter of the ES details the Brims Tidal Array Project (the Project), and provides the following:

- Approach to design envelope;
- Overview of Project site and key components of Project covered by the offshore EIA;
- Project Development Strategy and timescales; and
- Description of key design parameters required for the EIA for the offshore Project.

In addition it also provides information on:

- All offshore aspects of the Project including tidal turbines and turbine support structures;
- Electrical infrastructure (inter-array and export cables, and subsea cable connection hubs);
- Export cables corridors; and
- Landfall for export cables (up to Mean High Water Springs (MHWS)).

5.2 DESIGN ENVELOPE APPROACH

In accordance with the established principles of the Project design envelope (referred to throughout this Project ES as the design envelope) and advice provided by Marine Scotland Licensing and Operations team (MS-LOT) in the EIA Scoping Opinion (Supporting Document: MS-LOT, 2014) and subsequent consultations on the Project Description in 2015, BTAL has taken a design envelope approach to this EIA. The basis of the design envelope is to apply a “worst case” approach to the assessment of the different impacts associated with the Project.

Applying a design envelope approach to the EIA allows for the evolution of specific elements of the Project design such as turbine technology, site design, layout and electrical infrastructure to continue beyond submission of the Marine Licence application. This flexibility is important at this stage of development in the tidal technology industry as it will allow technology improvements to be applied at the time of construction and enable the most economically efficient technology to be used while retaining full compliance with environmental consenting regulations.

The purpose of the design envelope is to define a series of realistic design parameters that encompass all possible technological, engineering and design options that will be considered for the Project. The realistic design parameters must encompass all technology options and potential environmental impacts in sufficient detail to allow for a robust EIA. This ensures that the maximum potential benefits and adverse effects of the Project have been fully assessed whilst preserving sufficient design flexibility. The design envelope approach also allows for alternatives to be considered and documented as part of the impact assessment.

The approach will require that the impact assessment encompasses all potential technologies under consideration by the applicant, and may therefore require that impacts from a number of different scenarios are assessed separately, depending on the receptor. The approach allows the developer to maintain the necessary level of flexibility at the consenting stage, while ensuring that the assessment made in the EIA is robust and reflective of the worst case impact under any development scenario.

In finalising the design envelope, BTAL considered comments made by Marine Scotland and their statutory advisors in the Scoping Opinion received in 2013 as well as comments made in a review of the draft Project Description that was submitted for their review in early 2015. The Project design envelope has therefore been refined relative to that proposed in Scoping and is presented below.

5.3 PROJECT OVERVIEW

This ES considers the following components of the Project:

- All offshore aspects of the Project including tidal turbines and turbine support structures;
- Electrical infrastructure - inter-array and export cables, and subsea cable connection hubs; and
- Landfall for export cables (up to MHWS).

In addition to the components described above, onshore infrastructure landward of the export cable landfall will also be required to connect the Project to the electricity transmission network. This will comprise:

- Cable landfall above Mean Low Water Springs (MLWS), and transition pit;
- Onshore underground cable route;
- Temporary works including construction compound(s) and laydown areas to facilitate landfall works;
- Possible road access improvements; and
- Onshore substation.

Network reinforcement works will also be required to connect the Project to the electricity transmission network. These will be the responsibility of SHE-T.

In this application, BTAL is applying for Marine Licence and Section 36 consents through Marine Scotland, and we are providing a robust ES which fully satisfies the EIA Regulations for such an application for the offshore components up to MHWS.

Planning permission will be sought for the cable landfall (above MHWS) which will consist of a buried transition pit where the marine cables are joined to terrestrial cables, an underground cable route to a substation, the substation and associated temporary works through the Orkney Islands Council (OIC) under the appropriate Town and Country Planning (Scotland) Act 1997.

The design and planning consent process for grid transmission system infrastructure is the responsibility of the transmission system operator Scottish Hydro Electric Transmission Limited (SHE-T). SHE-T are currently designing a grid connection upgrade for the Orkney Islands, as part of these upgrade works SHE-T will provide a grid connection point for the Project. This grid connection will seek to integrate the Project onto the grid system, associated temporary works and onward connection to the wider grid network. The design of this grid upgrade work and the connection works associated with the Project is currently under way and will be subject to a full stakeholder consultation and planning permission process. The timing of the application for all onshore components will be dependent upon the confirmation of the grid connection point with SHE-T. Further information on the policy and legislation underpinning all offshore and onshore components is available in Chapter 3 Policy and Legislation. Further information on the application strategy and approach to EIA for the onshore components is available in Chapter 21 Overview of Onshore Impacts.

The offshore tidal array will comprise of up to 200 fully submerged tidal turbines with a maximum total installed capacity of 200MW. Electricity generated by the turbines will be transmitted to shore via a series of inter-array and export cables (see Figure 5.1).

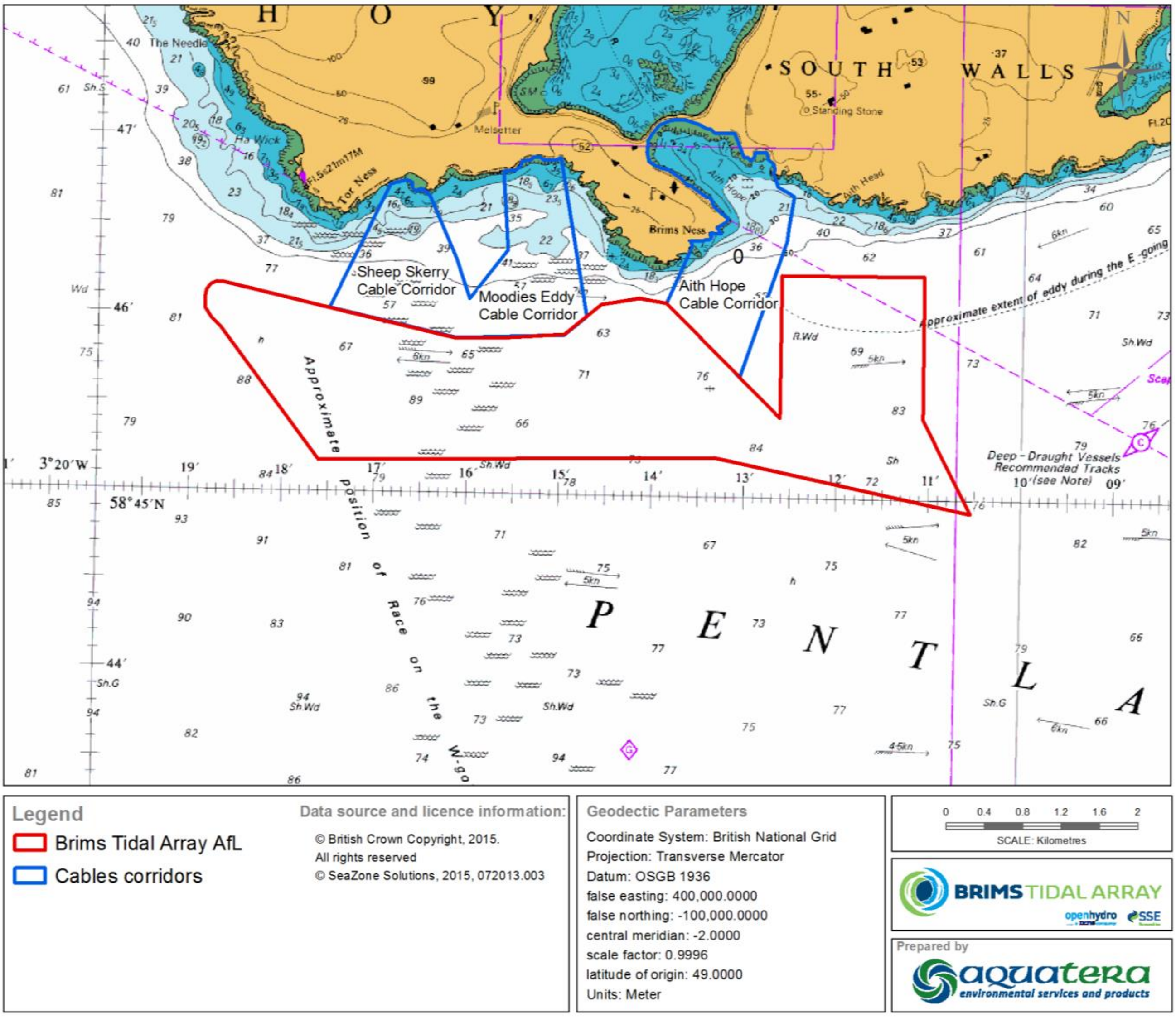


Figure 5.1: The Project Agreement for Lease (AfL) and cable corridor areas (Sheep Skerry, Moodies Eddy and Aith Hope)

Exact turbine locations will be defined based on tidal flow, water depths, seabed slope and sediment conditions; the optimum turbine locations may vary depending on the technology to be installed. An indicative turbine layout is shown in Figure 5.2. This layout is for illustrative purposes and will be refined during the detailed design phase. The total number of turbines installed will depend on the rating of the selected turbine. The assessment in the technical chapters has taken into account the range of potential layouts which may arise when applying the principles set out in Section 5.6.3 Array Layout, by applying a worst case approach as explained in Chapter 7 EIA Scope and Methodology.

Inter-array and export cables will be used to transmit electricity generated by the turbines to shore. The total number of inter-array cables required will depend on the number of turbines required for a 200MW array. Subsea cable connection hubs will be used to collect inter-array cables for connection into the export cables. It is expected that a maximum of 8 subsea cable connection hubs will be required; each hub will be connected to the onshore substation via up to two export cables (i.e. up to 16 export cables in total). The width of the export cable corridor from the AfL area to the cable landfall will depend on the total number of cables required to transmit electricity to shore. The worst case affected area for each cable will be up to 5m, including any cable protection required, resulting in a total affected width of 80m. Spacing will be required between each cable, and as a result the width of the cable corridor will exceed 80m, and will be dependent on the depth of water at each location. The proposed location of the export cable corridors are illustrated in Figure 5.1

The export cables will come ashore at one of three possible landfalls; either Sheep Skerry, Moodies Eddy or Aith Hope (Figure 5.1). The final landfall location will be confirmed during detailed design phase post consent determination.

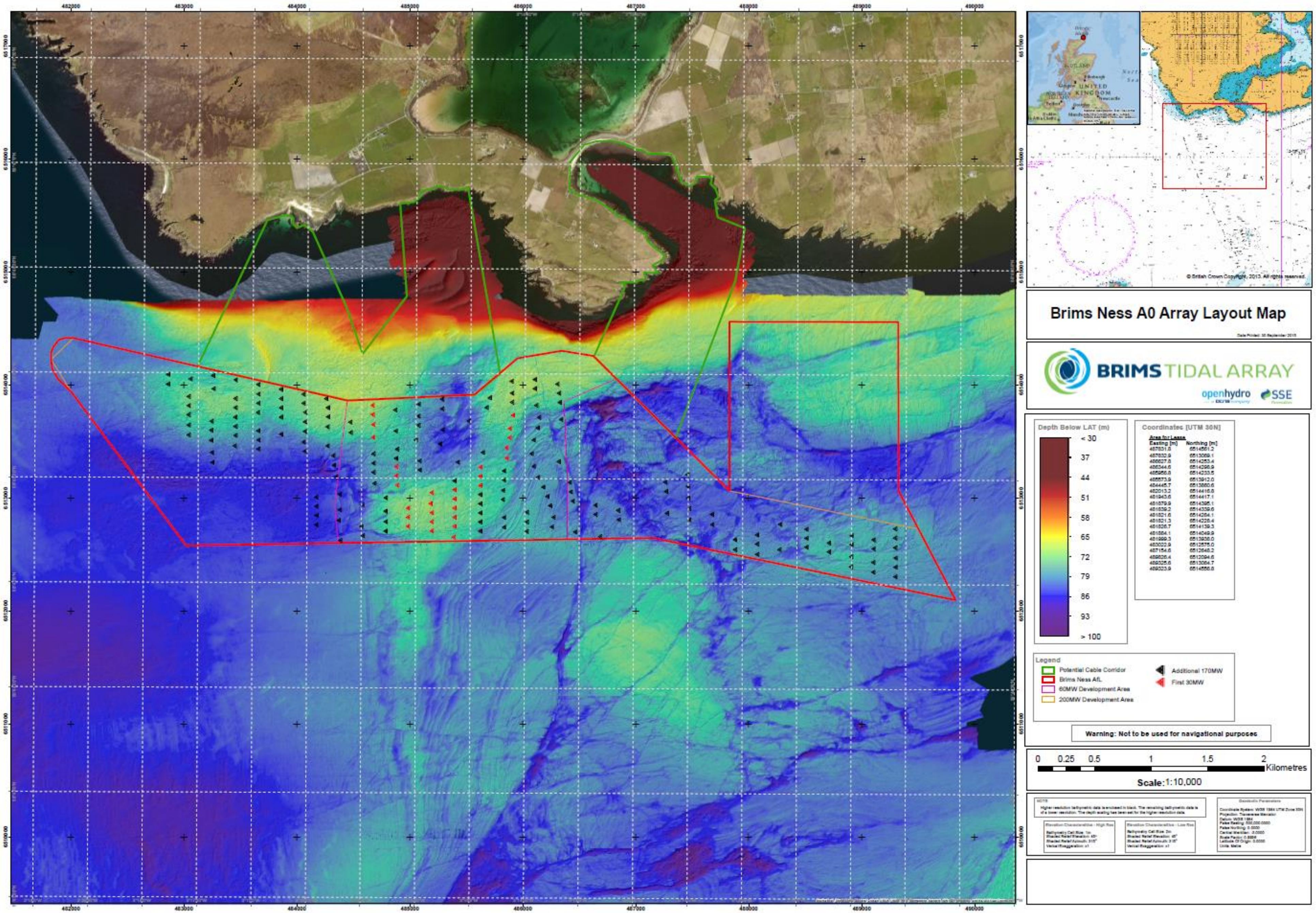


Figure 5.2: Indicative turbine layout

5.4 DEVELOPMENT STRATEGY

The Project has an AfL in place with The Crown Estate (TCE) to carry out investigations into the development of a 200MW array in the location indicated in Figure 5.3. The Project will be constructed in a number of Stages, an outline of which is provided below.

Please note the following differentiation between stages and phases to avoid potential confusion. BTAL uses 'Stage' to refer to a distinct period in the project build out programme (e.g. Stage 1 of up to 30MW in 2019). BTAL uses the term 'Phase' when referencing the three key sections of a project against which impacts are assessed, e.g. Construction/Installation, Operations/Maintenance and Decommissioning Phases. This is explained further detail in Section 7.6 Project Description Considerations.

This approach has been proposed based on the timelines for grid access provided by SHE-T and National Grid. Please note that these timelines are indicative and may be subject to change. The build out programme will be confirmed post consent determination during detailed design.

Figure 5.3: Breakdown of each stage of the Project

The capacity of Stage 1 of the Project will be up to 30MW. Devices installed in Stage 1 will have individual capacities of at least 1MW, resulting in an array size of up to 30 devices. An environmental monitoring plan for the Project will be developed, informed by the results of the environmental impact assessment, lessons learned from monitoring programs of similar tidal projects and close consultation with relevant stakeholders. There is a review period proposed for approximately one year post Stage 1. During this period, there will be an opportunity for BTAL, in consultation with relevant stakeholders, to further develop the monitoring strategy using an adaptive management approach. This will enable refinement of monitoring techniques and desired outcomes to ensure the monitoring strategy for the Project is informed by the best available data and seeks to answer any specific issues/knowledge gaps that remain. Monitoring results will be presented to Marine Scotland and relevant stakeholders on a regular basis. Stage 2 (A, B and C) will follow this review period in 2020 where the remaining 170MW is proposed to be installed over a three year period. Further detail on the proposed environmental management and monitoring will be available in Chapter 23 Environmental Mitigation, Monitoring and Management.

It should be noted that a minimum capacity of 30MW is required for Stage 1 of the Project to enable the economies of scale needed to make the Project financially viable, for the following reasons:

- The connection offer for the Project from National Grid is for 30MW in Stage 1. National Grid and SHE-T have designed and priced this connection based on the installation of grid infrastructure for a 30MW connection;
- A commitment to significant costs for the installation of this grid connection to the Orkney Islands is required to secure a grid connection;
- To develop the Project efficiently and economically it will be necessary for BTAL to invest in local infrastructure and

equipment to facilitate the deployment of the array. This is an issue of particular relevance to a remote location like Orkney where infrastructure requirements and associated costs are significant; and

- The Project will also be required to submit an application for a Contract for Difference (CfD) rate, the current auction rules for access to CfD's require that consents are in place prior to submitting a bid. The limited availability of CfD's for tidal energy projects require that an application of the full amount up to 30MW is required before 2019 to secure support for a commercially viable project.

In order to ensure the viability of the Project and to secure development finance a minimum project size of 30MW is required. The Project strategy post Stage 1 is also aligned with the grid connection offer received from National Grid.

5.5 PROJECT TIMESCALES

An overview of the planned timescale for the installation, operation and decommissioning of the Project is presented in Table 5.1.

Table 5.1: Project timescales

Activity		Timescales
Consent submission (Section 36, Marine Licence)		Q4 2015
Procurement and manufacturing		2018
Tidal array and offshore architecture installation	Stage 1 (30MW)	2019
	Review Period	2020
	Stage 2A (up to 95MW)	2021
	Stage 2B (up to160MW)	2022
	Stage 2C (up to 200MW	2023
Substation construction and onshore cable installation	Stage 1 (30MW)	2019
	Stage 1 and 2 (200MW)	2021
Operation	Stage 1 (30MW)	2019
	Stage 2A (up to 95MW)	2021
	Stage 2B (up to 160MW)	2022
	Stage 2C (up to 200MW)	2023
Operational Life		20 – 25 years
Decommissioning		There are two options for decommissioning: Re-powering the site using commercially available technology, subject to an agreement with TCE to extend the duration of the existing Lease and securing all necessary permits and consents; or

Activity	Timescales
	Decommissioning the site in accordance with requirements for decommissioning Offshore Renewable Energy Installations (OREIs) set out in the Energy Act 2004 and requirements of The Crown Estate AfL which requires decommissioning to be completed within 24 months.

5.6 OFFSHORE INFRASTRUCTURE/TIDAL ARRAY

5.6.1 Turbine Specification

The preferred technology for this Project is the OpenHydro Open-Centre Turbine which is a shrouded, horizontal axis turbine (Figure 5.4), incorporating some unique design features:

- **Simple construction:** manufactured from four key components: a horizontal axis rotor, a direct-drive permanent magnet generator, a hydrodynamic duct and a subsea gravity base type support structure. Only one moving part;
- **Maintenance:** No lubricant, seals, or gearbox mean reduced maintenance requirements and reduced risk of leakage/environmental contamination;
- **Seawater:** Seawater is used for both generator cooling and bearing lubrication;
- **Permanent magnet generator:** the advanced permanent magnet generator removes the requirement for a gearbox – a common cause of failure in large scale wind turbines. This general arrangement also provides smooth reaction torque and is relatively easy to seal from the surrounding seawater, as well as being flexible in that it may be configured to produce different voltage outputs; and
- **Bi-directional:** the turbine operates in both the ebb and flood direction without the need to yaw to orientate itself into the tide.

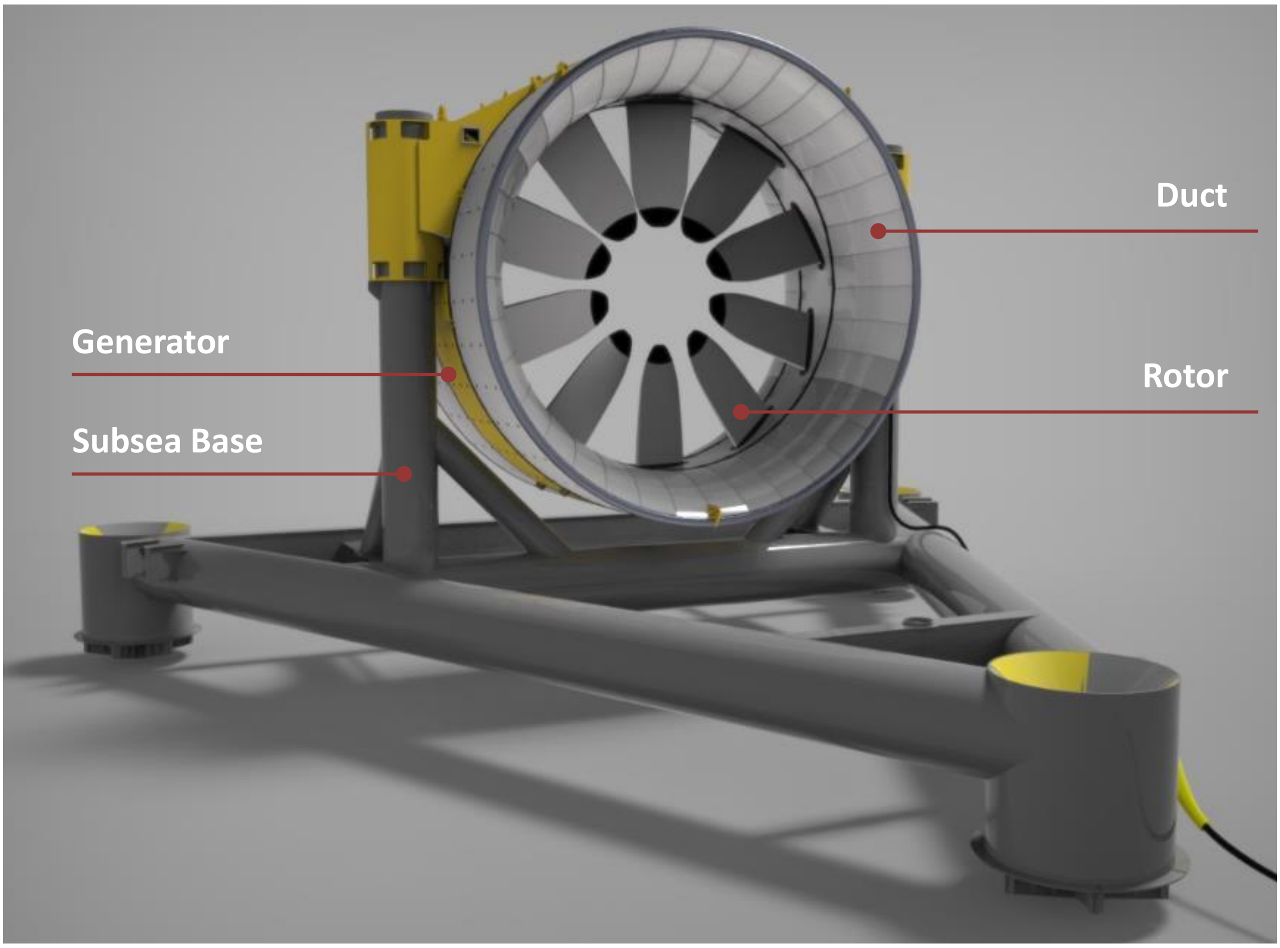


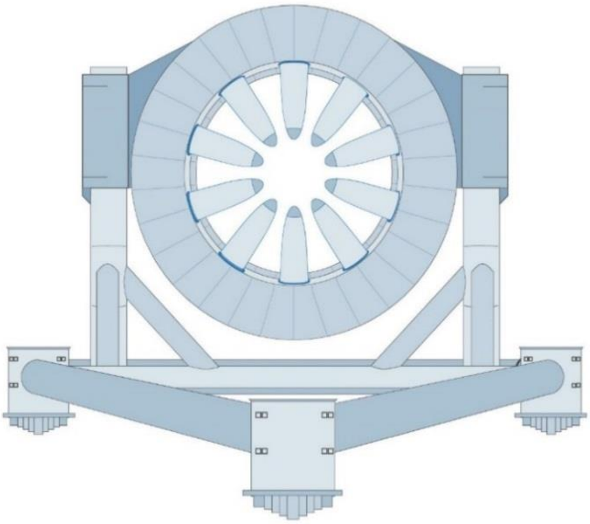
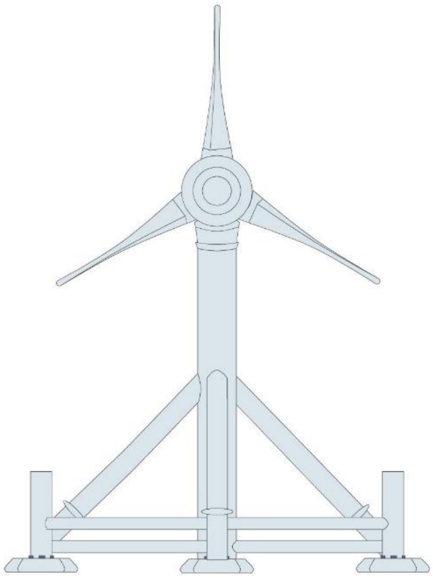
Figure 5.4: Open-Centre turbine key components

Alternative turbine technology options are also being considered for the Project. The other type of device design being considered is the unshrouded horizontal axis turbine, which typically has three blades with a fixed or variable pitch which rotate around a nacelle (Figure 5.5). The nacelle may be fitted with a yaw mechanism, which allows it to orientate into the flow to extract energy from the tide in both directions.

Table 5.2 compares the technologies.

Figure 5.5: Typical horizontal axis turbine (Xodus.com)

Table 5.2: Turbine types

Shrouded seabed mounted	Unshrouded seabed mounted
	

All device types will be seabed-mounted and will have minimum clearance from the uppermost point to sea surface at lowest astronomical tide (LAT) of 30m. Turbines will have a minimum clearance from the bottom of the rotor to the seabed of 4m.

To generate electricity the turbines will convert kinetic energy from the flow of water into electrical energy via the turbine blades turning the generator. The turbines being considered are bi-directional, using either active or passive approaches:

- Active: Uses a yaw system to re-orientate the nacelle, or a blade pitch system to adjust the pitch of the blades, during slack tide in order to optimise tidal flow from both ebb and flood tides;
- Passive: has fixed pitch blades which generate energy from flows in both directions (ebb and flood tides); and
- Some turbines also have independent blade pitching which can be modified to optimise the blades to tidal flows in different directions.

The rated power output of the turbines depends on a number of factors including device performance, site conditions and array layout. For the purpose of this assessment, it is assumed that all turbines will have a rated power output of at least 1MW. Given that the maximum capacity of the AfL area is 200MW, the total number of turbines required for the Project will decrease as the rated power of the tidal turbines increases. For example, if the turbines have a rated power output of 2MW only 100 turbines will be required.

All turbines have a design life of between 20 and 25 years. Table 5.3 describes the turbine specifications relevant to the Project.

Table 5.3: Turbine specification parameters relevant to the Project

Turbine parameters relevant to Project	Project parameter for impact assessment	Comments
Rated power output	At least 1MW	Rated power output of the turbines depends on a number of factors including device performance, site conditions and array layout.
Rotor diameter	13m – 23m	-
No. of rotors per device	All devices are single rotor	-
No. of blades per rotor	3 to 10	Shrouded turbines have 10 blades; Blade tips are retained within the outer venturi unshrouded turbines have three blades
Total Swept area	$115m^2$ – $415m^2$	Rotor area/rotor area minus open-centre area
RPM range	3 – 21rpm	-
Cut-in flow speed	0.5 – 1m/s	-
Cut-out flow speed	3.5 – 5m/s	
Min clearance between top of turbine and sea surface at LAT	30m minimum clearance	
Min clearance between bottom of rotor and seabed	4m	Clearance may be more depending on turbine and support structure configuration
Yaw system	Present on some unshrouded turbines	
Blade pitching	Some turbines have independent blade pitching functions. Where blade pitching is included, this ranges from 0-10 degrees	-
Design life	20 - 25 years	-

5.6.2 Turbine Support Structures (TSS)

The design of the Turbine Support Structures (TSS) varies according to the different turbines being considered and method of attachment to the seabed. Summary of options that will be considered include:

- Gravity base structures (GBSs), including subsea bases (SSBs);
- Drilled pin pile tripod; and
- Drilled monopile.

5.6.2.1 Gravity Base Structure (GBS) Including SubSea Bases (SSBs);

Gravity base structures (GBSs) are steel or concrete (or a combination of both) structures that use their own weight to attach to the seabed (Figure 5.6). The GBSs considered for the Project comprise either a three-point structure constructed from steel with ballast fill material as in the subsea base (SSB) or a combination of steel and concrete with a flat bottom that sits on the seabed. The dimensions of the flat bottomed GBSs are up to 30m by 40m and therefore will have a maximum footprint of 1,200m^2 per gravity base. The footprint of the three-point subsea base is up to 40m^2 as there are only three points that are in contact with the seabed. The total weight of the structures will vary depending on current speeds with increased weight and ballast required in higher energy environments.

Figure 5.6: Subsea Base, Dartmouth, Nova Scotia 2010 (OpenHydro)

5.6.2.2 Drilled Pin Pile Tripod

This method of attachment involves placing a braced steel tripod structure onto three pin piles which have been fixed in place with high strength grout. The tripod structure is then grouted onto the pin piles. The pin piles will have a diameter in the order of 1.3m with a depth of 5m. The total footprint of each pin pile will be 1.3m^2. Therefore the total footprint for three pin piles will be 4m^2. The maximum area of seabed occupied by each tripod structure (lattice and pin piles) would be 154m^2 although not all sections of the tripod will have direct contact with the seabed (part of the tripod structure will be raised slightly above the seabed) (Figure 5.7).

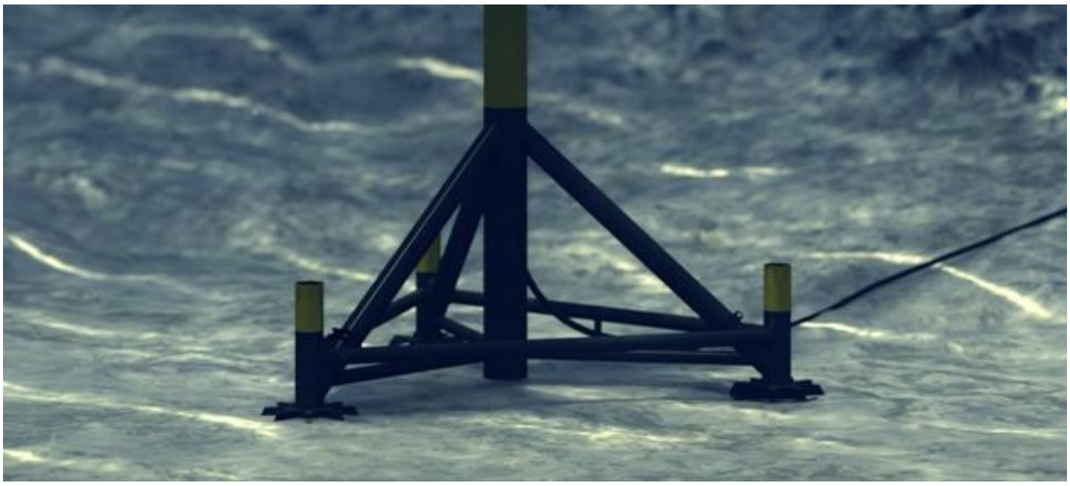


Figure 5.7: Typical pin pile support structure (www.alstom.com)

5.6.2.3 Drilled Monopile

Drilled monopiles are single cylindrical steel structures (piles) that are drilled into the seabed (Figure 5.8). Cylindrical steel transition pieces may also be required to attach the turbine to the monopile. The transition piece would be held in place over the top section of the monopile by a Remotely Operated Vehicle (ROV) actuated clamp. The turbine would then be winched down onto the top of the transition piece and locked in place with a series of clamps.

The diameter of the hole required for the monopile will vary depending on turbine type but is expected to range between 2.5m to 3m diameter and up to 12m deep. The height of the monopile, including the transition piece, ranges from 14m to 23.5m, depending on selected height of the turbine axis. The footprint for the monopile will range from 5m^2 to 7m^2. With the transition piece (which may extend both above and below the seabed) the total footprint of the monopile would be 20m^2. Once the monopiles have been installed they will be fixed in place with high strength grout.

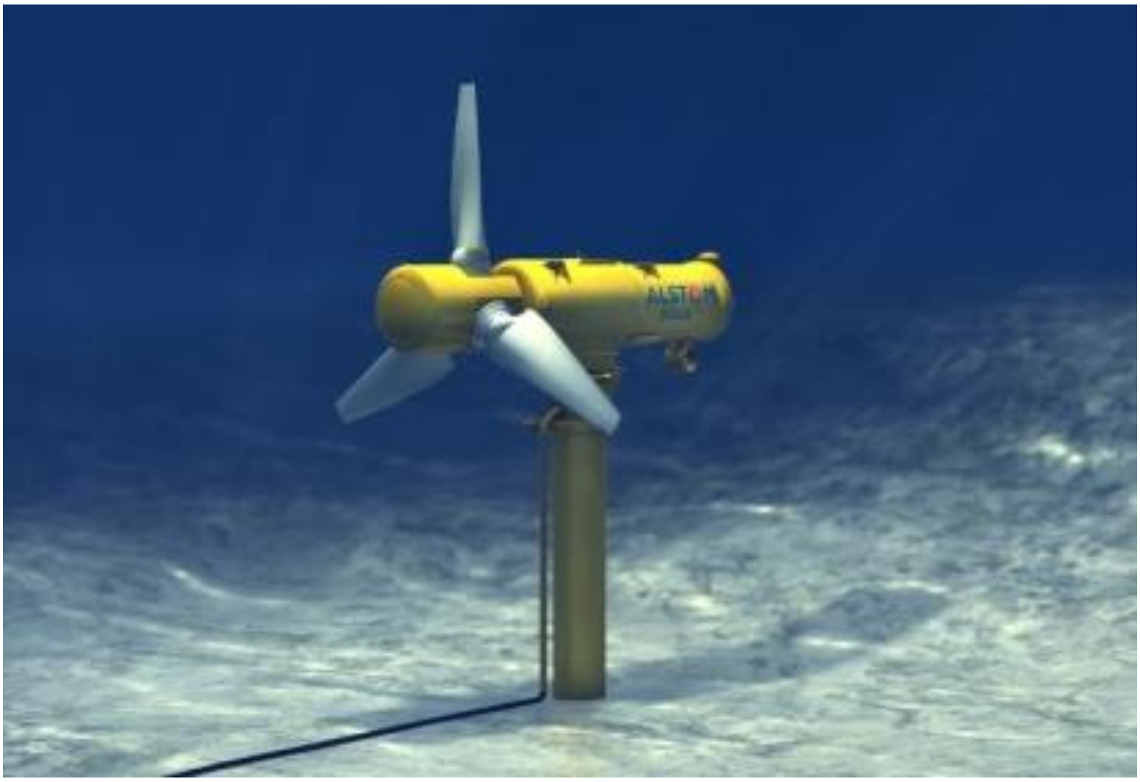


Figure 5.8: Typical drilled monopile structure (www.alstom.com)

Table 5.4 compares the three options.

Table 5.5 describes the TSS parameters relevant to the Project

Table 5.4 Turbine support structures (TSS)

Image of gravity base structure	

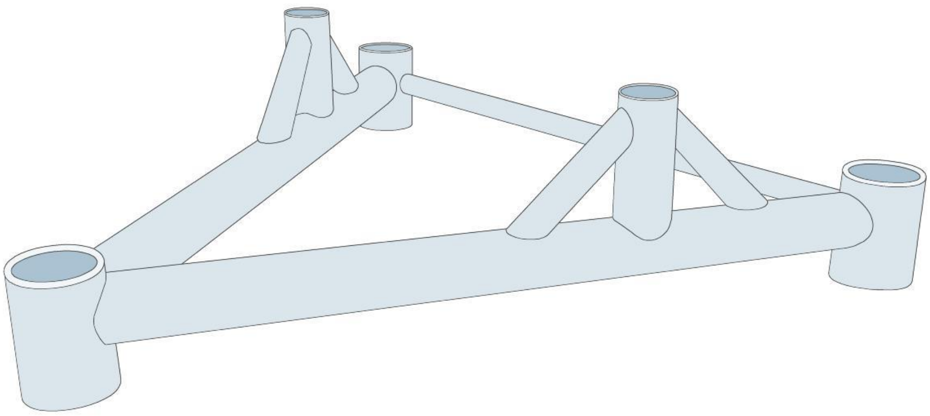



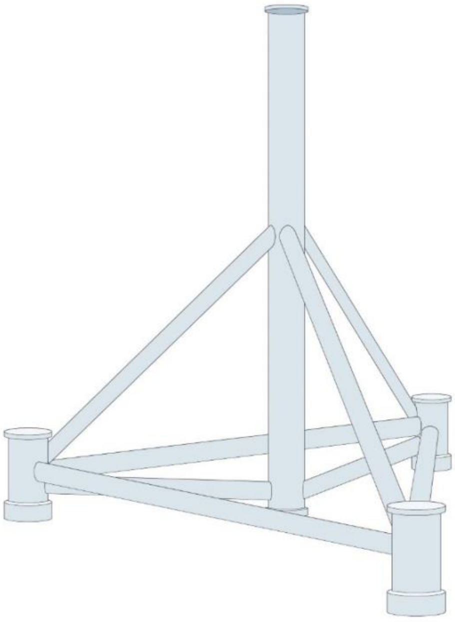
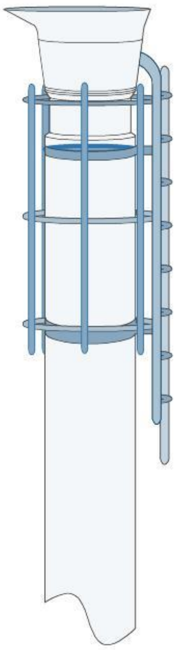
Image of drilled pin pile tripod	**Image of drilled monopile**
	

Table 5.5: TSS parameters relevant to the Project

Turbine Support Structure (TSS) type	TSS parameters relevant to the Project	Project parameters for impact assessment	Comments
Gravity base structure	Materials	Steel and concrete	-
	Design	Steel structure with flat rock bottom that sits on seabed	-
	Total footprint	30m x 40m = 1,200m^2	-
	Structure weight	Dry weight approx. 1,200 tonnes	
Subsea base	Materials	Steel and concrete	-
	Design (SSB)	Three point structure	-
	Total footprint (contact with seabed)	37.5m^2	-
	Structure weight	Dry weight approx. 1,200 tonnes	-
Drilled monopile	Materials	Steel	-
	Number of piles	1 per device	-
	Footprint of pile(s)	5 to 7m^2	-
	Total footprint of TSS (monopile with transition piece)	20m^2	-
	Pile diameter	2.5 – 2.8m	-
	Pile depth	11 to 12m	-
	Structure weight	Dry weight of 100 to 120 tonnes	-
Drilled pin pile tripod	Materials	Steel	-
	Number of piles	3	-
	Footprint of each pin pile	1.3m^2	Footprint for each pin pile
	Total footprint of all pin piles	4m^2	Footprint for three pin piles
	Total footprint of TSS	154m^2	Total area covered by pin pile tripod Only sections of tripod connected to the piles will be in direct contact with the seabed
	Pile diameter	Up to 1.3m	-
	Pile depth	5m	-
	Structure weight	Dry weight of 120 – 170 tonnes.	Weight depends on selected turbine axis height

5.6.3 Array Layout

Factors that will contribute to turbine layout include:

- Maximum and average current speeds;
- Current direction;
- Turbulence;
- Wave action;
- Bathymetry;
- Seabed slope and form;
- Turbine wake interaction;
- Installation and maintenance vessel operating requirements;
- Export cable layout;
- Environmental issues; and
- Navigational safety issues.

An indicative layout of tidal turbines within the AfL is shown in Figure 5.2. The final layout will be determined once an optimum turbine technology has been selected. The final layout will also depend on results from on-going resource assessments, seabed conditions and the outcome of various engineering studies. However, for the purpose of the EIA, an indicative turbine and inter-array cable layout has been generated as to inform the impact assessment.

The positioning and layout of the turbines will be influenced by site characteristics, turbine characteristics and will have to take into account spacing for both cross flow and down flow. Minimum cross flow spacing for the different turbines will be 80m. Minimum down flow spacing will be 150m. Both cross and down flow spacing will be influenced by resource availability, seabed conditions and turbine rotor diameters.

To optimise resources within the AfL area the turbines will be arranged in rows aligned perpendicular to the tidal flow. The total number of turbines per row, and number of rows, will be determined once the optimum turbine technology has been identified. Based on the pattern of tidal flow through the AfL area, it is likely that the total number of turbines per row would not exceed 15 turbines. In some parts of the AfL area the total number of turbines per row may be limited to 1 or 2 turbines only due to reduced resource and/or seabed conditions. The total number of rows is expected to range between 10 and 40 depending on turbine type, number of turbines per row, resource availability and seabed conditions.

Table 5.6: Array layout parameters relevant to the Project

Array layout parameters relevant to the Project	Project parameters for the impact assessment	Comments
Number of turbines (Stage 1)	30	Dependant on rated output of selected turbines
Number of turbines (Stage 1 and 2)	200	Dependant on rated output of selected turbines
Area of Crown Estate AfL area (total)	11.1km^2	-
Area of turbine deployment within AfL area	2.9km^2 for Stage 1; 8.5km^2 for Stage 1 and Stage 2 combined.	This will depend on selected turbines and array configuration
Minimum cross flow spacing	80m	Cross flow spacing depends on selected turbine, but there will be a minimum spacing between turbines of 80m.
Minimum down flow spacing	150m	Minimum down flow spacing between turbines will be 150m.
Turbine configuration	Turbines will be arranged in rows perpendicular to the direction of the prevailing tidal flow.	-
Number of turbines per row	Between 2 to 15 turbines per row	This will depend on selected turbine type and rating, resource availability within the AfL area and seabed conditions. Number of turbines per row will vary on a row by row basis
Total number of rows	Between 10 to 40 rows depending on number of turbines per row	Depends on turbine type and rating, resource availability and seabed conditions

5.6.4 Turbine Systems

5.6.4.1 Electricity Generation

All turbines will be fitted with either induction generators or permanent magnet generators to generate electricity. Depending on turbine type, some turbines may also require additional equipment for power conversion and conditioning to minimise power losses during transmission to shore and connection to the grid network. This equipment will be an integral part of each turbine.

5.6.4.2 Heating and Cooling Systems

There are no requirements for any heating or cooling systems on the turbine rotors or, in the case of the OpenHydro device, for the generator systems as these are cooled naturally by dissipating heat into the surrounding sea water. However, cooling systems will be required for internal generators and other electrical equipment e.g. power conversion units. All cooling systems will be closed circuit systems using water with non-toxic antifreeze or other type of non-toxic coolant e.g. MIDEL eN.

5.6.4.3 Lubricants

Lubrication will be required for turbine hydraulic systems and other equipment such as gears, gearboxes, brakes, shafts and bearings stored within the nacelle if a horizontal axis turbine (HAT) type turbine is chosen. The Open Centre Turbine uses seawater for lubrication. Where other lubricants are required these will be either mineral oils or bio-compatible/bio-degradable oils with low ecotoxicity. Typical inventories of these fluids will be in the range of hundreds to a maximum of one thousand litres (per device).

5.6.4.4 Protection Systems

Protection of the turbines from seawater corrosion and marine growth (fouling) is essential to prevent damage and ensure the turbines continue to operate efficiently. Offshore-standard anti-corrosion paints will be used on exterior parts of the turbine combined with sacrificial anodes to provide cathodic protection. Rotor blades, generator and gearbox nacelles will be treated with non-biocidal antifouling paint, compliant with EC Anti Fouling System Regulation (No. 782/2003) or superseding regulations. On some turbines, the nacelle and other cavities may be flushed and filled with dry nitrogen before deployment to provide further protection against internal corrosion and fire (Table 5.7).

5.6.4.5 Lighting and Marking

Requirements for marking and lighting of the Project during all phases have been determined in consultation with the Northern Lighthouse Board (NLB) and Maritime and Coastguard Agency (MCA) following consultation on the Navigational Risk Assessment (NRA).

Depending on the outcome of discussions with the MCA and NLB as part of the NRA it may be necessary to implement a 500m safety zone around vessels during TSS, turbine and cable installation to ensure the safety of vessels operating in the area (Table 5.7). Depending on the location used for turbine manufacture and assembly and method of transporting TSSs and turbines to the AfL area for installation, navigational lighting may also be required for any towing activities. Specific requirements for navigational lighting during towing will be agreed with the MCA and NLB as part of consultation on the NRA.

Table 5.7: Key parameters for turbine systems relevant to the Project

Turbine system parameters relevant to the Project	Project parameters for the impact assessment	Comments
Inventory of lubricants/oils and other liquids	800 to 1,000 litres	Volumes (per device) are approximate covering range of liquids including mineral oil, grease, hydraulic fluid, low toxicity biodegradable oil, biodegradable ethanol.
Lighting and marking	500m safety zone may be required around vessels during installation of turbines and export cables	Requirements for aids to navigation during operation are to be determined in consultation with NLB and MCA Navigational lights may be required for towing of turbines to and from the AfL area e.g. during installation and maintenance activities

5.7 ELECTRICAL INFRASTRUCTURE

5.7.1 Inter Array Cables

Each turbine will require its own inter-array cable. The cable connection design will be finalised as part of a detailed engineering and procurement process and is likely that connection of the inter-array cables to the TSS will require the use of dry-mate connectors although wet-mate connectors could be used if available. These will connect directly into the TSS or will connect to the TSS via a short jumper cable. Table 5.8 describes the inter-array parameters.

Each inter-array cable will have a voltage of up to 33kV and a cross sectional area of up to 500mm^2. Depending on the rated output of the turbines (which will be at least 1MW) for a 200MW array the maximum number of inter-array cables required for the turbines would be 200 (with up to 8 further inter-array cables for the subsea connection hubs). The number of inter-array cables required for a 200MW Project will decrease as the rated power output of the tidal turbines increases.

The final configuration of the inter-array cables within the AfL will be subject to detailed design and procurement and will depend on final turbine layout and options for using subsea hubs. Cables may also be bundled to reduce the overall footprint of the inter-array cables. It has been assumed for the purpose of the EIA that as a worst case (assuming cable protection with footprint width of 5m) inter-array cables will occupy approximately 0.36km^2 (3%) of the remaining seabed within the turbine deployment area that is not occupied by the TSSs.

The inter-array cables will be surface laid. This is necessary to provide flexibility for the cables to be picked up during maintenance. The cables will be anchored to the seabed to hold them in position during operation. The cables may include armour protection (possible double armour or interlocking armoured shells as used in the oil and gas industry) to provide mechanical protection and add additional weight to the cables which will help to hold the cables in position.

Table 5.8: Key parameters for inter-array cabling relevant to the Project

Cable and landfall parameters relevant to the Project	Project parameters for the impact assessment (Stage 1)	Project parameters for the impact assessment (Stage 1 and 2)	Comment
Number of inter-array cables	32	208	Worst case based on one cable per turbine plus one per subsea hub
Transfer voltage of inter-array cables	Approximately 13 – 33kV	Approximately 13 – 33kV	Could vary depending on selected technology and array design
Cross sectional area of inter-array cables	500mm^2	500mm^2	Maximum
Footprint of inter-array cables	0.07km^2 (approximately 0.6% of total AfL area)	0.36km^2 (approximately 3% of total AfL area)	Assuming 450m per inter-array cable

5.7.2 Protection

5.7.3 Export Cables

In the case of a subsea connection hub, it is anticipated that up to 16 export cables (4 for Stage 1) may be required to connect the tidal array to shore. In this case, each cable will have a voltage of at least 33kV, but potentially up to 132kV, and a diameter up to a maximum of 500mm. The primary purpose of the subsea hub is to reduce the number of cables coming ashore by combining the output from a number of inter-array cables into a smaller number of export cables, potentially with the additional function of increasing the transmission voltage to reduce transmission losses from the export cable.

The export cables will be buried where seabed conditions are favourable. However, as much of the seabed within the AfL area and along proposed export cable routes comprises hard rock substrate this may be limited. Where the cables cannot be buried cable protection may be required along the length of the export cables (from the AfL to landfall). This will also ensure cable stability in sections where the cables run perpendicular to the tidal flow.

Cable protection measures could include:

- Rock placement: placement of rocks and boulders of various sizes along the export cables resulting in the creation of a rock berm over the cable. The size and dimensions of the berm will depend on local bathymetric and tidal conditions. Rock berms in high energy environments are typically larger and comprise larger rocks and boulders than those required in less energetic environments. Rocks will be placed along the cable by a specialised vessel with a ROV controlled fall pipe to ensure accurate rock placement;
- Concrete mattresses: pre-formed articulate mattresses comprising a mesh of concrete block that are placed across cables. The thickness of protection provided can be increased by increasing the thickness of the mattress; or
- Grout bags: bags of hardened gravel, sand/cement grout or concrete placed over the cable. Grout bags can be pre-fabricated onshore or bags can be filled offshore using vessels with fall pipes.

Including cable protection, the maximum width of the area of seabed affected by each export cable will be 5m. For 16 cables, the total width of the area of seabed directly affected by the cables will be 80m. The affected area for Stage 1 will be up to 20m. For operational reasons, a space will be required between each subsequent cable. The required spacing will be dependent on the water depth at each location. As a result, the corridor width associated with the cables will be significantly wider than the cable affected area.

5.7.4 Export Cable Corridors Area of Search

The number and size of export cables will depend on a range of factors including array size, rated output of selected turbines, inter-array cable layout/configuration, number and size of subsea cable connection hubs, seabed condition, redundancy, landfall and export cable routes and options for bundling cables along export cable corridors. The final cable architecture will be designed to ensure the following:

- Turbines are fully maintainable during service without any effect on the output from other turbines;
- Turbines can be removed (disconnected from the inter-array cable) without any effect on the output from other turbines; and
- The power output from the turbines must not be affected if any cables are damaged.

The export cables will be brought to shore at one of three possible landfall locations (either Sheep Skerry, Moodies Eddy or Aith Hope) as shown in Figure 5.1. The final landfall location will be confirmed during detailed design phase post consent determination. The indicative cable corridors illustrated in Figure 5.1 provide access to each of the landfall locations. The distances from the AfL area to each of the landfall options are summarised in Table 5.9.

The preferred export cable route and final alignment and width of the preferred route will be determined during detailed design and will depend on:

- Total length of the cable route;
- Total number of export cables to be brought to shore;
- Options for bundling cables (this will be determined at detailed design through discussion with cable contractor);
- Seabed conditions based on results from detailed geophysical and geotechnical surveys (to be carried out post consent);
- Environmental conditions based on information from benthic surveys, marine archaeology desk study and post consent geophysical surveys;
- Suitability of the cable landfall (technical and environmental); and
- Preferred location for the onshore substation and grid connection.

Table 5.9: Key parameters for the export cables, export cable route and landfall

Cable and landfall parameters relevant to the Project	Project parameters for the impact assessment (Stage 1)	Project parameters for the impact assessment (Stage 1 and 2)	Comment
Number of export cables	Maximum 4 cables	Maximum 16 cables	-
Cable armour	Cables to include armoured coating	Cables to include armoured coating	-
Transmission type	Alternating Current (AC)	Alternating Current (AC)	-
Transfer voltage of export cable	Maximum 132kV	Maximum 132kV	-
Separation distances between cables	2 – 3 times water depth	2 – 3 times water depth	Recommended separation distances Spacing between cables may be reduced depending on rating and installation methodology
Export cable route length	2.5km Sheep Skerry 2.6km Moodies Eddie 6.5km Aith Hope	2.5km Sheep Skerry 2.6km Moodies Eddie 6.5km Aith Hope	-
Area directly affected by cable (corridor width per cable)	5m per cable including protection	5m per cable including protection	-
Area directly affected by cable (corridor width for all cables)	20m affected area (cable corridor)	80m affected area (cable corridor)	-
Diameter of cable	500mm (worst case diameter)	500mm (worst case diameter)	-
Length of cable route to be surface laid	Maximum 100% cable will be surface laid	Maximum 100% cable will be surface laid	Will depend on seabed conditions along cable route. In areas of hard bedrock cable will be surface laid

Cable and landfall parameters relevant to the Project	Project parameters for the impact assessment (Stage 1)	Project parameters for the impact assessment (Stage 1 and 2)	Comment
Length of cable route to be buried	Unknown	Unknown	Will depend on seabed conditions along cable route. May be option for cable burial in areas of soft sediment
Depth of cable burial	Approximately 1m depth (minimum)	Approximately 1m depth (minimum)	Cable burial will only be feasible in areas of softer sediment
Cable trench dimensions (for sections of export cable where burial possible)	1m depth (minimum) by 2m width	1m depth (minimum) by 2m width	Cable burial will only be feasible in areas of softer sediment
Cable protection and stabilisation measures	Rock placement Concrete mattresses Grout bags Cable armour	Rock placement Concrete mattresses Grout bags Cable armour	Assuming 100% of export cable corridor and all inter-array cabling will be protected
Length of cable route requiring protection and stability measures	Maximum 100% of cable length	Maximum 100% of cable length	Cable protection will be required along all sections of cable that are surface laid
Method to be used to bring cables ashore at landfall	Open Cut Trench or Horizontal Directional Drill (HDD)	Open Cut Trench or Horizontal Directional Drill (HDD)	-
Width of cable corridor at landfall	Maximum 20m (maximum affected area for 4 cables)	Maximum 80m (maximum affected area for 16 cables)	Depends on number of cables to be brought ashore and method of installation at the landfall

5.7.5 Cable Landfall

The export cables will be brought to shore using either traditional beach landing Open Cut Trench technique or Horizontal Direction Drill (HDD) techniques.

The size of the cable landfall at each of the three possible locations (Sheep Skerry, Moodies Eddy and Aith Hope) will depend on the number of export cables to be brought ashore and the selected landfall technique (Open cut trench or HDD). For 16 export cables in 6 bundles, assuming 15m separation between cable bundles, the maximum width of the corridor at the landfall (assuming cables are not buried) will be 85m. Information on the area required for onshore access, equipment laydown, working areas and construction compounds will be provided as part of the description of the onshore components. Please see Chapter 21 Overview of Onshore Impacts for further information on this element.

5.7.5.1 Open Cut Trench

For sea to shore landfall construction, the open cut method requires the excavation of a trench which is then back-filled following installation of the cable. For landfalls the trench is generally divided into two sections which consider an onshore portion and an offshore portion. Standard land based techniques can be employed for the onshore section of work, but specialist dredging/trenching equipment would be required for the offshore section to successfully protect the cable below the high energy littoral zone (i.e. surf).

The depth of excavation is dependent on site morphology and coastal processes, and that the open trench can remain stable and 'open' long enough to achieve the cable installation before burial. If site conditions do not allow this then temporary trench support will be required, usually in the form of steel sheet piling for cofferdam construction. These often require a burial depth of up to 3m below lowest expected beach level, to take into account long-term variations in beach profiles and in consideration of the security of the cable.

Once a trench has been formed, the offshore cable can be installed from the cable lay vessel by a combination of floating and pulling the cables ashore using a pulling head from a land-based winch.

5.7.5.2 Horizontal Directional Drill (HDD)

In coastal areas that are not suitable for open cut trench, horizontal directional drill (HDD) is the alternative method to install cables from sea to land. HDD involves drilling a hole at depth through the ground linking two points between which the cable will be installed; these are referred to as the entry and exit points, with the drilling rig being set up at the entry point. A solid conduit or duct will then be inserted into the hole to keep the hole open. The cables will then be pulled through the conduit/duct. Cables can be pulled from both an onshore or offshore direction.

The size and number of the HDD holes/ducts will depend on the size and number of cables requiring installation. The length and depth of the HDD ducts will depend on the mechanical properties of the submarine cables and the shore and near-shore conditions (geology and geotechnical) to be drilled under. The two HDD options include:

- Short HDD – this bores under cliffs to exit at some point on the beach between high and low water. Open cut methods would then be used for cable installation across the beach. The shorter HDD would rely on suitable access to the beach for construction of the beach trench; or
- Long HDD – this allows the cable to be installed under both the intertidal littoral zone and sea cliffs to a point offshore. This may also be conducted from sea to shore using an offshore HDD. Beach access would not be required for either of the long HDD options as the drill rig would be located above the MHWS some distance back from the coastline. The marine exit point for a long HDD is dependent on water depth, bathymetry and subsurface geology. A typical working estimate for maximum length of cable pull is 500m – 1,000m. Where it is determined that a land based long HDD is unsuitable, then an alternative option may be to use a sea-to-shore HDD which would involve placing the drill rig on an offshore jack-up rig. The operation is effectively identical to the land based long HDD, but with interchanged entry and exit points.

All three locations are suitable for accommodating cable landfalls and have reasonable space for setting up equipment (open cut trench or HDD). However, there may be a requirement to improve local access to the landfalls for bringing in construction equipment.

Selection of the preferred landfall location will depend on the preferred export cable route (to be determined during detailed design) and results from environmental and technical studies undertaken to support planning consent for the onshore components of the Project.

Table 5.10: Landfall installation techniques

Cable and landfall parameters relevant to the Project	Project parameters for the impact assessment (Stage 1)	Project parameters for the impact assessment (Stage 1 and 2)	Comment
Method to be used to bring cables ashore at landfall	Open cut trench or horizontal directional drill (HDD)	Open cut trench or horizontal directional drill (HDD)	-
Width of cable corridor at landfall	Maximum 20m (maximum affected area for 4 cables)	Maximum 80m (maximum affected area for 16 cables)	Depends on number of cables to be brought ashore and method of installation at the landfall

5.8 OFFSHORE INSTALLATION

The approach to turbine installation described below reflects operating conditions associated with the high tidal flow and impermeable (hard rock) seabed conditions present within the AfL area.

For most turbines the TSSs will need to be installed prior to turbine installation. Other turbines will be installed as single units with the turbine already attached to the TSS.

5.8.1 Turbine Support Structure (TSS) Installation

The main types of TSS will have different installation approaches described in Table 5.11.

Table 5.11: TSS installation techniques

TSS	Installation technique
Gravity Base Structure (GBS) including sub-sea bases (SSBs)	A number of installation techniques are possible for a Gravity Base Structure: • Utilising a heavy-lift installation vessel, with lifting capacity of ~400 tonnes and dynamic positioning (DP) capabilities. The base would be installed in two or more lifts, with positioning of the structures and the turbines assisted by ROV. • Utilising a specialised heavy-lift deployment barge to lower the gravity base as one unit with the turbine already attached. There will be no requirements for any intrusive seabed preparation works for GBSs or SSBs and there will be no drill cuttings generated from attachment of the GBSs to the seabed. In some locations, there may be a requirement to move or reposition some cobbles and boulders in the immediate vicinity of TSSs in order to even out the seabed. There will be no need for scour protection as the seabed consists of cobbles, boulders and exposed bedrock.
Drilled monopile	Installation of monopile TSSs requires use of specialist drilling equipment (e.g. drilling unit that sits on the seabed) and multi-stage operations to grout the monopiles into their socket. Drilling operations will generate drill cuttings.

TSS	Installation technique
	There is no requirement for scour protection as seabed consists of cobbles, boulders and exposed bedrock.
Pin pile tripods	Installation of pin pile tripod TSSs is similar to monopile installation and also requires use of specialist drilling equipment (e.g. drilling unit that sits on the seabed) and multi-stage operations to grout the monopiles into their socket. Drilling operations will generate drill cuttings. There is no requirement for scour protection as seabed consists of cobbles, boulders and exposed bedrock.

5.8.2 Turbine Installation

Once the TSSs are in place (for those that don't have turbines pre-attached), the turbines will be transported to the AfL either on a dedicated deployment barge or heavy lift vessel. Turbines with built in buoyancy will be towed to site using standard working class tug vessels.

Once the turbines are at site they will be lowered (or pulled down for buoyant turbines) by a winch to the top of the TSSs. ROVs will then be used to guide the turbines into place for attachment to the TSSs. The turbines will then be mechanically secured in place.

Turbines that are to be installed as a single unit (already attached to the TSS) will be assembled on dry land (e.g. port facility) before being loaded onto the deployment vessel and transported to the AfL area. Once at the AfL the entire turbine unit will be lowered into position on the seabed using three specialised deck mounted heavy lift winches. A specially designed steel recovery frame and lifting system can also be used to assist with the positioning of the single unit turbine structures on the seabed. The recovery and lifting frame can be attached to the deployment barge using a hydraulic winch system. Figure 5.9 gives an example of the technique.

Figure 5.9: Open-Centre turbine and subsea base installed on barge in France, 2011 (OpenHydro)

5.8.3 Installation Vessel Requirements

Some of the TSSs and turbines will be installed using a Dynamic Positioning (DP) construction vessel with a 250 to 400 tonne capacity heave compensated crane or an equivalent stable platform (moored barge). A jack up barge may also be required depending on site conditions, TSS and precise method of installation. Where turbines and TSSs are to be installed as a single unit, installation will be carried out using a purpose built twin hulled three point heavy lift deployment barge. Other smaller vessels e.g. tugs, vessels carrying ROVs, crew transfer vessels, dive boats and RIBs will also be required to support the installation operations (Figure 5.10). For these devices, there will be limited/no requirements for any seabed preparation e.g. levelling or infill prior to the installation of the TSSs.

Figure 5.10: Open-Centre turbine, barge and tug in the Bay of Fundy, Canada 2010 (OpenHydro)

5.8.4 Timing of Installation Activities

Although there are no specific seasonal constraints on turbine deployment, turbine installation and other construction activities will generally be carried out during months when weather is most favourable (e.g. April to September/October).

5.8.5 Sea State and Tide Conditions for Installation

TSS and turbine installation will generally take place around slack water periods on a neap tide in sea state 4 or less.

5.8.6 Duration of Installation Activities

TSS and turbine installation will occur over three years. Stage 1 (15 to 30 turbines) will commence in Q2 2019 and will continue for approximately 12 months to the end of Q2 2020. Stage 2 (85 to 170 turbines) will commence at the beginning of Q2 2021 and will continue for approximately 36 months with expected completion in Q2 2024. For both stages turbine installation will commence at the same time as installation of the export cables. Turbine installation will either be carried out at the same time as installation of the TSSs or will follow TSS installation. The inter-array cables will also be installed at the same time as the turbines.

All timescales provided above are approximate and are dependent on seabed and tidal flow characteristics within the AfL area and weather conditions at the time of installation.

Where moored barges or jack-up barges are to be used to assist with TSS and turbine installation, these will need to be anchored/positioned within the AfL area. The positioning of anchors/location of the jack up barge will depend on seabed conditions and array configuration.

During TSS and turbine installation, there may be requirements for vessels to take temporary shelter during periods of bad weather or between tides. Possible locations to be used as sheltered anchorages will be confirmed prior to submission. The final preferred location will be identified through consultation with key stakeholders during detailed design.

5.8.7 Navigation

Based on the outcome of discussions with the MCA and NLB as part of the Navigation Risk Assessment (NRA) a 500m safety zone may be required around vessels involved in turbine and cable installation e.g. barges and tugs. Navigational lighting is also likely to be required during installation on working/installation vessels and on any towed equipment.

Table 5.12 describes the key parameters.

Table 5.12: Key parameters relating to turbine installation

Turbine installation parameter relevant to the Project	Project parameters for the impact assessment	Comment
Vessels required for TSS installation	DP construction vessel with 250 to 400 tonne capacity heave compensated crane or equivalent stable platform (moored barge or jack up barge) Second DP construction vessel with 150 tonne capacity heave compensated crane Purpose built twin hulled three point heavy lift deployment barge Multicat work boat	This applies to GBSs, monopiles and pin pile tripods
Supporting vessels	ROVs, Tug boats, dive boats, RIBs and crew transfer vessels	-
Turbines	Turbines will also be installed using DP construction vessel with 250 to 400 tonne capacity heave compensated crane or equivalent stable platform (moored barge or jack up barge) Purpose built twin hulled three point heavy lift deployment barge will be used for some turbine types	-
Installation period (TSS and turbine)	All year but generally April to September/October when weather conditions typically more favourable (settled)	-
Tidal cycle required for TSS and turbine installation	Installation will typically take place at slack water on a neap tide	-
Required sea state for TSS and turbine installation	Sea state 4 or less	-
Duration of TSS installation including inter-array cable connections (per turbine)	Up to 6 days per TSS depending on TSS type	Monopile, pin pile
Turbine installation when using SSB with turbines connected onshore	30 minutes to three hours	Gravity base TSS
Duration and timing of turbine installation (all turbines)	See Table 5.1 Project Timescales	-
Seabed preparation	There will be limited/no requirement for any seabed preparation e.g. levelling or in-fill prior to the installation of the TSSs	-

Turbine installation parameter relevant to the Project	Project parameters for the impact assessment	Comment
Drill cuttings for monopile TSSs	Based on monopiles with maximum diameter of 2.8m and depth 12m maximum drill cuttings would be 74m^3 per monopile	
Drill cuttings for pin pile tripod TSSs	Based on pin piles with diameter 1.3m and depth 5m maximum drill cuttings would be 15.9m^3 per pin pile (47.8m^3 per tripod)	

5.9 OFFSHORE INSTALLATION - ELECTRICAL INFRASTRUCTURE

Key parameters and timescales to be used in the assessment are provided Table 5.13.

Table 5.13: Key cable installation parameters relevant to the Project

Turbine installation parameters relevant to the Project	Project parameters for the impact assessment	Comment
Phasing of export cable installation	2 cables laid per installation operation; 2 cables will serve up to 30MW capacity.	-
Timing and duration of export cable installation	4 cables in 2019/2020; Further 12 cables in 2021/2022	-
Phasing of inter-array cable installation	Installed with turbine systems	-
Timing and duration of inter-array cable installation	As turbine installation	-
Vessels required for cable installation	Specialised cable-laying vessel for export cables; DP vessel for inter-array cable connections following lay by turbine deployment vessel	-
Vessels involved in installing cable protection measures/cable stability measures	Specialised vessels with fall pipe (rock placement/grout bags) Specialised vessel with heavy lift capacity crane/winches (concrete mattresses/grout bags) ROVs may also be required to ensure accurate placement of cable protection	-
Duration of works installing cable protection/stability	As above	-
Timing for installation of cable protection/stability	As above	-
Landfall method of installation	HDD/open-cut trenching	-
Equipment required for installation of cables at the landfall	Open cut trench – dredging/trenching equipment, excavators, winches, steel sheet piling to create cofferdams (if required)	-

Turbine installation parameters relevant to the Project	Project parameters for the impact assessment	Comment
	HDD – drilling rig (usually located onshore but can be located on jack up barge (offshore)	
Drill cuttings	There may be a small release of drill cuttings to sea from HDD at seabed breakthrough	-

5.10 OFFSHORE OPERATIONS AND MAINTENANCE

5.10.1 Commissioning Activities

Commissioning of the turbines will take place at a number of stages during turbine deployment:

1. Factory testing;
2. Assembly (onshore);
3. Pre-installation testing (onshore); and
4. Connection of the turbines to the electrical export cables (following installation offshore).

The purpose of commissioning is to ensure the safe and reliable operation of the turbine's mechanical, electrical and control systems at the optimised design efficiency. Once the turbines are installed, final commissioning will include communications checks, hydraulic system operation checks, pitch and yaw (where appropriate for specific turbines), generation, over speed, trips and shutdowns, start up and autonomous control and power quality.

5.10.2 Duration of Commissioning Activities

For all turbines the majority of commissioning work will be carried out onshore to minimise the amount required offshore. However, once installed final commissioning of the turbines will be required. Initial commissioning of the first installed turbines could take up to 2 months. Following this commissioning of individual turbines is expected to take between 1 day and 1 week. Where possible individual turbines will be commissioned concurrently to minimise impacts on the duration of overall commissioning period. Commissioning of Stage 1 is expected to start at the end of Q2 2019 for completion at the end of Q4 2019. Commissioning of Stage 2 will commence Q2 2021 for completion by end of Q3 2023.

5.10.3 Operations and Maintenance

The array will have an operational life of up to 25 years. The turbines will be controlled remotely via an onshore control system. This control system will be located at a dedicated operations base, the location of which is still to be determined. It is planned that the operating system will be unmanned and will run automatically.

The turbines will also contain on-board monitoring systems including sensors and other monitoring equipment that will alert the operator to any operating anomalies. It is planned that the turbines will be monitored continually throughout their operational life. In the event that anomalies occur, or an emergency situation, the control system will be able to safely shut down individual turbines.

Maintenance will be required for all turbines. It is likely that this will need to be undertaken every 5 to 10 years depending on the turbine technology and tidal conditions in the AfL area. Maintenance could involve a planned complete overhaul of the turbines, which would require the removal of the turbine from the sea, or detailed inspections with the replacement of key components where necessary.

For all turbines, major maintenance overhauls will take place onshore (e.g. turbines will be removed from the water). Where turbines are removed from the water, maintenance will take place either at the quayside or at a specialised workshop depending on the level of work required e.g. replacement of parts or complete overhaul of turbine unit. In the case of the Open-Centre Turbine, maintenance is likely to be carried out with the turbine on the deployment barge, docked at a suitable quayside. For minor repairs it may be possible to carry out some maintenance at sea (turbines will remain in-situ), subject to suitable weather and tide conditions. These turbines would only be recovered from the sea for maintenance onshore in the event of a turbine failure. Where maintenance is to be carried out at sea all works will be undertaken at slack tide and in suitable sea states (e.g. wave height <2m).

Planned major maintenance activities are likely to take longer e.g. turbines could be removed from the water for up to 30 days per turbine depending on the work required and whether all replacement parts are available at the time of the maintenance.

In addition to planned maintenance of the turbines, regular inspections of the export cables using drop down cameras and inspection class ROVs will also be required.

5.10.3.1 Routine Inspections and Preventative (Minor) Maintenance

Planned maintenance activities vary for the different turbine technologies. For some turbines it will be necessary to carry out regular inspections e.g. every two years using ROVs. Minor or preventative maintenance activities may also need to be carried out for some turbines every couple of years to replace consumable and short life components. Specific timescales for minor or preventative maintenance will be determined on a case by case basis depending on the turbine technology and whether maintenance is to be carried out at sea or onshore (quayside maintenance). For most turbines minor/preventative maintenance is expected to be completed within seven days (onshore or at sea). Routine ROV inspections are expected to take approximately 20 minutes per turbine.

5.10.3.2 Vessels and Equipment Required for Inspections

It is likely that vessels involved in maintenance activities will be present in the Project site throughout the year. On average this is expected to be one vessel per day. However, there may be periods when there are more vessels e.g. two or three or no vessels depending on weather conditions and extent/type of maintenance works required. The key maintenance activities, and their duration, are described below.

Inspections of turbines and cables will be carried out using ROVs deployed from offshore small (25 – 30m) work class DP tugs or similar vessels. RIBs and dive boats may also be required.

5.10.3.3 Vessels and Equipment Required for Maintenance (Minor and Major)

Minor or preventative maintenance carried out at sea will involve the use of small (25 – 30m) work class tug or similar vessel, work class ROV and RIB.

Where turbines need to be removed from the sea for maintenance, this will require the use of large DP heavy lift crane vessels or purpose built twin hulled deployment barge developed specifically for the installation and removal of the OCT units (turbines and TSSs assembled onshore). Other support vessels will also be required including small DP vessel, crew transfer vessel (large 11m cabin RIB) and a dive vessel (6 -7m RIB).

5.10.3.4 Methods and Equipment Required for Planned Maintenance

Depending on the work required, major maintenance work will be carried out at the quayside or at a specialised workshop/facility. Maintenance works will require standard tooling, lifting and handling equipment. Maintenance activities vary across the different turbines. However, typical turbine maintenance activities are likely to include:

- Pitch unit maintenance;
- Blade replacement/maintenance;
- Nacelle inspection;
- System diagnostics;
- Fluid level check and maintenance;
- Anode replacement; and
- Auxiliary power systems maintenance.

5.10.3.5 Unplanned Maintenance

All turbines will be fitted with on-board monitoring systems to check turbine performance and identify any damage, anomalies or faults. Turbines will be designed to shut down safely in the case of severe faults or damage. Any requirement for unplanned maintenance will be detected at early stage through monitoring systems on the turbines. Depending on weather conditions, and extent of the damage or fault it should be possible for unplanned maintenance to be performed in a reasonable time frame.

Where contingency retrievals and repair operations are required these will be identical to those required for planned maintenance and would be carried out on a case-by-case basis.

5.10.4 Location for Operation and Maintenance Activities

The onshore base for operations and maintenance (Operation and Maintenance) activities has not yet been identified. Facilities required at the selected Operation and Maintenance base will include:

- Deep water quay or slipway;
- Good access to site ;
- Large laydown areas;
- Heavy lift facilities (crane) e.g. 200 tonnes to lift turbines from water or off deployment/maintenance vessels;
- Open air bays for routine minor maintenance, supported by mobile cranes, forklifts, cherry pickers;
- Good road access to allowing for the unrestricted access of large component parts including the nacelles where required;
- Covered bays with overhead crane for major maintenance; and

- Spare part storage, offices, and welfare facilities.

5.11 DECOMMISSIONING

It is the intention of BTAL to re-power the Project at the end of the consent period. However, this would only be carried out with full agreement from all relevant parties and once the necessary consents are in place.

The decommissioning process is the reverse of the installation procedure and requires the same plant and machinery. Removed turbines would be disposed of in line with all local regulations and any parts and materials which could be salvaged would be recycled. Monopile and pinpile foundations will be cut off at the seabed.

Where the installation is to be repowered the export cables would be left *in situ* and re-used.

The impacts associated with decommissioning will be the same or less than those identified for installation. This is reflected in the decommissioning sections of each of the technical impact assessment chapters.

A detailed decommissioning plan will be submitted to the Department of Energy and Climate Change (DECC) for approval in line with the Energy Act (2004). Please see Chapter 3 Policy and Legislation for further information on this.

5.12 VESSEL INVENTORY

Table 5.14: Vessel requirements

<table>
<tr><th>Activity</th><th>Vessel</th><th>Time present in AfL area</th></tr>
<tr><td>Installation of TSSs</td><td>One of:
DP construction vessel with 250 to 400 tonne crane lift capacity plus DP construction vessel with 150 tonne crane lift capacity;
Purpose built twin hulled three point heavy lift deployment barge; and/or
Jack-up barge/moored barge depending on site conditions and selected TSS.
Support vessels: small DP vessels with ROV on board, crew transfer vessels (RIBS), dive vessels (RIBS), tug boats</td><td rowspan="2">Stage 1: 2019 - 2020
Stage 2: 2021 - 2023</td></tr>
<tr><td>Installation of turbines</td><td>Selection of:
DP construction vessel with 250 to 400 tonne crane lift capacity plus DP construction vessel with 150 tonne crane lift capacity;
Purpose built twin hulled three point heavy lift deployment barge; and/or
Jack-up barge/moored barge depending on site conditions and selected TSS.
Support vessels: small DP vessels with ROV on board, crew transfer vessels (RIBS), dive vessels (RIBS), tug boats</td></tr>
<tr><td>Installation of cables</td><td>Specialised cable installation vessel</td><td>Stage 1: Early 2019
Stage 2: 2020/2021</td></tr>
</table>

Activity	Vessel	Time present in AfL area
Installation of cable protection and stability measures	Specialised vessels comprising one of: Vessel with fall pipe (rock placement); and/or Heavy lift crane vessel for concrete mattresses and grout bags Inspection class ROVs	Stage 1: 2019 Stage 2: 2020/2021
Landfall activities	Jack up barge for sea to shore HDD	Stage 1: 2019 Stage 2: 2020/2021
Routine inspections	Offshore small (25 – 30m) work class DP tug or similar with ROV on-board RIBS and dive boats may also be required	Ongoing
Preventative maintenance	Small (25 – 30m) work class tug or similar vessel, work class ROV and RIB	Ongoing
General maintenance	Where turbines need to be removed from the sea for maintenance, this will require the use of large DP crane vessels or the purpose built twin hulled three point heavy lift deployment barge for installation of OCT with TSS as single unit Other support vessels will also be required including small DP vessel, crew transfer vessel and dive boats	Every 5 years for each turbine – ongoing for project life
Vessel fuel inventory	For the purpose of the assessment vessel fuel inventory is based on the amount of marine diesel carried on board a standard large DP installation vessel. Large DP vessels carry between 6,000,000 and 8,000,000 litres of marine diesel in a number of separate tanks. The worst case scenario for assessing accidental spillages of fuel from vessels is to assume leakage of one tank (approximately 600,000 litres of marine diesel).	Vessels likely to be on site on an ongoing basis from 2024 for maintenance duties.

5.13 MITIGATION MEASURES

Project design mitigation measures and general mitigation measures have been included here so that the reader can be made aware of these measures prior to reading technical chapters. These measures have been established in project development and can be applied to many potential impacts. They are therefore applied to all chapters for the purpose of carrying out the assessment. These are standard practice measures based on specific legislation, regulations, standards, guidance and recognized industry good practice that are put in place to ensure significant impacts do not occur.

Project Specific Measures are listed and discussed in each Chapter as relevant.

Table 5.15: Project design mitigation measures

Ref	Mitigation Measure Description
	All Phases
PD01.	The cable locations (route corridors), numbers (bundling) and installations methods have been designed to minimise disturbance to the seabed, commercial fisheries, and any potential sites of archaeological or cultural heritage importance
PD02.	To minimise risk of pollution, any necessary cooling systems will be closed circuit systems using water with non-toxic antifreeze or other type of non-toxic coolant. Lubricants used will be either mineral oils or bio-compatible/ bio-degradable oils with low ecotoxicity
PD03.	The AfL area has been revised, with 80% of the area for investigation shifted to the west, and the remaining 20% overlapping with the original site. Initial consultation identified this as a positive step to mitigate the risk of vessels using the western approaches to Scapa Flow, including tankers and the Scrabster-Stromness ferry. The barrier effect of the tidal array equates to only 0.9% of the cross sectional area of the Pentland Firth therefore this positioning minimises potential impacts of the barrier effect on fish.
PD04.	Floating devices were initially under consideration in the original design envelope, but were removed, in order to reduce the risk of collision as well as potential for loss of station. This design was also changed from a minimum clearance of turbines below the water level to LAT (approximate chart datum) of 20m to 30m.
PD05.	In June 2015, surface piercing technologies including hubs were removed from the Project design envelope, meaning that the entire Project will be seabed mounted and will not contain any surface piercing element. This significantly reduces the potential for vessel collision, which had previously been identified as the main hazard at the NRA stakeholder workshop, prior to this decision being taken. It also mitigates the disturbance of birds, visual landscape and physical processes.
PD06.	The maximum installed capacity and maximum limit to the number of turbines will reduce the potential effects arising from the turbines and TSS.
PD07.	A deploy and monitor strategy will be adopted i.e. continual monitoring of activities during device deployment to ensure that potential impacts identified and adaptive management measures are applied appropriately from the commencement of construction. A Project Environmental Management Plan will be developed in consultation with relevant stakeholders which will include mitigation and monitoring measures to ensure there are no significant environmental effects from the Project.
PD08.	The construction and installation, operation and maintenance and decommissioning timescales provide a time limit for the maximum duration of effects.

Ref	Mitigation Measure Description
PD09.	Protection against the effect of EMF may include armour protection (possible double armour or interlocking armoured shells). The use of these methods will increase the distance between marine species sensitive to EMF and the EMF source.
PD10.	The introduction of Project components and artificial substrates including TSS gravity bases will provide artificial refuges for fish or shellfish species.
PD11.	During operation, smaller vessels may be used for maintenance purposes. This will therefore reduce underwater noise levels and associated potential impacts.
PD12.	All TSS (and turbines) will be installed over a period of approximately 4 years, resulting in intermediate sediment release/disturbance during installation and allowing sufficient time for any sediment to disperse. In addition, the location of the Project is such that strong tidal currents will provide quick dispersion of any sediment released/disturbed over the installation period proposed.
PD13.	Construction vessels will not be operating continuously during the installation phases therefore reducing disturbance and potential injury to sensitive fish species.
PD14.	All sites of high importance and, where possible all sites of any potential archaeological or cultural heritage importance will be avoided through Project design e.g. placement of TSSs and location of inter-array cables and export cable routes. Geophysical anomalies identified from only a single type of response may be given an avoidance buffer of 20m, while anomalies identified from several types of survey (such as MBES04, SSS03 and M028, which may represent the remains of the Canadian) and known wrecks may be given an avoidance buffer of 50m. This is in order to take account of a potential debris scatter field around a wreck, or a multiple response representing the tip of a wreck that extends further than the core location of the anomaly.
	Construction
	None
	Operation and Maintenance
PD15.	All turbines will be fitted with on-board monitoring systems to check turbine performances and identify any damage, anomalies or faults
	Decommissioning
	None

Table 5.16 General mitigation measures

Ref	Mitigation Measure Description
	All Phases
GM01.	BTAL will follow best practice in terms of communication and awareness. All planned shipping movements, operations at sea and seabed fixtures will be described and broadcast to the fishing community through channels such as Notices to Mariners (the UK Hydrographic Office weekly updates), the Kingfisher Fortnightly Bulletin, FishSAFE, Fishermen's Awareness Charts, the International Cable Protection Committee (http://www.iscpc.org), via Fisheries Liaison Officer and any other forms of communication identified as appropriate.
GM02.	The construction and operation of the Project will be undertaken in line with the description of ES, however over the duration of detailed technical design an engineering change notification system will be implemented to ensure coherence with ES technical description. If any part of the detailed design is assessed by BTAL to potentially result in technical differences to those reported in the ES, a process of consultation will be initiated with relevant statutory consultees to determine level of material changes and appropriate actions.
GM03.	An Ecological Clerk of Works (ECoW) will be appointed to audit site activities and will advise on implementation of mitigation.
GM04.	BTAL will prepare an Environmental Management Document (EMD) to guide on-going operations and maintenance activities during the lifetime of the Project. The EMD will also set out the procedures for managing and delivering the specific environmental commitments for each receptor made in the ES over the operational period.
GM05.	The Pollution Control Plan will form part of the wider EMD to manage the potential for accidental pollution, management of materials on site and response for any pollution events
GM06.	BTAL will develop a Supplier Evaluation procedure which will be implemented prior to tender/contracting potential sub-contractors, which will include an environmental performance evaluation as part of the selection process. Contractors will be contractually required to take account of and implement the relevant committed mitigation measures as well as other recognised construction best practice measures including those adopted by BTAL.
GM07.	A Vessel and Navigational Safety Management Plan will be developed for construction and operational phases of the Project setting out: Number and individual vessel details; Operation of ducted propellers; and Vessel routes, working ports and frequency of operations. This will be agreed with relevant consultees prior to commencement of works.
GM08.	A project risk register will be updated and maintained via dedicated workshops between various engineering disciplines, to ensure the potential for accidental events are identified and managed in advance for all operations and control actions identified.
GM09.	Any vessels required from international waters, or exceeding the thresholds set out in IMCA guidance will be audited to ensure that they have a Ballast Management Plan, with up to date records prior to operations on site.
GM10.	An Emergency Response Cooperation Plan (ERCoP) will be prepared for the Project following the template provided by the MCA in MGN 371. This will be submitted to the MCA for approval prior to construction
GM11.	Large vessels (> 400GRT) will have Shipboard Oil Pollution Emergency Plans (SOPEPs) which will include a response strategy to reduce potential impacts in the unlikely event of a large accidental release.

Ref	Mitigation Measure Description
GM12.	Supervisory control and data acquisition (SCADA) system to be carried out continuously and will alarm if abnormal measurements are received indicating a potential problem
	Construction and Installation
GM13.	BTAL will submit a Cable Laying Strategy and method statement to Marine Scotland with details of: Geophysical survey outputs; Planned deployment corridor and micrositing options; Cable protection proposals; and Method Statement including minimum depths and protection. Any rock sourced will only be from an appropriately licensed operator/facility who possess all relevant consents and licences. Only material considered suitable for use in the marine environment will be used.
GM14.	BTAL will prepare a Construction Environmental Management Document (CEMD) which will describe the: Construction Method Statements (including scope, frequency and hours) and construction processes; Site Lighting, Marking and designation strategy during construction; Detailed site layout, and micro-siting options; Description of vessel routes; Safety and emergency response procedures; Construction team and management; and Project schedule, duration and phasing. The CEMD will include but not be limited to: a Water Protection Plan; an Ecological Management Plan; Species Protection Plan and a Post Construction Restoration Plan. The CEMD will be agreed with Orkney Islands Council, Marine Scotland, and other relevant consultees The CEMD will also set out the procedures for managing and delivering the specific environmental commitments for each receptor made in the ES over the construction period. The CEMD will be agreed with statutory consultees and periodically revised to account for emerging best practice and standard procedures.
GM15.	Temporary Safety Zones will be established during construction and maintenance activities to limit non-project vessels from entering these areas. The extent and duration of the Safety Zones will be agreed with the NLB and MCA prior to application (maximum 500m radii) and communicated through the issue of Notice to Mariners.
GM16.	A detailed geophysical survey of the Sheep Skerry cable corridor will include a magnetometer survey of the proposed area to identify any metallic contacts, where contacts are identified these will be avoided in the first instance, if there is a likelihood of direct impact, measures will be made to avoid contact with the feature.
GM17.	A Landfall Installation Plan will be developed in consultation with SNH and Marine Scotland which will help minimise potential adverse effects on morphology, habitats and species at the shore
	Operation and Maintenance
GM18.	There will be appropriate inspection and maintenance procedures in place for all elements of the Project
	Decommissioning
	None

Consultation Process

Chapter 6

6 CONSULTATION PROCESS

This chapter of the ES describes the overall consultation process that has been undertaken and will continue throughout the course of the Project. This chapter outlines the results of this consultation process so far and outline the plans for ongoing engagement. Detailed information on topic specific consultation is included in study specific sections throughout the ES. Key comments raised through consultation and details on how these have been addressed can be seen in the Gap Analysis (Supporting Document: BTAL, 2015e).

Since the award of the AfL in 2010, BTAL has been actively consulting a wide range of stakeholders including statutory and non-statutory stakeholders and members of the public on the Brims Tidal Array Project (the Project). All consultation has been carried out in line with relevant legislation and guidance (see Section 6.1). BTAL is committed to the highest environmental standards and best practice throughout the entire Project lifecycle and as part of this, recognises the importance of early consultation that continues throughout the Project in order to integrate public and stakeholder concerns and opinions into the Project decision making process. Consequently, consultation with both statutory and non-statutory stakeholders has been an integral aspect of the EIA process since the commencement of the Project. The primary aim of the consultation process is to facilitate two way communications about the Project with all relevant stakeholders. This allows any environmental concerns to be identified at an early stage and the opportunity for the Project team to ensure that these concerns can be adequately addressed during the EIA process.

Alongside the overarching EIA consultation process, extensive consultation has also been undertaken for the Navigation Risk Assessment (NRA) and the Habitats Regulations Appraisal (HRA).

6.1 LEGISLATION, GUIDANCE AND ADVICE

There are a number of directives, best practice guidance and advice available regarding consultation procedures that should be undertaken for a large marine renewable development. The EU Directive on Public Participation (Directive 2003/35/EC The Marine Scotland Licensing and Consents Manual (ABPmer, 2012) provides project level consenting and consultation guidance to facilitate development of offshore energy projects within Scottish waters.

The requirement of pre-application consultation has recently been introduced under the Marine Scotland Act 2010 through the Marine Licensing (Pre Application Consultation) (Scotland) Regulations 2013 (PAC Regulations) which make consultation a statutory requirement for certain licensable activities including:

"*The construction of a renewable energy structure in or over the sea or on or under the seabed, where the total area in which the structure is to be located exceeds 10,000 square metres*" (Marine Scotland, 2014).

The Marine Licensing (PAC) (Scotland) Regulations 2013 came into force on 1 January 2014 and apply to all relevant Marine Licence applications submitted to Marine Scotland Licensing Operations Team (MS-LOT) on or after 6 April 2014. The purpose of the new regulations is to allow local communities, environmental groups and other interested parties to comment on proposed marine developments at an early stage i.e. before an application is submitted to MS-LOT.

The PAC regulations also require that a report on the consultation be included with the Marine Licence Application. The Pre Application Consultation Report has been produced in compliance with that requirement (Supporting Document: BTAL, 2015a).

6.2 HIGH LEVEL SUMMARY OF CONSULTATION APPROACH

For successful stakeholder engagement it is essential that the following is undertaken:

- The stakeholders and groups/individuals interested in or affected by the Project are identified;
- Information is issued at the appropriate time to all interested parties in an accurate and understandable manner;
- Early and continuous dialogue is held between those affected by the decisions and those responsible for making the decisions;
- The information provided by the stakeholders and interested parties is considered and incorporated in the decision making process and final decision for the Project; and
- Feedback is provided to all stakeholders and interested parties explaining the actions taken and how the final decision has been influenced by the process.

An Agreement for Lease (AfL) was issued by The Crown Estate in 2010 for a tidal array up to 200MW to Cantick Head Tidal Developments Limited. A Project Briefing Document (Supporting Document: CHTDL, 2010) was subsequently issued to stakeholders in order to begin the consultation process and make stakeholders aware of the plans for the Project. This process facilitated the communication to BTAL of any issues or concerns that stakeholders may have at the commencement of the Project. The issue of the Project Briefing Document was followed up by meetings with statutory stakeholders, non-statutory stakeholders, fishing representatives and local fishermen and landowners (Table 6.1).

In 2013, following more detailed site surveys, a site boundary review exercise was initiated with The Crown Estate. Further stakeholder consultation was also undertaken at this time. As a result of this process, the Project site boundary was changed, as detailed within Chapter 4 Site Selection and Alternatives. The name of the Project was also changed to Brims Tidal Array. Two public exhibitions were subsequently held in Hoy and Stromness in September 2013 (Supporting Document: BTAL, 2015a: Appendix 1).

An Environmental Scoping Report was issued in August 2013 (Supporting Document: BTAL, 2013). A Scoping Opinion was received from Marine Scotland in April 2014 (Supporting Document: MS-LOT, 2014), containing responses from MS-LOT and other stakeholders to the Scoping Report. This Scoping Opinion identified the main stakeholder concerns, and was used to inform the relevant Environmental Statement chapters. Further consultation on key issues raised in scoping, and on the baseline characterisation and methodology, has continued throughout the EIA process.

BTAL submitted a draft Project Description to MS-LOT for consideration in January 2015. MS-LOT consulted with Scottish Natural Heritage (SNH), Marine Scotland Science (MSS), Orkney Islands Council (OIC), Northern Lighthouse Board (NLB) and Maritime and Coastguard Agency (MCA) and provided detailed responses in February 2015. The primary outcome of this exercise was a revision of the design envelope with surface piercing and floating turbines being removed from consideration for the EIA. Offshore surface piercing hubs were also removed meaning that the design envelope brought forward as part of this application consists of no surface piercing elements for the offshore project elements. Further detail on the design envelope can be found in Chapter 5 Project Description.

In 2015 two further public exhibition events were held in Hoy and Kirkwall. These events provided BTAL with the opportunity to update interested parties on the Project and the EIA process and to collect further feedback from the local community before finalising proposals. As detailed below (Table 6.1) and in the Pre Application Consultation Report, these events were held in compliance with PAC requirements (See 6.4 below and Supporting Document: BTAL, 2015a).

Table 6.1 shows a summary of consultation events and key stakeholder meetings that have been held thus far.

Table 6.1: Summary of consultation events and key meetings with stakeholders

Date	Event
1st March 2010	Agreement for Lease awarded to Cantick Head Tidal Developments Limited (CHTDL) by The Crown Estate.
25th January 2011	Initial meeting with MS-LOT, MSS and SNH to introduce the Project, establish communication lines and outline strategy for development of the Project.
1st February 2011	Meeting with navigational stakeholders (MCA and Department for Transport) to discuss approach to shipping and navigation.
8th March 2011	Meeting with fisheries stakeholders alongside TCE to introduce the Project, set out timescales and gather feedback and ideas for further engagement.
7th June 2011	Meeting with key local Orkney fisheries interests including members of Orkney Fisherman's Society (OFS), Orkney Sustainable Fisheries Limited (OSF), Orkney Fisheries Association (OFA), Scottish Fisherman's Federation and Marine Scotland local fisheries. Key objective was to introduce the Project, listen to concerns of local fisheries interests and take opportunity to gather as much information on the nature of the fishing industry in Orkney and how it may be impacted by the Project.
22nd November 2011	Project team attended TCE public information day to provide an update on the Project development
April 2012	Issue of Project Briefing Document, along with covering letter, to all stakeholders indicated in Table 6.2
28th May 2012	Meeting with MS-LOT and SNH to discuss Project updates, survey methodology and consenting strategy. Project Briefing Document responses also discussed.
4th September 2012	Consultation meeting with OIC and SNH to discuss onshore proposals
8th November 2012	Consultation meeting with OIC and SNH to provide update on site selection for onshore components of the Project
22nd November 2012	Telcon to discuss the bird and marine mammal survey methodology with MS-LOT and MSS
26th February 2013	Meeting with SNH, MSS and MS-LOT to discuss marine mammals and ornithology surveys. Overview of year one results provided.
12th March 2013	Written response received from SNH regarding Marine Mammals survey and approach
16th April 2013	Written response received from MS-LOT regarding Marine Mammals survey and approach
July 2013	PHA Consultation carried out with Orkney Fishermen's Association, OIC Marine Services, RNLI Stromness and RYA Scotland, Orkney Dive Boat Operator's Association (ODBOA), Kirkwall Kayak.
2013	The Crown Estate consultation and consultation with other stakeholders resulting in site boundary revision. The name of the Project was changed to Brims Tidal Array. Further details on dates and process in Site Selection and Alternatives.
August 2013	Submission of Scoping Report to MS-LOT.

Date	Event
4th September 2013	Public Exhibition at Community Room, North Walls Community School, Hoy. Estimated attendance of 53 (12.00-20.00).
5th September 2013	Public Exhibition Stromness Community Centre, Stromness. Estimated attendance of 20 (17.00-20.00).
30th January 2014	Post Scoping Review with MS-LOT, SNH, SEPA and OIC
April 2014	Scoping Opinion received from MS-LOT.
August 2014	Written response received from SNH regarding Marine Mammals – approach to assessment.
29th August 2014	Meeting with Marine Scotland to review consenting strategy and discuss design envelope
22nd September 2014	Navigation Review undertaken with MCA, NLB via teleconference to review consenting strategy and discuss design envelope.
2nd October 2014	Review of ornithology and marine mammal survey results, analysis and approach to EIA with SNH, RSPB and MS-LOT. Design envelope and consenting strategy also discussed.
5th November 2014	Consenting progress update with MS-LOT. It was agreed at this meeting to schedule fortnightly calls between BTAL and MS-LOT to review progress and key actions. First call commenced in February 2015.
14th January 2015	Draft Project Description issued to Marine Scotland for review and distribution to key consultees. Responses received in February 2015 along with further consultations described below resulted in surface piercing hubs and floating technology being removed from the design envelope.
10th February 2015	Comments on draft project description received from MCA and NLB via MS-LOT
17th February 2015	Comments on draft project description received from SNH via MS-LOT
18th February 2015	Comments on draft project description received from OIC via MS-LOT
10th April 2015	Baseline and EIA Methodologies for Physical Processes, Commercial Fisheries, Fish Ecology, Ornithology and Marine Mammals submitted to MS-LOT for review and distribution to statutory consultees for comment
15th April 2014	Baseline and EIA Methodology for Marine Archaeology submitted to MS-LOT for review and distribution to statutory consultees for comment
27th May 2015	Confirmation email from MS-LOT that MSS were content with the BTAL benthic survey and assessment methodologies
3rd June 2015	Hazard Review Workshop held, at Orkney Marine Services Harbour Authority Building.
4th June 2015	Public Exhibition advertisement Orcadian Orkney news website. Confirmation received via email from MS-LOT that it fulfils PAC requirements.
11th June 2015	Public Exhibition advertisement Orcadian Orkney news print edition.
12th June 2015	Final Project Description issued to MS-LOT
18th June 2015	Written confirmation received from Marine Scotland of project list for inclusion in cumulative impact assessment.

Date	Event
30th June 2015	Meeting with Scottish Fisheries Meeting with Scottish Fishermen's Association (SFF) and Scottish Pelagic Fishermen's Association (SPFA) in Aberdeen to provide project update.
9th July 2015	Feedback from MS-LOT received on all baselines and methodologies submitted in April.
22nd July 2015	Public Exhibition at Kirkwall Town Hall. Attendance of 7 16.00-20.00).
23rd July 2015	Public Exhibition at Community Room, North Walls Community School, Hoy. Attendance of 14 (13.00-20.00).
7th September 2015	Email received from MS-LOT on Gate Check requirements, application requirements and advert templates for Marine Licence and Section 36.
5th November 2015	Marine Mammal CRM/ERM/PCoD workshop with SNH, MSS and MS-LOT
30th October 2015	Gate Check submission by BTAL
24th February 2016	Gate Check response received from MS-LOT
9th March 2016	Gate Check Closure meeting with MS-LOT

6.3 WEBSITE

A Project website (http://sse.com/whatwedo/ourprojectsandassets/renewables/Brims/) was launched in 2013. The website included information on BTAL and the Project including key project documentation. A new dedicated web page for the project was set up in 2016 (www.openhydro.com/brims) to facilitate public consultation. A copy of this ES and other relevant documentation will be available for download via this website. Contact details for any general, Project or media queries are also made available on the website.

6.4 PUBLIC PRE APPLICATION CONSULTATION COMPLIANCE

According to the requirements of public Pre Application Consultation (PAC), there must be at least one public event held which provides local communities and any relevant stakeholders or interested parties the opportunity to consider and comment upon a prospective application. Statutory consultees must also be informed that an application is to be submitted to Marine Scotland.

This public event must be held in an accessible and local venue. There must be sufficient notice given which includes the time and location of the event. This must be published in a local newspaper.

Prior to these regulations coming into force (1st January 2014), there were two public events held in September 2013 (4th September in Hoy, and 5th September in Stromness). There were an estimated 53 people in attendance in Hoy, and 20 people in Stromness. Feedback forms were available during the event and were received from six individuals or groups in Hoy and five individuals in Stromness. All feedback received was positive, with four of these specifically mentioning the added employment opportunities as a result of the Project. Full details of the events and the feedback received can be seen in the Appendices of the BTAL Pre Application Consultation Report (Supporting Document: BTAL, 2015a).

Subsequent to the regulations being introduced, a further two exhibition events were held in July 2015. The first was held in Kirkwall Town Hall on 22nd July 2015, and the second was held in North Walls Community School on 23rd July 2015. During these events project information was presented on display boards allowing attendees to browse the information in their own time. The Project team were present to answer any questions or queries and to collect feedback from stakeholders. There were seven attendees at the Kirkwall event and fourteen at the Hoy event.

Feedback from the event was positive with an emphasis on the opportunities for the creation of employment in Hoy. Relevant comments have been fed back to the Project team and employment opportunities are covered in Chapter 19 Socio-economics. No comments were made in relation to amendments to the Project.

In compliance with PAC requirements, the events were advertised in The Orcadian newspaper. Stakeholders were also notified 6 weeks in advance of the events. Full details of the events can be seen in the Appendices of the BTAL Pre Application Consultation 2015 Report (Supporting Document: BTAL, 2015a).

6.5 EIA CONSULTATION REQUIREMENTS

6.5.1 Stakeholders

Due to the scale and nature of the Project, interest is attracted from a significant number of stakeholders. As well as those statutory stakeholders with whom it is a requirement for consultation to be undertaken, BTAL identified a significant number of non-statutory and community stakeholders. Through the stages of the Project, we have included these additional stakeholders in consultations wherever possible.

The full list of stakeholders is listed in Table 6.2. Those stakeholders who were sent a Project Briefing Document are marked with an asterisk (*). Those stakeholders who were sent a Scoping Report are marked with a '**†**'.

Table 6.2: List of statutory, non-statutory and community stakeholders

Statutory	
Chamber of Shipping (COS)* †	Maritime and Coastguard Agency (MCA)* †
Department for Transport*	Ministry of Defence (MOD)* †
Department of Energy and Climate Change*	Orkney Islands Council Marine Services*
Health and Safety Executive (HSE)* †	Orkney Islands Council*
Marine Scotland Compliance (MSC)*	Scottish Environmental Protection Agency (SEPA)*
Marine Scotland-Licensing Operations Team*	Scottish Natural Heritage (SNH)*
Marine Scotland-Science	The Crown Estate (TCE)* †
Non Statutory	
Association of Salmon Fishery Boards (ASFB)* †	Orkney Ferries*
Association of Scottish Shellfish Growers*	Orkney Fisheries Association*
British Ports Association*	Orkney Fisherman's Society Limited*†
British Surf Association (Surf GB)*	Orkney Harbour Authority
British Telecom (Radio Network Protection Team) †	Orkney Islands Sea Angling Association*
British Trout Association*	Orkney Renewable Energy Forum (OREF)*
British Trust for Ornithology	Orkney Sailing Club*
BT (Network Radio Protection)*	Orkney Sustainable Fisheries
Civil Aviation Authority (CAA)*	Orkney Tourism Group*

Collaborative Offshore Wind Research Into the Environment	Orkney Trout Fishing Association*
County Archaeologist*	Pentland Ferries*
Defence Estates*	Ports and Harbours (PH)* †
European Marine Energy Centre*	Royal Air Force
Federation of Scottish Aquaculture Producers (Scottish Aquaculture Research Forum)*	Royal Commission in the Ancient and Historical Monuments of Scotland*
Fishermen's Association Limited*	Royal National Lifeboat Institution*
Flotta Community Council*	Royal Society for the Protection of Birds (RSPB)* †
Flotta Development Trust*	Royal Yachting Association (RYA)* †
Forestry Commission*	Salmon Net Fishing Association*
Friends of the Earth (Scotland)*	Scottish Aquaculture Research Forum*
Graemsay, Hoy and Walls Community Council*	Scottish Association of Marine Science
Greenpeace*	Scottish Canoe Association (SCA)* †
Highland and Islands Enterprise	Scottish Environment Link*
Highlands and Islands Airport Limited*	Scottish Fishermen's Federation (SFF)* †
Historic Scotland (HS)* †	Scottish Fishermen's Organisation (SFO)* †
Hoy Community Council	Scottish Government Planning (SGP)* †
Hoy Development Trust*	Scottish Hydro Electric Transmission PLC
Inshore Fisheries Group (IFG)* †	Scottish Pelagic Fishermen's Association
Institute of Ecology and Environmental Management	Scottish Renewables Forum*
International Council for Exploration of the Sea	Scottish Surfing Federation
International Maritime Organisation	Scottish Water*
International Tanker Owner's Pollution Federation (ITOPF)*	Scottish Wildlife Trust (SWT)* †
International Union for Conservation of Nature	Scrabster Harbour Trust
Joint Radio Company (JRC)*	Sea Mammal Research Unit
Local Fisheries*	South Ronaldsay and Burray Community Council*
Longhope Sailing Club*	South Ronaldsay and Burray Development Trust*
Marine Conservation Society*	Surfers Against Sewage (SAS)* †
Marine Safety Forum (MSF)* †	The Fisheries Committee*
Moray Firth Sea Trout Project (MFSTP) †	The Mountaineering Council of Scotland*
National Air Traffic Services (NATS)*	Transport Scotland (TS)* †
National Biodiversity Network	UK Cable Protection Committee*
National Trust for Scotland*	UK Civil Aviation Authority *
NERL Safeguarding (NATS)	UK Marine Management Organisation
North District Fisheries Board*	UK Oil and Gas*
North of Scotland Industries Group*	United Kingdom Hydrographic Office*
Northern Lighthouse Board (NLB)* †	Visit Orkney*
Orkney Archaeological Trust/Orkney Archaeology Society*	Visit Scotland*

Orkney Dive Boat Operators Association*	Whale and Dolphin Conservation (WDC)* †
Dive boat operators	Orkney Marinas
Kirkwall Kayak Club	Orkney Sailing club
Local Fishermen	Orkney Tourist Group
Local Landowners	Sea Angling
Orkney Dive Boat Operator's Association	Supply Boat Operators*

*Indicates stakeholders who were sent the Project Briefing Document.
† Indicates stakeholders who were sent the Scoping Report.

6.5.2 Scoping

In April 2012 a Project Briefing Document was provided to local and national stakeholders in order to begin the EIA and HRA process. The full list of stakeholders and those who responded to this Project Briefing Document can be found in Appendix A of the Brims Tidal Array Environmental Scoping Report 2013 (Supporting Document: BTAL, 2013).

As part of this pre-scoping consultation, BTAL also held meetings with Statutory Nature Conservation Bodies (SNCBs) and other key stakeholders including local fishermen and landowners. Responses from the Project Briefing Document and consultation meetings with stakeholders were used to inform the Scoping Report. Full details of this can be seen in the Gap Analysis (Supporting Document: BTAL, 2015e).

The Environmental Scoping Report with Preliminary Hazard Analysis was produced and submitted to Marine Scotland in August 2013. A HRA Screening Report was also produced at this time. This report outlined the Baseline Characterisation Strategy, the current data gaps and the strategy for stakeholder consultation in order to fill in these gaps. An Impact Assessment Strategy was also outlined with a plan for consultation. It was proposed that the relevant stakeholders would be consulted throughout the Project design process to ensure that any potential issues could be identified at the earliest possible time.

The Scottish Government and Marine Scotland provided a Scoping Opinion by way of response in April 2014. This also included responses from a number of other stakeholders (Table 6.3).

Table 6.3 gives a brief overview of the comments and opinion that were received as part of the consultation process. Specifically, these are issues that were advised by stakeholders that should be addressed in the Environmental Statement. This consultation activity includes the Scoping Opinion that was received from stakeholders in response to the issue of the Scoping Report. It also includes consultation activity that took place subsequently, in the form of individual meetings, workshops and correspondence with statutory, non-statutory and local stakeholders. These issues are addressed in further detail in the chapter to which they are relevant. A summary of feedback from all consultees is provided in the Gap Analysis (Supporting Document: BTAL, 2015e).

Table 6.3: Overview of requirements for ES from the Scoping Opinion and other consultation and the action taken as a result of consultation

Topic	Issue	Comment/ Opinion provided in scoping opinion or in subsequent consultation	Action taken
General Approach	Non-Technical Summary	ES should describe various options for the Project and the mitigation measure against each potential adverse impact.	Comments taken into account for the Non-Technical Summary
	Installation and Construction	ES should include details on the proposed installation and consultation methods including project management. There should also be details on operation and maintenance activities and consider any potential environmental, navigational or other effects.	ES takes any potential impacts from installation, construction and decommissioning into account.
	Decommissioning	Any potential environmental effects as a result of decommissioning should be assessed in the ES	
Physical Environment	Geology	Comments were received from SEPA in relation to pollution, drainage and flood risk	These matters are discussed in Chapter 8 Geology and Hydrology. SEPA will continue to be consulted on these matters.
	Marine Archaeology	ES should address the predicted impacts on both the marine and onshore terrestrial elements of the Project. A suitable qualified archaeological/ historic environment consultant should be consulted for advice. A full archaeological assessment of the impact of the Project should be conducted.	Comments have been taken into account and are addressed in Chapter 18 Marine Archaeology and Cultural Heritage.
	Physical Processes	Some items that were not mentioned in the Scoping Report were brought to attention such as the possible change in coastal process, and waves.	Comments from Northern Lighthouse Board following completion of the Navigational Risk Assessment, MSS, OIC, SEPA, and SNH have been discussed in Chapter 15 Shipping and Navigation.
Biological Environment	Benthic Ecology	Consultation with key statutory stakeholders (MSS and SNH) was undertaken and advice was taken on how to assess the potential impact on vulnerable habitats.	The best practicable options to avoid these habitats where possible were agreed with consultees.

Topic	Issue	Comment/ Opinion provided in scoping opinion or in subsequent consultation	Action taken
		It is recommended that the ES present information on the main biotopes found within the Project site.	The scope of the baseline assessment and all survey methodologies and results were verified and approved in consultation with SNH and MSS. During the consultation process there were no revisions provided to the original list of potential impacts as provided in the Scoping Report.
	Coastal and Terrestrial Ecology	Advice was given to discuss the timing of certain stages of the Project in order to avoid disturbance of breeding birds.	Comments were taken into account and are addressed in Chapter 10 Coastal and Terrestrial Ecology.
	Fish Ecology	The main diadromous fish species present in the area should be fully explored.	Comments have been taken into account and are discussed in Chapter 12 Fish Ecology.
	Marine Mammals	MS-LOT recommended a full encounter assessment for marine mammals be carried out.	Encounter rate assessment can be found within the Chapter 13 Marine Mammals. A Vessel and Navigational Safety Management Plan will be developed for construction and operational phases of the Project. This will be agreed with relevant consultees prior to commencement of works. Other comments from MS-LOT as well as RSPB, WDC, and OIC have been taken into account and addressed in Chapter 13 Marine Mammals.
	Ornithology	It may be necessary to consider the timing of each stage of the Project so as to minimize the impact on breeding birds	Comments received from SNH, MSS and RSPB have been taken into

Topic	Issue	Comment/ Opinion provided in scoping opinion or in subsequent consultation	Action taken
			account and discussed in Chapter 14 Ornithology.
Human Environment	Commercial Fisheries	Advice from Orkney Fisheries Association (OFA) emphasized that it is essential to identify the economic impact on fisheries through an understanding of the links between fishing fleet and buyers and processors.	In consultation with Orkney Fisheries Association and local fishermen, advice regarding the best way to interpret data was taken. Consultation with MSS, SFF, SPFA, OFA and local fishermen will continue throughout the Project, particularly in reference to the cable route and corridor options.
	Recreation and Tourism	Comments were received from OIC and the Royal Yachting Association regarding recreational resources.	These comments were taken into account and supplemented by conducting interviews with a number of key recreation and tourism stakeholders including Orkney Sailing Club, Orkney Marinas, Orkney Harbours, Hoy Development Trust, Hoy Community Council, Dive Boat operators, Scrabster Harbour Trust, Sea Angling, Orkney Ferries and Orkney Tourist Group in June 2015.
	Shipping and Navigation	Comments were received from MCA, MS-LOT, MSS, NLB, OIC, OFS, OFA, DfT, OIC Marine Services, RYA Scotland, Orkney Dive Boat Operator's Association, Kirkwall Kayak Club, RNLI Stromness, SFF, Scottish Pelagic Fishermen's Association. Local Stakeholders also consulted through Hazard Review Workshop held on 3rd June 2015 at Orkney Marine Services Harbour Authority Building. 21 local representatives of Shipping and Navigation were invited, with 11 attending.	Comments were used to inform baseline data. This is discussed in Chapter 15 Shipping and Navigation.
	Socio-economic	Consultation was undertaken with many groups including European Marine Energy Centre (EMEC), Highlands and Islands Enterprise (HIE), Orkney Islands Council Economic Development, Orkney Islands Council Housing	MS-LOT through the MSS Marine Analytical Unit gave some specific feedback. This and other specific feedback has

Topic	Issue	Comment/ Opinion provided in scoping opinion or in subsequent consultation	Action taken
		Services, Orkney Ferries, Orkney Sailing Club, Orkney Marinas, Orkney Harbour Authority, Hoy Development Trust, Hoy Community Council, Scrabster Harbour Trust, Dive boat operators, Transport Scotland, MS-LOT and MSS Marine Analytical Unit. Majority of feedback received was positive. All groups were supportive of the Project and were willing to use their resources to help mitigate any issues. The potential impacts on local transport infrastructure should be taken into account.	been taken into account in Chapter 19 Socio-economics.

6.6 REFERENCES

Marine Scotland. (2014) Guidance on Marine Licensable Activities subject to Pre-Application Consultation. The Scottish Government.

ABPmer. (2012) Marine Scotland Licensing and Consents Manual. [online] Available at: http://www.gov.scot/resource/0040/00405806.pdf.

EIA Scope and Methodology

Chapter 7

7 EIA SCOPE AND METHODOLOGY

7.1 INTRODUCTION

This chapter sets out the approach taken to the Environmental Impact Assessment (EIA) for the offshore components of the Brims Tidal Array Project (the Project), in accordance with legislative framework. Under European legislation, transposed into United Kingdom and Scottish law, certain development projects are required to undertake an Environmental Impact Assessment (EIA) to identify and reduce potential impacts arising as a result of a Project. An outline of the general approach taken in the assessment of the likely impacts of the Project is also provided. Detailed assessment methodology can be found within each technical chapter of this Environmental Statement (ES).

7.2 EIA REGULATIONS

The European Council 'EIA Directive', 85/337/EEC, as amended by Directive 97/11/EC, 2003/35/EC and 2009/31/EC, requires that an EIA is to be completed in support of an application for development consent for certain public and private projects, as discussed within Chapter 3 Policy and Legislation. In Scotland, the EIA Directive has been transposed into regulations, whereby the Scottish Ministers can consider whether any proposal for marine works or the construction or operation of a generating station, is likely to have a significant impact on the environment.

This ES has been prepared to meet the requirements of EIA regulations:

- The EIA Directive (Council Directive 85/337/EEC as amended by Council Directive 97/11/EC, 2003/35/EC and 2009/31/EC and 2014/52/EU);
- The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended); and
- Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended).

The individual technical assessments have been carried out with reference to relevant legislative and policy requirements and where relevant this is detailed in each technical chapter.

7.3 RELEVANT EIA GUIDANCE

The EIA approach has been informed by EIA guidance (IEMA, 2004; SNH, 2014). Each technical chapter details any relevant legislative/recognised best practice guidance which has informed the approach.

7.4 EIA PROCESS

An EIA is required to support the consent applications associated with the Project. It supports decision making for joint Marine Licence and Section 36 consent applications. The EIA process represents an assessment of the potential impacts of the Project on the environment. The focus and direction of the EIA is shaped by the content of the Scoping Report and guided by advice received through the formal Scoping Opinion.

7.4.1 Screening

Screening is the procedure for determining whether or not an EIA is required for a particular development proposal.

The Project is listed as an Annex II development, defined in EIA Directive (85/337/EEC as amended 97/11/EC, 2033/35/EC and 2009/31/EC), as "*Industrial installations for the production of electricity, steam and hot water*". BTAL made the decision that an EIA will be required for the Project; therefore no screening opinion was sought from Scottish Ministers. Pre-scoping consultation took place to inform key consultees of the Project, with issue of a Project Briefing Document (PBD) to introduce the Project and engage the Licensing Authority, stakeholders and the local community at the earliest opportunity.

7.4.2 Scoping

Scoping allows for the identification of main issues for consideration within the EIA process and extent of environmental information to be submitted to Scottish Ministers within the ES. The scoping process more specifically allows for the agreement of what effects are likely to be significant and should therefore be covered within the ES; it specifies how they should be covered and methodologies to be used for impact assessments.

A Scoping Report was submitted to Marine Scotland Licensing Operations Team (MS-LOT) and Orkney Islands Council (OIC) in August 2013 (Supporting Document: BTAL, 2013), with navigational Preliminary Hazard Analysis (PHA) and Habitats Regulations Appraisal (HRA) screening. All documentation formed a written formal request for a Scoping Opinion under the Electricity Work (Environmental Impact Assessment) (Scotland) Regulations of 2000. The submitted scoping report contained detail of the scope of environmental assessment for both offshore and onshore aspects of the Project. Given the revised scope of the Project design envelope (Section 7.6), details to support an onshore planning application will no longer be included within this ES (Section 7.6.5 Summary of Application).

A Scoping Opinion was received from MS-LOT in July 2014 (Supporting Document: MS-LOT, 2014). Comments received from the Scoping Opinion, and additional consultation, were used to inform the selection of survey methodologies for the EIA.

EIA regulations guidance states that the developer should submit a draft outline of the ES, giving an indication of what they consider to be the main issues. The Scoping Opinion, and additional consultation, identifies a number of areas that consultees wished to see addressed within the EIA. The content of the ES reflects these requirements (Section 7.5). Table 7.1 identifies the main stages of the EIA process that the Project has followed.

Table 7.1: Stages of the EIA process

STAGE	TASK	AIM/OBJECTIVE	WORK/OUTPUT (EXAMPLES)
Study	Definition of study area	Geographical focus for the assessment. How the study area has been defined	Documents tailored to stakeholders groups, consultation
Scoping	Scoping study	To identify the potentially significant direct and indirect impacts of the proposed development and CIA	Targets for specialist studies (e.g. hydrodynamic studies, sediment quality)
EIA	Definition of Assessment Methodology	To characterise the existing environment	Background data including existing literature and specialist studies
EIA	Specialist studies	To further investigate those environmental parameters which may be subject to potentially significant effects	Specialist reports
EIA	Impact assessment	To evaluate the existing environment, in terms of sensitivity To evaluate and predict the impact (i.e. magnitude) on the existing environment To assess the significance of the predicted impacts To assess the significance of cumulative effects	Series of significant adverse and beneficial impacts Identification of those impacts not assessed to be significant
EIA	Mitigation and optimisation measures	To identify appropriate and practicable mitigation measures and enhancement measures	The provision of solutions to minimise adverse impacts and maximise opportunities as far as possible Feedback into the design process, as applicable
EIA	Pre-Application Consultation	Advertising of application for licensing must occur at least 12 weeks prior to submission of joint s36/Marine Licence Application	Joint s36/Marine Licence Application
EIA	Environmental Statement	Production of the ES in accordance with EIA guidance including a Non-Technical Summary (NTS)	ES NTS; Written statement; Figures Environmental mitigation, monitoring and management plans
EIA	Post Submission	Liaison and consultation to resolve matters or representations/objections	Addendum to ES

EIA CONSENT DECISION

In summary the purpose of the EIA process is to establish the baseline conditions and assess the potential impacts of a given development on defined receptors by way of:

- Characterise the existing environment and establish a baseline against which all potential effects are assessed;
- Determine sensitivity of particular receptors;
- Assess the magnitude of effect that may arise due to the Project;
- Determine impact significance, based on sensitivity of receptor and magnitude of effect;
- Assess the significance of cumulative impacts;
- Identification of mitigation and monitoring measures; and
- Support decision making for consent determination.

7.5 STRUCTURE OF THE ENVIRONMENTAL STATEMENT

This ES document is a significant output of the EIA process. It communicates the process and findings of the EIA. The ES for this Project is presented in three volumes as outlined below and described in Table 7.2.

- Volume 1 Non-Technical Summary
- Volume 2 Environmental Statement Brims Tidal Array
- Volume 3 Supporting documents (DVD)

Table 7.2: Content of the ES

Volume	Content
Volume 1	This volume is a single overarching NTS which covers the offshore element of the Project.
Volume 2	Includes the offshore array, offshore hubs and the offshore export cable corridor up to the landfall and associated works. This volume will accompany the application for consent under Section 36 and Marine Licence applications.
Volume 3	Supporting documents include: • Project Briefing Report • Scoping Opinion Report • Habitats Regulations Appraisal (HRA) • Pre Application Consultation (PAC) Report • Underwater Noise Technical Report • Navigational Risk Assessment • Marine Traffic Survey Reports • Environmental Scoping Report • Benthic Survey Report • Multibeam Survey Report • Towed Hydrophone Data Analysis • Ecological And Hydrogeological Desk-Based Study • Seabird Technical Report • SLVIA Baseline Report • Collision Risk to Diving Seabirds • Collision Risk Modelling – Atlantic Salmon • Breeding Birds Survey Report • Wintering Barnacle Goose Survey Report • Marine Historic Environment Baseline Report • Geophysical Survey Report • Baseline Physical Processes Report • Physical Processes Modelling Report • Intertidal Survey Report • Marine Mammals and Basking Shark Visual Survey Report • Potential Encounter Rate and Collision Risk For Marine Mammals And Basking Shark Assessment And Otter Survey Report

Chapters contained within Volume 2 are detailed in Chapter 1 Introduction, Figure 1.4. Supporting Documents are detailed in full within Table 1.2 EIA chapters and supporting studies.

7.6 PROJECT DESCRIPTION CONSIDERATIONS

7.6.1 Scope

The scope of the EIA is to assess the effects of the following Project components:

- Offshore tidal generators;
- Turbine support structures (TSS);
- Inter-array cables;
- Offshore subsea hub(s); and
- Offshore export cable up to MHWS.

Separate impact assessments have been carried out for each phase of the Project as follows:

- Construction and installation;
- Operations and maintenance; and
- Decommissioning.

7.6.2 The Project Site

The Project site is defined as The Crown Estate (TCE) Agreement for Lease (AfL) area and the Area of Search (AoS) for the export cable corridor. Specific Project study areas are defined for each technical chapter. These define the geographic focus for each impact assessment as determined by technical authors and through the consultation process.

7.6.3 Onshore Elements

This ES covers the offshore components up to MHWS. The onshore elements of the Project (from MLWS) will be subject to a separate planning application and associated EIA. Chapter 1 Introduction and Chapter 21 Overview of Onshore Impacts provide information on the onshore components and the consenting strategy for the Project.

7.6.4 Wider network reinforcements

As outlined in Chapter 1 Introduction, additional grid infrastructure will be required to connect the BTAL Project to the grid network.

These wider network reinforcements will be the subject of a separate EIA and planning process that will be the responsibility of SHE-T. Further detail is provided in Chapter 1 Introduction and Chapter 21Overview of Onshore Impacts.

7.6.5 Summary of Application

As detailed in Section 1.6 Consenting Strategy, BTAL is applying for both Marine Licence and Section 36 consents through Marine Scotland. The intention of this document is to represents a robust ES which fully satisfies the EIA Regulations for such an application for the offshore components of the Project up to MHWS.

At a later date, planning permission will be sought for the cable landfall (above MLWS) which will consist of a buried transition pit where the marine cables are joined to terrestrial cables, an underground cable route to a substation, the substation and associated temporary works through the Orkney Islands Council (OIC) under the appropriate Town and Country Planning (Scotland) Act 1997.

7.6.6 Design Envelope

The 'Rochdale Envelope' is based on planning case law and has been adopted in connection with other offshore and marine renewable consent applications where a level of flexibility is required in the Project Description. The Rochdale Envelope describes the limits of design proposed for the Project, providing both minimum and maximum parameters within which the Project worst case scenario will be assessed. A Rochdale Envelope is used when the final design of a project has not been agreed but due to restrictions on timescale, the assessment and consenting processes must be progressed. So long as the final design of the Project remains within those maximum parameters which were assessed, any parameters within this envelope can be considered to have also been assessed.

The Rochdale Envelope is described as the Design Envelope (Chapter 5 Project Description), for the purpose of this ES. Refinement of the design envelope has taken place since the formal submission of the Scoping Report. Refinement is based on scoping opinion requests, with the primary change being the removal of surface-piercing and floating elements of the Project.

7.6.7 Criteria for Selecting Worst Case Scenario

Each technical chapter details the maximum worst case design envelope parameters (i.e. the worst case scenario) for each topic-specific assessment. Therefore the description of the design envelope used for topic-specific assessments varies. This enables a focused worst case approach to impact assessment for each receptor. Each chapter author has used expert judgement to define each worst case scenario. This principle has been applied throughout this EIA whereby each chapter of the ES presents the description of the design envelope parameters to be assessed, clearly defined in table form (Example: Chapter 12 Fish Ecology, Table 12.1).

7.7 ENVIRONMENTAL ASSESSMENT METHODOLOGY

The general approach to EIA as described in this chapter has been adopted across all topics so far as possible. Where a deviation from this high level methodology has been necessary, this is described in the technical chapter. Chapters which deviate from this high level methodology include:

- Shipping and Navigation; and
- Socio-economics.

To assess the potential impacts of the Project, the magnitude of the impact being assessed has been evaluated against the sensitivity of the receptor in question. This will allow for potential significant impacts to be clearly determined.

The environmental effects of the Project have been assessed for each environmental topic (Section 7.5), by comparing the baseline environmental conditions (i.e. the situation without the Project) with the conditions that would arise should the Project be constructed, installed, operated, maintained and decommissioned. Mitigation measures implemented by the Project are taken into consideration before impact assessment takes place (Section 7.7.5 Mitigation Measures). This enables residual impacts to be assessed (Section 7.7.6 Residual Impacts).

Each assessment is based on the description of the Project, outlined in Chapter 5 Project Description and definition of the worst case parameters (Section 7.6.7 Criteria for Selecting Worst Case Scenario). The chapter author has set out, within each technical chapter, key assumptions made during assessment, enabling a transparent approach to impact assessment.

7.7.1 Assessment Criteria

To assess the potential impacts of the Project, the magnitude of the effect being assessed has been evaluated against the sensitivity of the receptor in question. Firstly, criteria are defined for sensitivity of the receptor and magnitude of the impact.

7.7.1.1 Sensitivity of the receptor

Receptors are defined as a biological or physical resource, or user group that would be affected by any phase of the Project. Sensitivity of a receptor is classified using a reference point along a continuum. For the purpose of this ES, sensitivity is classified using the following scale:

- High;
- Medium;
- Low; and
- Negligible.

When considering the sensitivity assessment criteria of each receptor, the following factors have been regarded (IEEM, 2010):

- Vulnerability of the receptor;
- Recoverability of the receptor; and
- Value/ importance of the receptor.

The value or importance of a receptor may depend upon its frequency or extent of occurrence at an international, national, regional or local level.

7.7.1.2 Magnitude of impact

Impact assessment involves the evaluation and prediction of the magnitude of impact of the Project on the existing environment. Spatial extent, impact duration, impact reversibility and impact likelihood, are all factors for consideration of the magnitude of impact. For the purpose of this ES, magnitude is classified using the following scale:

- High;
- Medium;
- Low;
- Negligible; and
- Positive.

In defining sensitivity of receptors and magnitude of impact, technical experts draw upon relevant legislation, recognised best practice guidance, policy objectives, designations or protected status, consultation outcomes and local/regional expertise. Where relevant, these will be quoted within each technical chapter.

7.7.2 Approach to Assessing Significance of Impacts

To assess the potential impact of the Project, the magnitude of the impact being assessed has been evaluated against the sensitivity of the receptor in question, in order to determine impact significance.

The assessed level of magnitude and sensitivity are put into a matrix to determine the overall level of significance of the impact on a given receptor (Table 7.3). Where magnitude is considered positive, then this conclusion will follow into impact significance, for all levels of receptor sensitivity.

An impact classified at moderate or major, is considered significant under EIA regulations (IEMA, 2004).

Table 7.3: Matrix for assignment of impact significance

Sensitivity of Receptor	Magnitude of effect			
	High	**Medium**	**Low**	**Negligible**
High	*MAJOR*	*MAJOR*	*MODERATE*	*MINOR*
Medium	*MAJOR*	*MODERATE*	*MINOR*	*MINOR*
Low	*MODERATE*	*MINOR*	*NEGLIGIBLE*	*NEGLIGIBLE*
Negligible	*MINOR*	*NEGLIGIBLE*	*NEGLIGIBLE*	*NEGLIGIBLE*

7.7.3 Phased Approach

The entire life cycle of the Project is considered. Potential impacts are identified for each phase of the Project and then compared with the environmental baseline to identify the potential interactions of the Project with the environment. Potential impacts were determined through Scoping.

Potential impacts are listed for each phase of the Project, as defined within Chapter 5 Project Description:

- Construction and installation;
- Operations and maintenance; and
- Decommissioning.

7.7.4 Baseline Description

Each technical chapter contains a detailed description of the current environmental or social conditions, termed the 'baseline conditions'. Baseline conditions are described for all of the relevant environmental and social characteristics that may be impacted by the Project. The description includes existing conditions and those likely to occur in the absence of the Project. Baseline information was gathered for the Project from both desk-based and field studies. Impacts are assessed in the context of the predicted baseline conditions during the lifetime of the Project.

The baseline, at the Project site, draws upon the existing environment surveyed between 2012 and 2015. Where projects are built and operational at the time of writing, these have been considered to form part of the baseline environment. Other projects, which are reasonably foreseeable (i.e. those in construction or in the planning system) are considered within cumulative impact assessment (Chapter 22 Cumulative Impact Assessment).

7.7.5 Mitigation Measures

Mitigation measures have been identified during the EIA process and have been informed through stakeholder consultation and specific surveys and studies, along with best practice industry guidance for renewable and marine and coastal developments. Mitigation measures considered to avoid or reduce potential impacts of the Project include; project design mitigation, general mitigation and specific mitigation.

BTAL have committed to considering current best practice to minimise the risk of adverse impact to the physical, biological or social environments on site and in the surrounding area.

The Project will also draw on key knowledge from the marine renewable industry and the studies (such as underwater noise and wildlife interaction) completed on existing industry knowledge of tidal devices, including those types under consideration for the Project, to inform potential effects and possible mitigation.

7.7.5.1 Project Design Mitigation

The EIA has been an integral part of developing the Project appraisal and Project design (Chapter 5 Project Description). For the purpose of this ES, Project design mitigation is defined as Project design features which have been established during Project development which will minimise the potential impacts on receptors. Project Design Mitigation Measures have been included in Chapter 5 Project Description (Table 5.15).

7.7.5.2 General Mitigation

General mitigation encompasses standard good practice measures based on specific legislation, regulations, industry standards, and industry specific guidance. Examples include: Vessel and Navigational Safety Management Plans, Environmental Management Plans, Pollution Control Plans, etc.

7.7.5.3 Specific Mitigation

Specific mitigation measures are those that are specifically implemented to minimise the impacts on a particular receptor. For example, a vessel management plan will be developed in consultation with SNH and Marine Scotland which will aim to develop a standard transit route and range of vessel speeds for traffic to and from the AfL area with the aim of minimising collision risk. Specific Mitigation measures have been listed and discussed in each chapter as relevant.

7.7.6 Residual Impacts

Residual impacts are those that remain once all options for removing, reducing or managing potential impacts have been taken into account. This ensures that mitigation measures have been fully considered within the final impact assessment. The residual significance of the Project impact upon the receptor is provided, by the technical author, as the conclusion of the assessment. Summary tables of residual impacts are presented (Chapter 24 Summary of Key Impacts) and provide an overview of residual impacts and their significance for all Project phases (construction and installation, operation and maintenance and decommissioning).

7.8 CUMULATIVE IMPACTS

It is necessary to consider the potential impacts on given receptors which may occur as a result of interaction with other projects, works or operations. These interactions are assessed through Cumulative Impact Assessment (CIA). In this case, cumulative impacts are those arising from interactions with similar projects, i.e. other marine renewable developments while in-combination impacts are considered to be those arising as a result of interactions between the Project and other non-wet renewables projects for example, pier developments or oil and gas developments. Depending on the specific nature of potential cumulative and in-combination impacts, assessment might be necessary for the different phases of the Project, e.g. construction and installation, operation and maintenance and decommissioning. The approach to CIA for the Project is detailed within Chapter 22 Cumulative Impact Assessment.

7.9 REFERENCES

ABPmer. (2012). Marine Scotland Licensing and Consents Manual. The Scottish Government Commissioned Report No. R.1957.

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Geology and Hydrology

Chapter 8

8 GEOLOGY AND HYDROLOGY

8.1 INTRODUCTION

This chapter of the Environmental Statement (ES) describes the aspects of the geology, soils and hydrology in the vicinity of the landfall areas of search and the potential impacts on these receptors as a result of bringing the export cables ashore within one of three possible landfall areas of search. This assessment covers the landfall construction, operation and decommissioning up to the Mean High Water Spring (MHWS) for the Brims Tidal Array Project (the 'Project'). The area required for onshore access, equipment laydown, working areas and construction compounds will be provided as part of the description of the onshore components in a separate future application and screened for EIA.

This chapter is supported by a desk based Geological and Hydrological Baseline Desk Study undertaken by Dr John Flett Brown (Supporting Document: Flett Brown, 2015). Where detailed baseline information is not available, other relevant information has been used.

Related chapters include Chapter 9 Physical Processes, which describes offshore aspects of the Project including the export cables areas of search and which also covers the coastal environment.

8.2 STUDY AREA

The geographical area for this assessment includes the three areas under consideration for the export cable to be brought to shore, up to MHWS. The export cables will be brought to shore at one of three possible landfall locations (Sheep Skerry, Moodies Eddy or Aith Hope) as shown on Figure 8.1.

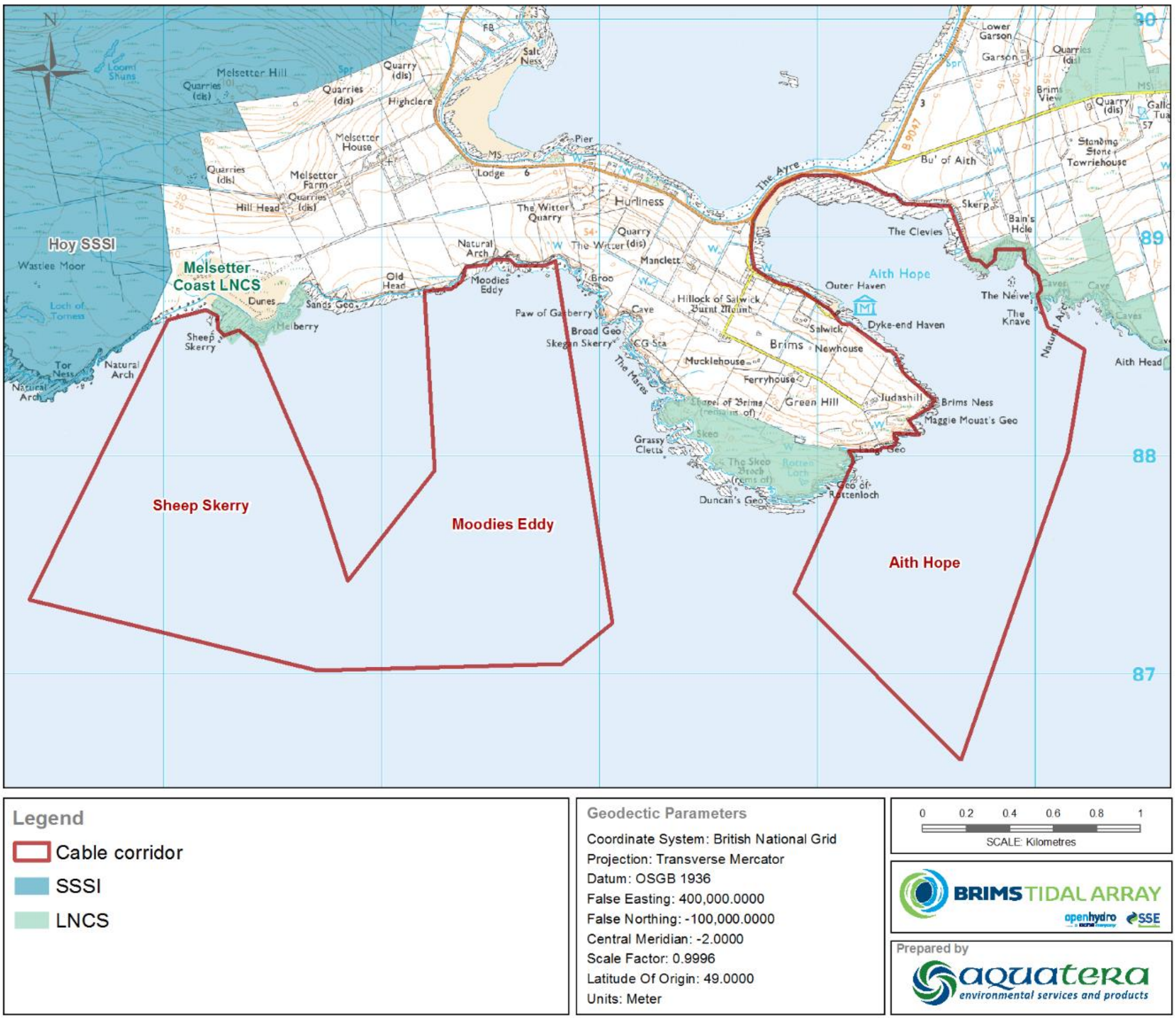

Figure 8.1: Study area for geology, soils and hydrology showing designated sites

8.3 DESIGN ENVELOPE CONSIDERATIONS

The Project has taken a design envelope approach. The basis of the design envelope is to apply a “worst case” approach to the assessment of the different impacts associated with the Project. With this in mind the maximum “worst case” project parameters considered for the assessment of geology and hydrology are presented in Table 8.1 below. The Project is considering three different potential landfalls as described above. Each of these landfalls is assessed separately, in line with this approach.

Table 8.1: Design envelope parameters for assessment of geology, and hydrology

Project parameters relevant to the assessment	Maximum Project parameters for the impact assessment	Explanation of maximum Project parameters
Location of cable landfall	Sheep Skerry Moodies Eddy Aith Hope	Three separate landfalls are being considered and each is assessed separately.
Method to be used to bring cables ashore at landfall	Open Cut Trench or Horizontal Directional Drill (HDD)	
Width of cable corridor at landfall	Stage 1: maximum 20m (maximum affected area for 4 cables) Stage 2: maximum 80m (maximum affected area for 16 cables)	Stage 1: 5m per cable for 4 cables Stage 2: 5m per cable for 16 cables
Duration of works	Stage 1: 4 cables in 2019/2020 Stage 2: 12 cables in 2021/2022 Two cables laid per installation operation	Assume construction activities occur throughout the year

8.4 LEGISLATIVE FRAMEWORK AND POLICY CONTEXT

As the Project boundary ends at MHWS, in addition to the EIA Regulations the following legislation is also relevant to this assessment:

- The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR);
- The Water Environment and Water Services (WEWS) (Scotland) Act 2003; and
- The Pollution Prevention and Control (Scotland) Regulations 2012 (PPC 2012).

The Water Framework Directive (WFD) came into force in December 2003 and is implemented in Scotland through the *Water Environment and Water Services (Scotland) Act 2003*. This provides Ministers with the powers to make regulations to control activities which could affect the water environment. SEPA's powers under CAR are defined as for the purpose of 'protecting the water environment' and include authorising activities including abstractions, impoundments, building and engineering works, and activities liable to cause Pollution. Activities likely to cause pollution to the water environment require authorisation under CAR. A key objective of this Directive is the achievement of 'good ecological status (as a minimum) of all natural waterbodies by 2015.

Under the terms of the Water Framework Directive, all river basin districts are required to be characterised. This process requires SEPA to produce an initial assessment of the impact of all significant pressures acting on the water environment. Surface water bodies are defined as being whole or parts of rivers, canals, lochs, estuaries or coastal waters. The main purpose of identifying waterbodies is so that their status can be described accurately and compared with environmental objectives.

In addition to these regulations, there are a number of guidance documents and best practice guidelines related to prevention of pollution in the water environment, including:

- Land Use Planning System SEPA Guidance Note 17. Marine development and marine aquaculture planning guidance;

- The guidance advises that water quality and potential pollution risks should be reported in the ES and that the principles included in the Pollution Prevention Guidelines and CIRIA C584 should be considered;
- CIRIA (Construction Industry Research and Information Association) Report C532, Control of water, pollution from construction sites: Guidance for consultants and contractors;
- CIRIA Report C584D, Coastal and marine environmental site guide (C584D); and
- SEPA pollution prevention guidance: Available at: http://www.sepa.org.uk/regulations/water/guidance/.

8.5 SUPPORTING SURVEYS AND STUDIES

- The geological information is summarised from the desk based Geological and Hydrological Baseline Study (Supporting Document: Flett Brown, 2015) undertaken by Dr John Flett Brown. The report examines the topography, potential flooding, regional geology, structural geology, hydrology and groundwater flow with statutory hazard evaluation for an area including south Hoy and a region of the Pentland Firth centred on the peninsula of Brims stretching to about 4km south.
- Technical data used within these reports include multibeam echo-sounder (MBES) survey data, sidescan sonar survey data, geological maps, surface water flow maps and water table maps.

8.6 DATA GAPS AND UNCERTAINTIES

Given the extensive publicly available datasets for the Pentland Firth and Orkney Waters strategic development area and site-specific survey work undertaken for the Project no significant data gaps or uncertainties related to the Geology and Hydrology assessment have been identified.

The Sheep Skerry corridor was included as an additional cable route corridor and landfall option after extensive geophysical surveys were carried out for the original Project Area of Search. A multi-beam echo-sounder (Supporting Document: Aquatera, 2015c) and benthic ROV survey have since been carried out within the Sheep Skerry corridor and provide good coverage of the seabed. However, no sidescan sonar survey work was carried out which would supplement the MBES to provide additional baseline information on seabed texture and features on the seabed. Nevertheless, the information available is deemed sufficient to carry out an appropriate assessment of the conditions of the seabed and its suitability as a potential cable route corridor.

The landfall Area of Search (AoS) in the Sheep Skerry corridor was assessed during the previous site walkover and an initial assessment of landfall suitability (subsequently leading to its identification as a potential option) was made. This assessment is further augmented with information from the Sheep Skerry Phase 1 Habitat and Intertidal surveys (Supporting Document: Aquatera, 2015a) carried out to inform the baseline of the Coastal and Terrestrial Ecology Chapter. Therefore sufficient information is available to carry out an appropriate assessment of the Sheep Skerry landfall AoS.

A minor uncertainty lies around the design envelope for the landfall cable as the location and installation method has not been finalised. As a result the impacts assessed assume a worst case scenario for the three landfall options rather than specific impacts relating to one particular site. This approach allows for in a robust assessment which ensures that the worst case impact is considered.

8.7 CONSULTATIONS

Feedback from consultations are summarised in Chapter 6 Consultation Process. The key points raised by stakeholders regarding geology, soils and hydrology are presented in Table 8.2. These comments were raised during the Scoping consultation. At the time of Scoping, some onshore infrastructure around and beyond MHWS was being considered. However, the current application does not include any infrastructure beyond the export cables up to MHWS.

Table 8.2: Key issues raised by stakeholder during consultation

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Drainage systems	SEPA	Pollution from site activities	Follow SEPA Controlled Activities Regulations (CAR)	See Section 8.9.4
Drainage systems	SEPA	Sustainable drainage systems	Ensure all developments treated by Sustainable Drainage Systems are in line with Scottish Planning Policy	The Offshore Project does not involve infrastructure in the onshore area.
Flooding	SEPA	Risk of flooding to site	Assess SEPA Flood Maps	See Section 8.9.4
Geology	OIC	A draft geological Local Nature Conservation Site, known as Melsetter Coast, is located on the South Hoy coast, to the west of the Area of Search for the cable landfall area. The site extends between Sheep Skerry and Sands Geo and consists of a restricted outcrop of the Hoy Lavas. The lava forms a distinctive coastal platform in front of a small dune system at Melberry.	Considered in assessment of potential landfall corridor at Sheep Skerry.	See Section 8.9.7

8.8 ASSESSMENT METHODOLOGY

8.8.1 Assessment Criteria

The general methodology used for this assessment is described in Chapter 7 EIA Scope and Methodology.

Table 8.3 defines the sensitivity for the various environmental receptors considered in this chapter.

Table 8.4 provides examples of the criteria that were used to classify the potential magnitude of impacts on different components of the physical environment. Table 8.5 provides the impact significance considering the sensitivity of the receptor and the magnitude of the impact.

A matrix approach has been used in combination with expert judgement and experience from other development projects concerning the geological and hydrological environment to determine impact significance to the geological, hydrological and soil receptors.

Table 8.3: Definitions for sensitivity of geology and hydrology

Sensitivity	Criteria
High	The receptor has little ability to absorb change without significantly altering its present character, is of high environmental value or of national importance.
Medium	The receptor has moderate capacity to absorb change without significantly altering its present character, is of moderate environmental value or of regional importance.
Low	The receptor is tolerant of change with only minor detriment to its present character, is of low environmental value or of local importance.
Negligible	The receptor is tolerant of change without perceptible detriment to its present character or is of negligible environmental value.

Table 8.4: Definitions for magnitude of effect on geology and hydrology

Sensitivity	Criteria
High	High risk of pollution/sediment release during construction, operation or decommissioning, substantial temporary or long-term change in water quality resulting in a temporary but long-term change in WFD status. Major change in geomorphological conditions i.e. major change in sediment deposition or erosion patterns, major reduction in morphological diversity, major interruption to fluvial processes such as channel platform evolution, all with major consequences for ecological quality but localised to one section of the watercourse. Widespread change to qualifying interest in designated geological sites.
Medium	Moderate risk of pollution/sediment release during construction, operation or decommissioning, moderate temporary change in water quality resulting in a temporary reduction in WFD status. Moderate change in geomorphological conditions i.e. moderate change in sediment deposition or erosion patterns, moderate reduction in morphological diversity, moderate interruption to fluvial processes such as channel platform evolution, all with moderate consequences for ecological quality. Localised damage to qualifying interest in designated geological sites.
Low	Minor risk of pollution/sediment release during construction, operation or decommissioning, relatively minor temporary change in water quality resulting in a temporary, but measurable, reduction in WFD status. Minor change in geomorphological conditions i.e. minor change in sediment deposition or erosion patterns, minor reduction in morphological diversity, minor interruption to fluvial processes such as channel platform evolution, all with minor and localised consequences for ecological quality. Localised damage to geological features of local importance but non-designated.
Negligible	Negligible risk of pollution/sediment release during construction, operation or decommissioning, negligible or minor transient change in water quality with no discernible effect on watercourse ecology or WFD status. Negligible change in geomorphological conditions i.e. no discernible change in sediment patterns or fluvial processes, negligible change in morphological diversity. Any changes are likely to be highly localised. Impacts on geology highly localised
Positive	An enhancement of the availability or quality of a resource

Table 8.5: Assignment of impact significance for geology and hydrology based on sensitivity of receptor and magnitude of effect

Sensitivity of Receptor	Magnitude of effect			
	High	Medium	Low	Negligible
High	*MAJOR*	*MAJOR*	*MODERATE*	*MINOR*
Medium	*MAJOR*	*MODERATE*	*MINOR*	*MINOR*
Low	*MODERATE*	*MINOR*	*NEGLIGIBLE*	*NEGLIGIBLE*
Negligible	*MINOR*	*NEGLIGIBLE*	*NEGLIGIBLE*	*NEGLIGIBLE*

For the purposes of this assessment, any impact classified as moderate or major is considered significant.

8.9 BASELINE DESCRIPTION

8.9.1 Introduction

Bringing a cable from the oceanic environment across a beach and intertidal zone onto dry land is accomplished by two main methods. Open cut trenching is possible where significant wave heights and cliff heights are small. Where this is not the case, drilling a low angle borehole from the cliff top out into the open sea emerging below wave base would be necessary (horizontal direction drilling, HDD). Either method would involve impacts on geology, soils, hydrology and coastal geomorphology. In addition, aspects of the physical environment influence the technical feasibility of cable landfall construction techniques.

Potential impacts on geology, soils, hydrology and coastal geomorphology will be addressed by examining the topography, flooding, regional geology, structural geology, hydrology and groundwater flow within the Project Study Area. More detail on these topics can be found in the supporting documents (Supporting Document: Flett Brown, 2015).

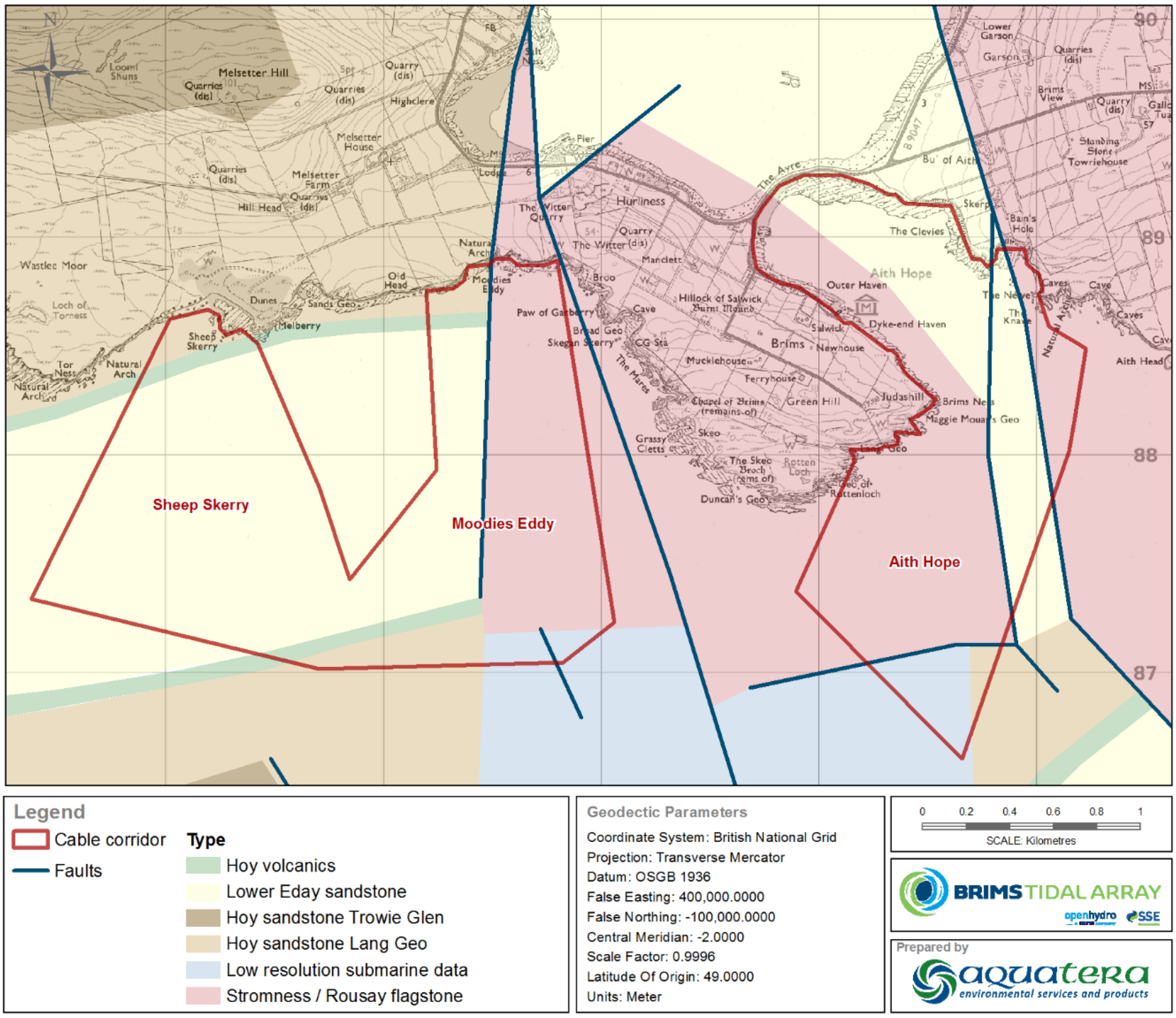

Figure 8.2: Geology of the study area

8.9.2 Onshore Geology

In the study area of Melsetter, Brims and Longhope comprising the Area for Lease (AfL) area and potential cable landfalls the geology consists of Middle Devonian flagstones and sandstones (See Figure 8.2). This area is bisected by the approximately north-south Brims – Risa Fault zone, a high angle reversed fault extending from Houton, through Hoy across the Pentland Firth to Brough and on to central Caithness. The older upper Stromness and Rousay Flagstone Formations are found mainly on the eastern side of the Brims – Risa Fault. The lower Eday Sandstone and the Hoy volcanics lie close to the eastern side of the fault and are caught in the bifurcation of the fault system. Hoy sandstones are located on the west side of the fault.

This Brims–Risa Fault throws down to the west, ± 200m, putting younger rocks of the Hoy Sandstone Group against older rocks of Rousay and Lower Eday age on the east. On the south coast of Hoy near Witter Hill the Brims–Risa Fault is clearly a reversed fault which heads east at 60°. These flagstones are deformed for about 12m within a fault crush zone. The style of deformation adjacent to and within the fault zones indicates that they are sinistral strike-slip faults, with a reverse displacement.

The major reverse faults dip east, between 50° and 85° and include the Brough, Brims–Risa and East Scapa faults.

Early extensional tectonics during the Middle Devonian probably initiated the major fracture systems which were then reactivated as thrusts faults during the Permian inversion of this area. These faults are probably related to the “Great Glen” left-lateral transcurrent fault which passes close to the eastern side of Orkney. Although small-scale movements still occur on the “Great Glen” at the present time fault movement and seismic events are not considered as major hazards over the AFL.

The upper Stromness and Rousay Flagstone formation consist of cycles of lacustrine sediments including siltstones and mudstones interbedded with sandstones. These cycles follow the 100,000 year Milankovitch eccentricity cycle which controlled the climate during the wet periods of the Lake Orcadie sedimentary system. During the maximum wet periods permanent Lake conditions existed over the area for about 10,000 years during which fish remains were preserved on the lake bed. There is a basal fish bed within the Rousay Formation containing fossil fish (*Osteolepis panderi*) and stromatolites. About 210m of Rousay Formation is estimated on the Brims Peninsula.

Lower Eday Sandstone is exposed in the west of South Walls. It joins the Brims–Risa Fault east of Binga Fea. At the exposure on the shore of Aith Hope it is with a wide zone of crushed and crumpled beds. The formation consists of a lower unit of mixed sandstones and mudstones, with the proportion of sand increasing upwards. This passes into an upper, thicker sandstone unit incorporating fluvial, aeolian and beach deposits. At Brims site the upper porous aeolian facies is ± 50m thick in a total section of ± 130m.

The Hoy Volcanic Formation is of variable thickness throughout Orkney reaching its largest extant in Rackwick and North Hoy. The lower member is a relatively thick tuff or tuffaceous sandstone up to 15m thick. This is overlain by alkali basalt, 20m thick.

The Hoy Sandstone Formation found on the western side of the fault system is a monotonous succession of braided fluvial sandstones of Givetian age — Frasnian Age consisting of red, pink, and yellow sandstones with subordinate bands of marl. Many exhibit current bedding and trace fossils. These rocks were deposited as the Orcadian Basins evolved to a system of “through drainage”.

8.9.3 Topography

Orkney's topography is generally low lying with smooth relief. The highest areas reach over 200m, but the majority of the archipelago is below 100m, with significant areas below 30m. This topography was formed by ice sheets and glaciers passing over the islands during the last Ice Age. Hoy has higher and more dramatic topography than the rest of Orkney, with heights in the north of the island frequently over 300 or 400m. The highest point is the Ward Hill of Hoy, which at 479m is also the highest point in Orkney. Central and southern Hoy are slightly lower and more undulating than the north, although much land remains over 200m. Along the west coast this height is expressed in Hoy’s cliffs which reach over 300m high in the north, reducing gradually towards the south.

High cliff coastlines are a feature of the south west tip of the island of Hoy. The rich variety of cliff and cliff-related forms along this coast include steep and overhung profiles; sea-stacks; arches; caves; and shore platforms, all reflecting the dominant geological control of horizontally bedded, fractured and faulted Devonian Sandstone. Near to the study area, high cliff coastlines are a prominent feature. Exposed abrasion surfaces slope at a gentle angle towards the sea where the coastline is more dominated by shingle and boulder beaches. The effect of high energy wave action on the gently inclined sedimentary rocks has been to produce a series of constantly eroding and evolving near-vertical cliffs.

The littoral zone of the study area is characterised by mixed boulder and cobble beaches and wave cut platform slabs, backed by cliffs. The majority of the study area has foreshore backed by wave eroded rocky cliffs from 6m to 38m high. Only 1.9km of the study area, principally within the inner part of Aith Hope, has low sloping beaches with very low, 1 – 2m, and erosional soil and boulder clay cliff lines behind the beach.

Figure 8.3 Melsetter (JF Brown, 2015)

8.9.3.1 Sheep Skerry

The Melsetter Links have been a working source of constructional sand in Hoy. The excavation of sand lies behind around 10m high dunes. These dunes separate it from the shore. On the west side there is a stream that cuts through the dune complex on to the beach with about a 2° access slope over some 200m. On the west side of the links is the volcanic plug outcrop of Melberry. The land behind this potential landing spot is low lying rising slowly to about 17m before decreasing down to sea level near the Lodge of Melness and into North Bay.

8.9.3.2 Moodies Eddy

This section of coast consists of large boulders on top of bedrock backed by a 6m to 10m cliff with bare bedrock extending about 500m to 800m from the shoreline. As such it is unsuitable for an open cut trench cable landing solution; therefore HDD would be likely in this location.

8.9.3.3 Aith Hope

To the west of this AoS is bare rock rising to 6m in the western part with cliffs of 16m height in the eastern part. This coastline is not conducive for a trenched cable landfall. The underlying rock is Rousay Flagstone and it likely would be necessary to drill across fault zones.

This coastal section which includes Brims Village lies north west/south east under the ridge of Brims Peninsula rising steeply behind the village to about 35m. This geography shelters this whole coastline from the prevailing west and south west winds. South of the lifeboat station the land is low for about 200m. It then rises to the headland of Brims Ness at 15m.

North Aith Hope has a gradient of about 1.5° from the sea up to the 2m contour this makes for an easy trench access.

The Clevies extend from the low lying shore of Aith Hope north to shoreline with a backing cliff of 4m which rises to 15m. Behind the shoreline these the small cliffs are in Lower Eday Sandstone's which are quite homogeneous and very suitable for horizontal drilling solutions. The presence of the major faults system about 150m behind the cliff may put constraints on such horizontal drilling solutions.

8.9.4 Flooding

The 1:200 year flood envelope of the SEPA Interactive Flood Map (see Figure 8.4) shows the whole causeway of The Ayre as subject to flooding as are the areas below 2m on the coast. There are no other major areas of flooding within the study area. However, resolution of the map does not account for smaller catchments and burns with a catchment area of less than 3km^2.

Note that there is a potential for flooding due to sea level rise within the Long Hope Bay and the north end of Aith Hope. Therefore it would be wise to locate infrastructure at least 2m above the present high tide level.

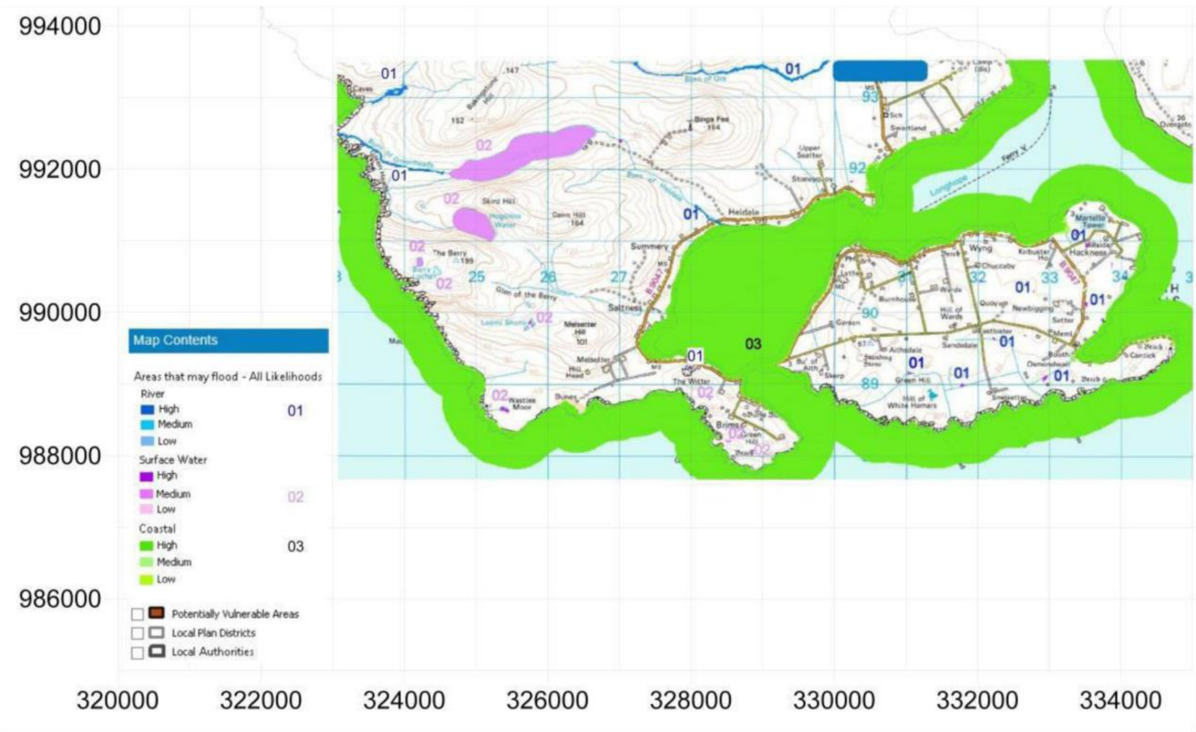

Figure 8.4: SEPA flood map

8.9.5 Soils

The variation in soil types in Orkney is very much dependent upon the parent material: Old Red Sandstone, boulder clay, peat, blown sand, fluvio-glacial deposits, or a basement inlier of metamorphic or igneous rock, depending upon the location.

Within the study area three different soil types are present: brown earth soils and gley soils which are found between Sheep Skerry and Summery and podzols found on the Brims peninsula (see Figure 8.5). The gleys are generally surface water gleys in which the downward movement of water is hindered. The brown soils develop on the more strongly sloping land and are often characterised by hardened horizons. The brown soils and non-calcareous gleys are capable of supporting arable crops and permanent grass, and peaty gleys can support some grassland.

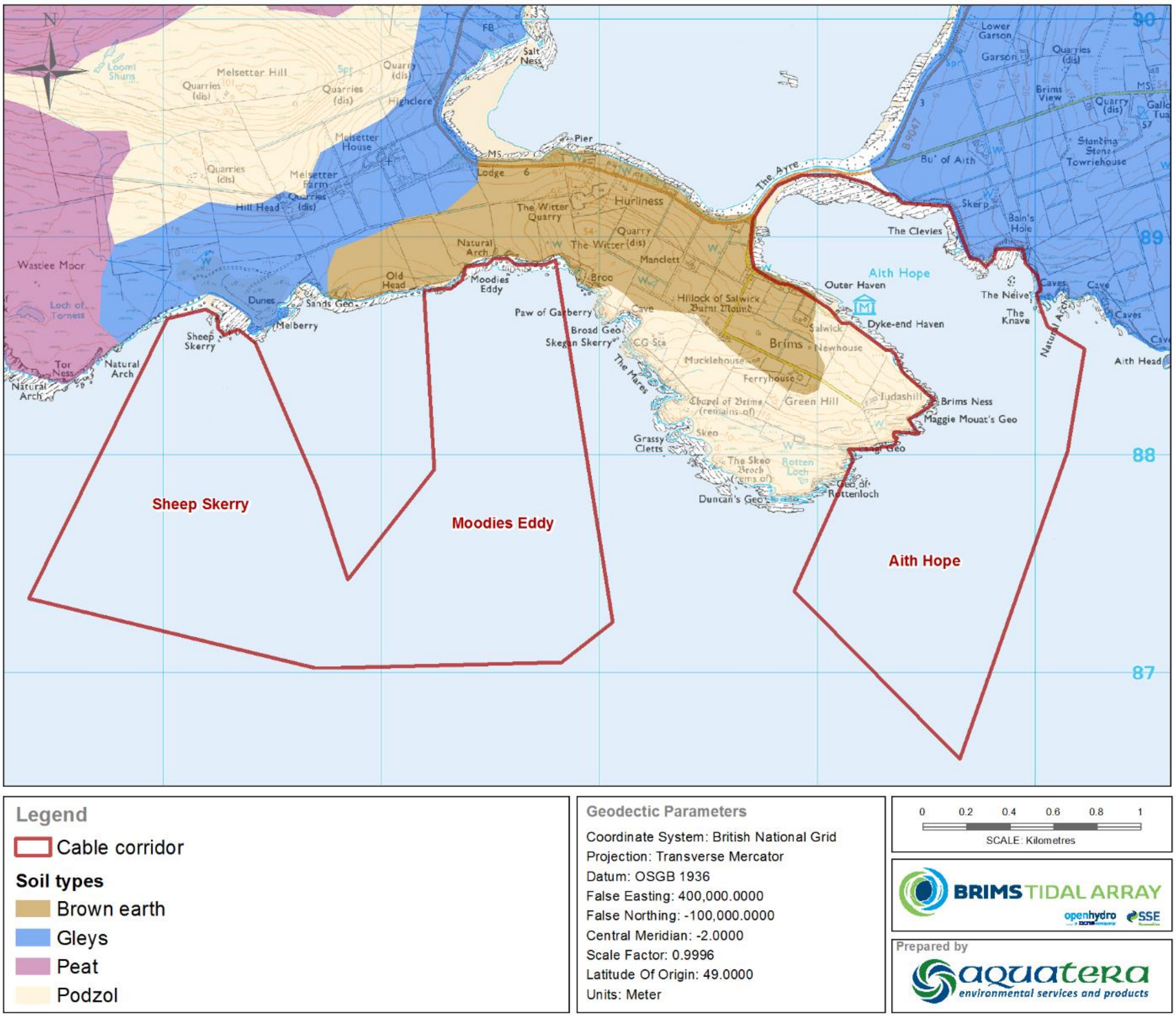

Figure 8.5: Soil types within the study area

8.9.6 Hydrology and Hydrogeology and Groundwater Flow

There are no watercourses flowing into the sea within the study area. The water table in the study area is almost the same as surface elevation at the coast. Surface flow of precipitation and groundwater flow within the aquifers are very similar as a result of this. The direction of water flow within the water table in the study area is towards to coast. As a result of this if any pollution event does occur, it is unlikely to affect the ground water but flow into the sea instead.

The Old Head to Tor Ness water body (WB ID 200222) has been identified as overlapping with the BTAL AfL and has been classified by SEPA as having an overall status of Good with High confidence in 2013 with overall ecological status of Good and overall chemical status of Pass. SEPA set environmental objectives for this water body over future river basin planning cycles in order that sustainable improvements to its status can be made over time, or alternatively that no deterioration in status occurs, unless caused by a new activity providing significant specified benefits to society or the wider environment (SEPA 2016).

8.9.7 Designated Sites

The only designated site with geological interest within the study area is the Melsetter Coast Local Nature Conservation Site (LNCS). This is a 6.0 hectare area that was designated due to the Hoy Lava outcrop which is found between Sheep Skerry and Sands Geo. The lava forms a distinctive coastal platform in front of a small dune system at Mulberry. On the west, north and east the lava is bounded by Monchique dykes and only the top of the flow is visible. To the west the lava is overlain by channelled and cross-bedded Hoy Sandstone which is well exposed as far as Ha Wick. Further to the north, the cliffs rise sharply to over 180m and the exposure becomes inaccessible. The Sheep Skerry landfall area of search is located within this site (Figure 8.1).

8.9.8 Summary

The underlying geology of the study area is middle Devonian sediments consisting of the Caithness Flagstone group and the overlying Eday Sandstone group. These are characterised by fine to medium grained sandstones, siltstones and mudstones. There is also a section of Hoy Lava which is designated as a Local Nature Conservation Site at Melsetter Coast. The Sheep Skerry landfall AoS is located within this designated site. The littoral zone is characterised by mixed boulder and cobble beaches and wave cut platform slabs, backed by cliffs. Soils are brown earth, gley soils and podzols. There are no watercourses flowing into the sea within the study area. The study area is also outside the 1:200 year flood envelope.

Open cut trenching could be undertaken at Sheep Skerry or North Aith Hope. Other potential landfalls would necessarily involve HDD. There are no watercourses flowing into the sea within the study area, and no private water supplies, so no direct or indirect impacts on watercourses or private water supplies are anticipated.

8.10 POTENTIAL IMPACTS

8.10.1 Construction and Installation

- Contamination of soils, surface water or groundwater from spills; and
- Disturbance or loss of features of geological interest.

8.10.2 Operation and Maintenance

- Disturbance of loss of features of geological interest.

8.10.3 Decommissioning

- Contamination of soils, surface water or groundwater from spills; and
- Disturbance or loss of features of geological interest.

8.11 MITIGATION MEASURES

8.11.1 Project Design Mitigation and General Mitigation

All Project Design and General Mitigation measures are set out in Chapter 5 Project Description, Table 5.15 and Table 5.16 respectively. These are standard practice measures based on specific legislation, regulations, standards, guidance and recognised industry good practice that are put in place to ensure significant impacts do not occur.

8.11.2 Specific Mitigation

The assessment of the potential effects on the baseline physical processes environment has revealed that no potentially significant impacts will arise to the identified shoreline geological, hydrological and soil receptors following implementation of best practice guidance as outlined in general mitigation measures. Due to this, no specific mitigation measures have been identified for these receptors.

8.12 RESIDUAL EFFECTS

8.12.1 Construction and Installation

8.12.1.1 Contamination of Soils, Surface Water or Groundwater from Spills

The effects of contamination would be the same for each landfall AoS.

During construction activity, potential pollutants will be present in the site area. These will include fuel, lubrication oils, chemicals, unset concrete, grout and drilling fluid as well as waste water from staff facilities. Any pollution incident occurring on site may adversely affect the quality of nearby surface waters, groundwater or site soils. Through implementation of the mitigation measures listed in Section 8.11 any residual impacts on WFD objectives, will be not significant.

The length of the cable to be trenched will be short (i.e. across the intertidal and possibly the shallow near-shore zones only) as a result any spills or pollution around this area would run directly into the sea and not surface waters, ground waters or site soils. Spills or pollution events further inland relating to machinery and staff facilities would be very localised. The soils in the area are poorly drained so spills and pollution would take a long time to permeate into the soils, resulting in the pollution having likely been contained before any impact could occur. The ground and surface waters in the study area all run towards the sea so any spills would be unlikely to accumulate in the surface and ground waters but run into the Pentland Firth which would have an impact on the local marine ecology (see Chapter 14 Ornithology, Chapter 13 Marine Mammals, Chapter 12 Fish Ecology and Chapter 11 Benthic Ecology).

For HDD there will be more lubrication oils and drilling fluid present. As a result a pollution event would have a higher likelihood of occurring. The drilling locations for HDD would mean that due to the ground and surface waters run into the sea any spills would be unlikely to accumulate in the ground or surface water but run into the Pentland Firth which would impact on the local marine ecology.

Any contamination of soils, surface water or ground water from spills would therefore be low in magnitude, temporary in duration, caused by infrequent activities and reversible within a very short period of time.

Table 8.6: Summary of residual effects soils and water during construction and installation

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Contamination of Soils, Surface Water or Groundwater from Spills	Soils, surface water and ground water within the Melsetter, Brims and Longhope area and potential cable landfalls, Old Head to Tor Ness Waterbody	Low	N/A	Minor	Contamination would be low in magnitude, temporary and reversible within a very short period of time	Minor

8.12.1.2 Disturbance or Loss of Features of Geological Interest

Sheep Skerry

During construction activity some of the bedrock will have to be removed for the landfall cables using either HDD or open cut trench techniques. The landfall at Sheep Skerry is a designated LNCS for the outcrop of Hoy Lava that is present here making this site the worst case site.

For trenching this could cause localised damage to the bedrock and superficial geology and may result in fracturing within nearby sections of the bedrock due to the trenching occurring at the surface. The length of the cable to be trenched will be relatively short. The back fill of the trenches will likely use the rock that was excavated. If fracturing of the nearby sections occurs it will be very localised and unlikely to cause noticeable damage to features of geological interest, such as the Hoy Lavas which are a LNCS. Therefore disturbances or loss of geological interest will be low in magnitude, localised but permanent.

However, if the Sheep Skerry corridor is to be utilised as a landfall corridor, the laval outcrop would be avoided as it would be impractical to bring export cables to shore at this location, and a median path is likely to be selected which follows a relatively gentle path through the rippled sand avoiding rocky outcrops.

The Sheep Skerry corridor is potentially of medium sensitivity, however as this area is likely to be avoided, the magnitude of impacts is likely to be low and impact significance is assessed as minor.

Table 8.7: Summary of residual impacts on features of geological interest during construction and installation

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Disturbance or loss of features of geological interest	Melsetter Coast LNCS	Medium	N/A	Low	Localised removal and fracturing of bedrock should be avoided at Sheep Skerry	Minor

8.12.2 Operation and Maintenance

The only impact with any probability of occurring during the Operational Phase is the result of contamination during maintenance activity. There is no scheduled maintenance for the landfalls and export cables, therefore any maintenance activity would be limited to rare occurrences where a cable had to be dug up and reburied. These impacts are expected to be very similar in nature to construction impacts and would be avoided through the implementation of best practice measures for pollution prevention.

Table 8.8: Summary of residual effects of the on geology, soils and hydrology

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Disturbance or loss of features of geological interest	Melsetter Coast LNCS	Medium	N/A	Low	Localised removal and fracturing of bedrock should be avoided at Sheep Skerry	Minor

8.12.3 Decommissioning

The intended Project lifetime is 25 years, and after such time, the Project will either be decommissioned, involving the full or partial removal of onshore elements, or repowered. Any decommissioning or repowering programme will cause effects that are similar in type but lower magnitude than during the construction phase; refer to

Table 8.6 8.6 and Table 8.7.

8.13 SUMMARY

- Open cut trenching and horizontal directional drilling (HDD) for the landfall will involve impacts on geology, soils, hydrology and coastal geomorphology within the study area.
- The Sheep Skerry and North Aith Hope areas are most likely to involve open cut trenching, while other landfalls would necessarily involve HDD.
- The Melsetter Coast LNCS is designated for geological interest. The Sheep Skerry landfall is within this designated site. However, impacts on this site due to trenching are not expected to be significant as there would be only localised damage to the bedrock and superficial geology and if fracturing of the nearby sections occurs it will be very localised and unlikely to cause noticeable damage to features of geological interest, such as the Hoy Lavas.
- There is the potential for contamination of soils, surface water or groundwater from spills. However, general mitigation measures to implement best practice measures for pollution control and prevention will keep these impacts from becoming significant.
- There are no watercourses flowing into the sea within the study area and as the study area ends at MHWS, no impacts associated with groundwater flow are anticipated.
- The 1:200 year flood envelope of the SEPA Interactive Flood Map shows the whole causeway of The Ayre as subject to flooding as are the areas below 2m on the coast. There are no other major areas of flooding within the study area and no permanent above ground infrastructure is included in this Project.
- Maintenance activities needed for the export cables are anticipated to infrequent, and impacts would be similar to those for construction.
- Decommissioning, or repowerment, will occur after the 25 year intended lifespan. In the case of decommission, full or partial removal of onshore elements will occur. Decommissioning or repowerment will involve similar, but reduced, impact seen during construction.

8.14 REFERENCES

Orkney Islands Council, Natural Heritage Annex 1: Local Nature Conservation Sites, June 2012.

SEPA Water body information sheet for water body 200222 in Orkney and Shetland (Accessed via http://www.environment.scotland.gov.uk/get-interactive/data/water-body-classification/ February 2016)

Physical Processes

Chapter 9

9 PHYSICAL PROCESSES

9.1 INTRODUCTION

This chapter of the Environmental Statement (ES) describes the physical process environment of the proposed Brims Tidal Array Project (the Project), covering the Project site (i.e. the Agreement for Lease (AfL) area and the area of search for the potential export cable corridors, including the three potential landfall locations on Hoy) and a wider Project study site of surrounding seabed and shoreline.

A summary description of key aspects relating to the existing physical process environment is provided, covering the tide, wave and sediment transport regimes and the associated geomorphology. This recognises that the baseline conditions are not static, but are subject to considerable natural variability and could, potentially, be sensitive to change.

An assessment of the sensitivity of the receptor(s), the magnitude of the effects and their overall significance upon the baseline conditions resulting from the construction, operation and maintenance, and decommissioning phases (including an option for repowering) of the Project is then provided, as well as an assessment of those effects resulting from cumulative interactions with other existing or planned projects. Also provided are considerations with regard to potential mitigation measures, where appropriate.

This chapter was written by Royal HaskoningDHV on behalf of BTAL and incorporates survey results and interpretations from other contributors, including Aquatera, Osiris Projects and Partrac. It also uses the modelling tools available for the Project study site from The Crown Estate's Marine Modelling Enabling Action (MMEA) project, developed by the Danish Hydraulics Institute (DHI).

The assessment draws from findings of earlier studies and surveys undertaken to inform work within the wider Pentland Firth and Orkney Waters (PFOW) strategic area. It also incorporates datasets and findings from surveys and research studies and publications of relevance to the present study site from various third parties. All of these previous useful outputs are listed in Table 9.2 and Table 9.3.

The assessment process has been informed by the following:

- Discussion with key stakeholders as part of the EIA process;
- Collation and review of existing data and reports;
- Interpretation of field survey data specifically collected for the Project;
- Consideration of the existing evidence base from across the industry regarding the effects of tidal devices and tidal array developments on the physical process environment;
- Numerical modelling of baseline tidal hydrodynamics and changes due to the Project;
- Expert-based assessments of changes in wave propagation and sediment transport; and
- Application of expert-based judgement in assessing the significance of effects on the physical process environment.

The potential effects upon the physical process environment have been assessed conservatively using a defined and agreed design envelope (Chapter 5 Project Description) for the Project. This chapter should be read in conjunction with Supporting Document (BTAL, 2015b), and Supporting Document (RNDHV, 2015b)

9.2 STUDY AREA

Consideration of the potential effects of the Project on the physical process environment receptors is required over the following spatial scales:

- Near-field Project site – see Figure 9.1 (i.e. the Agreement for Lease (AfL) area and the area of search for the three possible export cable corridors, including the three potential landfall locations on Hoy); and
- Far-field Project study site – see Figure 9.2 (i.e. the wider area of the Pentland Firth and adjacent shores that might potentially also be affected, directly or indirectly, by the Project, e.g. due to disruption of tides, waves or sediment pathways).

The near-field Project site is well defined and is shown in Figure 9.1. However, in order to define the far-field Project study site for the physical process environment consideration needs to be given to both the present-day baseline conditions and the potential effects during the life-cycle of the Project, including the construction phase, the operation and maintenance phase and the decommissioning phase (including an option for repowering). Based upon the above considerations, the far-field Project study site is shown in Figure 9.2. The latter boundary is for indicative purposes only and not fixed. If an individual assessment demands, the boundary will be extended as necessary to fully capture all potential effects on the physical environment. In the consultee comments on the Physical Processes Method Statement (BTAL, August 2014) provided to BTAL by Marine Scotland (Marine Scotland, 2015), it is noted that Scottish Natural Heritage considers *"the 'zone of potential effects'* [to be] *appropriate in area both as the minimum 'domain' for the modelling and for the impact assessment generally. It includes all of the coastline that could conceivably see significant effects"*.

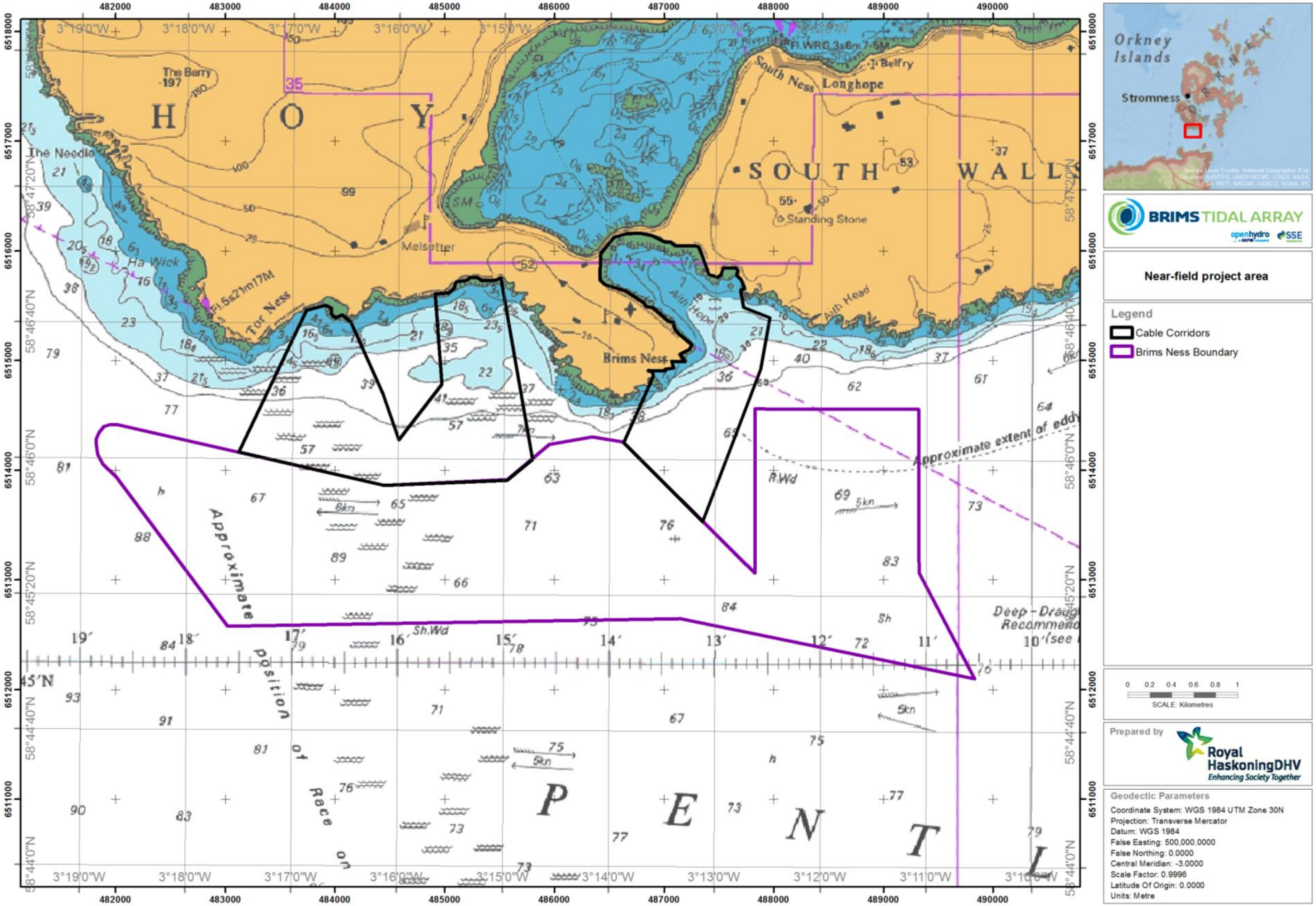

Figure 9.1: Near-field Project site

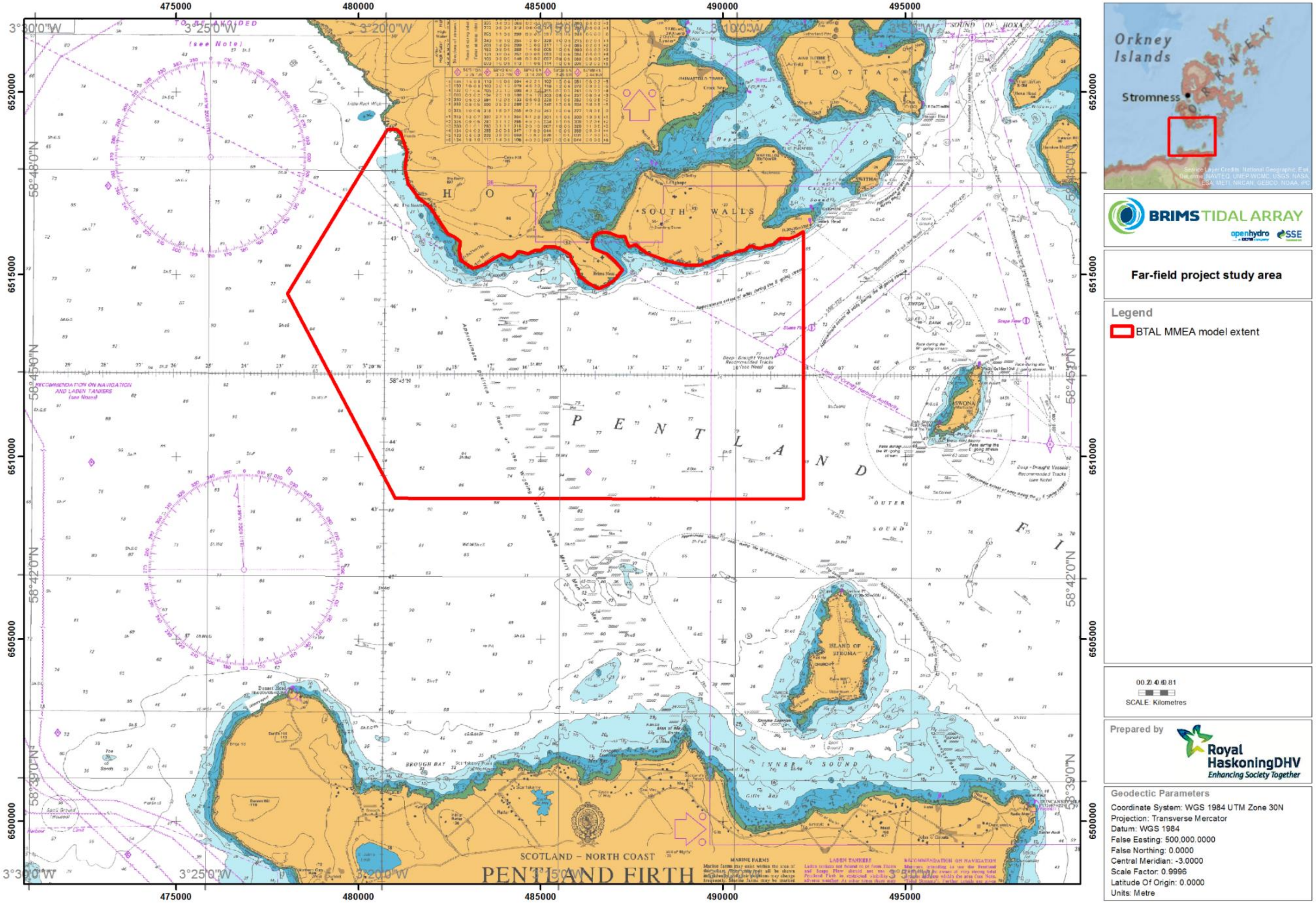

Figure 9.2: Far-field Project study site

9.3 DESIGN ENVELOPE CONSIDERATIONS

The purpose of the design envelope is to define a series of realistic design parameters that encompass all possible technological, engineering and design options that will be considered as the Project continues to evolve. This will ensure that a "worst case" approach is applied to the assessment of different impacts associated with the Project whilst retaining sufficient flexibility to enable evolution of specific elements (e.g. turbine technology, site layout, etc.) to continue beyond submission of the Marine Licence application.

The worst case assumptions are stated in Table 9.1 in terms of both general arrangements (e.g. Project phases, timescales and layout) and specific elements (turbines, TSS, navigation buoys, connector hubs, inter-array cables, export cables, cable laying/cable protection, and cable landfall). It should be noted that there is not necessarily a single arrangement that presents the worst case for all aspects of the physical process environment; rather different aspects have bespoke consideration to confirm the worst case assumptions.

An indicative layout has been defined in the Project Description based upon the maximum Project parameters stated in Chapter 5 Project Description. This indicative layout has been used as the basis for the impact assessment, including the numerical modelling. It is acknowledged that the final arrangements will depend on the turbine type, rating and numbers, resource availability and seabed conditions, but the indicative layout that has been used provides a pragmatic and suitably robust configuration, based upon both maximum numbers of turbines and TSS (at minimum spacings) and maximum dimensions of turbines and TSS. Subtle amendments to this layout (e.g. micro-positioning of turbines) within the bounds of the defined spacing arrangements will not have a significant bearing on the outcome of the impact assessment. Reductions to the number of turbines and TSS within the layout or reductions in their dimensions will lead to lesser impacts than has been assessed here.

Table 9.1: Design envelope parameters for technical assessment

Project parameters relevant to the impact assessment	Maximum Project parameters for the impact assessment	Explanation of maximum Project parameters
General arrangement: Area for Lease	Seabed area: 11.1km^2	Maximum area of the AfL, within which the seabed features and physical processes could directly be affected by Project infrastructure
General arrangement: Project phasing and capacity	Phase 1: 30MW Stage 2A: 65MW (95MW) Stage 2B: 65MW (160MW) Stage 2C: 40MW (200MW) Stage 1 and Stage 2: 200MW	Maximum capacity installed during each stage of the Project which could affect seabed features and physical processes, with Stage 2 being built in a number of sub stages as defined.
General arrangement: Project construction timescales	Stage 1: Up to 1 year Stage 2: Up to 4 years	Maximum timescales during which construction activities could affect the seabed features and physical processes, depending on the number, capacity and type of turbine.
General arrangement: Project Operation and Maintenance timescales	Stage 1: Up to 25 years Stage 2: Up to 25 years	Maximum timescales during which operation and maintenance activities could affect the seabed features and physical processes

Project parameters relevant to the impact assessment	Maximum Project parameters for the impact assessment	Explanation of maximum Project parameters
General arrangement: Project decommissioning timescales	Stage 1: Up to 2 years* Stage 2: Up to 2 years* * unless the site is repowered to extend the duration of the existing lease	Maximum timescales during which decommissioning activities could affect the seabed features and physical processes. As per the Energy Act 2004 and the requirement of The Crown Estate AfL.
General arrangement: Turbine numbers	Stage 1: 30 turbines Stage 2: 170 turbines Stage 1 and Stage 2: 200 turbines	An indicative layout has been defined in the Project Description based upon these maximum Project parameters and this has been used as the basis for the impact assessment. It represents a pragmatic and suitably robust configuration which would lead to the maximum potential effect on the seabed features and physical processes.
General arrangement: Turbine spacing	Minimum cross-flow spacing: 80m Minimum down-flow spacing: 150m	
General arrangement: Turbine layout	Turbines will be arranged in rows perpendicular to the direction of the prevailing tidal flow, with 2 – 15 turbines per row and between 10 and 40 rows in total.	
Specific element: Turbine	Turbine type: Seabed mounted (shrouded or unshrouded) Rated power output: At least 1MW Rotor diameter: 13 – 23m No. rotors per device: Single rotor No. blades per rotor: 3 (unshrouded) to 10 (shrouded) Total swept area: 115 – 415m^2 RPM range: 3 – 21 rpm Min clearance between blade tip and sea surface: 30 m Min clearance between blade tip and seabed: 4m Installation: As a single unit (with TSS) by dedicated deployment barge or heavy lift vessel, or in staged operations by workboats and specialised construction vessels.	Maximum rotor diameter has greatest potential effect on the tidal regime.
Specific element: Gravity base structure (GBS) turbine support structure (TSS)	Seabed contact: flat bottom Dimensions: 30 x 40m Seabed footprint: 1,200m^2 Installation: Heavy lift installation vessel or heavy lift deployment barge Seabed preparation: None Scour protection: None	Maximum dimensions of GBS have greatest potential effect on seabed features and physical processes.
Specific element: Subsea base structure (SSB) turbine support structure (TSS)	Seabed contact: three points Seabed footprint: 37.5m^2 Installation: Heavy lift installation vessel or heavy lift deployment barge Seabed preparation: None	Maximum dimensions of SSB have greatest potential effect on seabed features and physical processes.

Project parameters relevant to the impact assessment	Maximum Project parameters for the impact assessment	Explanation of maximum Project parameters
	Scour protection: None	
Specific element: Drilled pin pile tripod turbine support structure (TSS)	No piles per turbine: 3 Pile diameter: 1.3m Pile depth (below seabed): 5m Seabed footprint: 1.3m^2 (per pile), 4m^2 (per three piles) Installation: Specialist drilling equipment Drill cuttings: 6.6m^3 per pin pile (20m^3 per tripod) Scour protection: None	Maximum quantities of drill cuttings have greatest potential effect on seabed features and physical processes.
Specific element: Drilled monopile turbine support structure (TSS)	No piles per turbine: 1 Pile diameter: 2.5 – 2.8m Pile depth (below seabed): 11 – 12m Pile height (above seabed):14 – 23.5m Seabed footprint: 5 – 7m^2 (pile only) or 20m^2 (incl. transition piece, where needed) Installation: Specialist drilling equipment Drill cuttings: 74m^3 per monopile Scour protection: None	Maximum quantities of drill cuttings have greatest potential effect on seabed features and physical processes.
Specific element: Inter-array cables	Stage 1: 32 cables Stage 1 and Stage 2: 208 cables Cross-sectional area: 500mm^2 Stage 1 footprint: 0.07km^2 (0.6% of total AfL area) Stage 1 and Stage 2 footprint: 0.36km^2 (3% of total AfL area) Installation: Surface laid and anchored Cable armour: double armour or armoured shells	Maximum lengths of cable have greatest potential effect on seabed features and physical processes.
Specific element: Cable connecting hubs	Stage 1: 4 subsea hubs Stage 1 and Stage 2: 8 subsea hubs Hub length: 15m Hub diameter: 7m Seabed footprint: 37.5m^2 per hub	Maximum number and dimensions of subsea hubs have greatest potential effect on seabed features and physical processes.
Specific element: Export cables	Stage 1: 4 cables Stage 1 and Stage 2: 16 cables Diameter: 500mm Cross-sectional area: 0.2m^2 Width of seabed affected: 5m per cable Installation: Surface laid and protected Cable protection: rock placement, concrete mattresses or grout bags along 100% of length	Maximum lengths of cable and maximum lengths of cable protection have greatest potential effect on seabed features and physical processes. Worst case export cable parameters are associated with subsea cable connecting hubs

Project parameters relevant to the impact assessment	Maximum Project parameters for the impact assessment	Explanation of maximum Project parameters
Specific element: Export cable corridors	Option 1: Sheep Skerry (2.5km length, 0.2km^2 or 1.9% of total AfL area) Option 2: Moodies Eddy (2.6km length, 0.2km^2 or 1.9% of total AfL area) Option 3: Aith Hope (6.5km length, 0.52km^2 or 4.7% of total AfL area)	Maximum lengths of cable and maximum lengths of cable protection have greatest potential effect on seabed features and physical processes.
Specific element: Cable landfall	Installation: Open cut trench or short HDD or long HDD	Open trenching has greatest potential effect on seabed features and physical processes.
Specific element: Navigational lighted buoys	None required	Consultation with the Northern Lighthouse Board (NLB) following completion of the Navigational Risk Assessment (NRA).
Specific element: Maintenance	1 vessel per day on average (increasing to 2 – 3 vessels for specific works)	Maximum number of vessels in close proximity per day have greatest potential effect on seabed features and physical processes.

9.4 LEGISLATIVE FRAMEWORK AND POLICY CONTEXT

The methods followed for assessing the potential impacts arising from the Project on the physical processes were generally consistent with existing National Policy Statements (NPS) of relevance to Nationally Significant Infrastructure Projects (NSIPs) within the energy or renewable energy sectors, namely:

- Overarching NPS for Energy (EN-1) (DECC, 2011); and
- NPS for Renewable Energy Infrastructure (EN-3) (DECC, 2011).

However, the Project is not a NSIP and, due to its physical setting and specific Project characteristics, it was not necessary to conduct all of the specified tasks in EN-1 and EN-3 in the manner which they propose. Therefore, the key aspects of EN-1 and EN-3 which have provided the framework for the assessments are summarised below.

EN-1 (Paragraph 5.5.7) sets out that the ES should include an assessment of the effects on the coast. In particular, applicants should assess the impact of the Project on physical processes and geomorphology.

With regard to the sub-tidal environment, EN-3 (Paragraph 2.6.113) states that where necessary, assessment of the effects on the sub-tidal environment should include:

- Loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes;
- Environmental appraisal of inter-array and export cable routes and installation methods;
- Habitat disturbance from construction vessels' extendible legs and anchors;
- Increased suspended sediment loads during construction; and
- Predicted rates at which the sub-tidal zone might recover from temporary effects.

With regards the intertidal environment, EN-3 (Paragraph 2.6.81) states that an assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about:

- Any alternative landfall sites that have been considered by the applicant during the design phase and an explanation of the final choice;
- Any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation of the final choice;
- Potential loss of habitat;
- Disturbance during cable installation and removal (decommissioning);
- Increased suspended sediment loads in the intertidal zone during installation; and
- Predicted rates at which the intertidal zone might recover from temporary effects.

These aspects of existing NPS have informed the assessments made here.

9.5 SUPPORTING SURVEYS AND STUDIES

9.5.1 Data Sets and Information Sources

A vast quantity of publicly available information sources and data sets on offshore bathymetry, geology, seabed sediments and geotechnical properties within The Crown Estate's Pentland Firth and Orkney Waters (PFOW) strategic development area have previously been collated and analysed within a desk study analysis of ground conditions (Halcrow, 2009). This existing information, supplemented with additional ROV seabed video footage, was used to develop geotechnical ground models and assess the quantity and quality of existing data sets with a view to helping to specify the needs for more detailed Project-specific geophysical surveys. In that previous study, relevant existing data sets were identified, purchased and integrated into a GIS, and then reviewed and interpreted to provide a high-level overview of geomorphological and geotechnical properties.

The main data sets and information sources collated and included within the GIS are summarised in Table 9.2.

Further information was derived from a series of BGS commercial and research reports and a selection of peer-reviewed papers published in scientific journals. Earlier data, from between 1973 and 1993, was also mapped into the GIS from other reputable sources (e.g. NERC, BGS, UKHO).

Table 9.2: Principal data sources collated and used within a geotechnical desk study analysis of ground conditions (Halcrow, 2009)

Data Type	Source	Type	Date*	Comments
Bathymetry	SeaZone	Vector and raster	2005	Based on UKHO data
	FRS	Raster	2007-08	Surveyed using multi-beam echo sounder
	Aquatera	Raster	Undated	Including slope and roughness of the seabed
	BGS	Paper copy (analogue)	Undated	Echo sounder lines
Bedrock geology	BGS	DigRock250	2007	1:250k scale
	BGS	Paper copy (analogue)	Undated	Sparker and pinger lines
Seabed sediments	BGS	DigSBS250	2003-09	1:250k scale
	BGS	Survey logs	Various	Boreholes, vibrocores, sediment cores and grab samples
	FRS	ROV seabed video footage	Undated	DVDs
Tidal currents	SeaZone	Tidal diamonds on Admiralty Chart 5058	2008	Based on UKHO data

* Digital publication date (actual survey date may differ)

Outputs from the earlier desk study specifically relating to the Pentland Firth in general and the Project in particular have proven an effective starting basis for the Project of an understanding of the baseline physical process environment.

9.5.2 Literature Sources

In addition, there is also considerable published and 'grey' literature relating to the physical process environment of the seabed and adjacent shoreline areas which has been collated and reviewed to further enhance the understanding. These information sources are listed in Table 9.3.

Various charts and maps were also used, including Ordnance Survey Explorer Map 462, UK Hydrographic Office Admiralty Chart 2162 (Pentland Firth and Approaches) and Admiralty Chart 1954 (Cape Wrath to Pentland Firth including Orkney Islands) and British Geological Survey's DigBath2050 (bathymetry), DigRock250 (seabed geology) and DigSBS250 (seabed sediments).

Table 9.3: Principal data sources collated and used in developing an understanding of the baseline physical process environment

Author/Publisher	Date	Title
Scottish Executive	2007	Scottish Marine Renewables SEA - Geology, Seabed Sediments and Sediment Transport
Scottish Executive	2007	Scottish Marine Renewables SEA - Marine and Coastal Processes
The Scottish Government, Marine Scotland, AECOM and METOC	2011	Pentland Firth and Orkney Waters Marine Spatial Plan Framework
The Scottish Government, Marine Scotland, AECOM and METOC	2011	Pentland Firth and Orkney Waters Regional Location Guidance for Marine Energy
Steers	1973	The Coastline of Scotland
Ramsay and Brampton	2000	Coastal Cells in Scotland: Cell 10 Orkney
Mather, Smith and Ritchie	1973	Beaches of Orkney
McKirdy	2011	Landscape Fashioned by Geology: Orkney and Shetland
Dargie	1998	Sand Dune Vegetation Survey of Scotland: Orkney (3 Volumes)
Scottish Power Renewables	2012	Proposed Ness of Duncansby Tidal Array – Request for a Scoping Opinion
MeyGen Limited.	2011	MeyGen Phase 1 EIA Scoping Document
MeyGen Limited.	2012	MeyGen Tidal Energy Project Phase 1 Environmental Statement – Physical Environment and Sediment Dynamics
HR Wallingford	2004	2D Modelling of the Effects of Opening the Churchill Barriers to Tidal Flow
Dounreay Particles Advisory Group	2006	Third Report of the Dounreay Particles Advisory Group
Leslie	2012	Shallow Geology of the Seabed in the Vicinity of Orkney and the Sutherland Coast
Hutchinson, Millar and Trewin	2001	Coast erosion at a nuclear waste shaft, Dounreay, Scotland

Thorough desk-based reviews of these literature sources has revealed a large quantity and high quality of existing data and information that has been used to develop the understanding of the baseline seabed and shoreline geology and sediments, tidal regime, wave regime, sediment regime and morphological features.

9.5.3 Project Surveys

Following the aforementioned review of previous data sets and literature sources some gaps in the understanding of the baseline environment were highlighted. These gaps were subsequently filled through a series of metocean, geophysical and benthic surveys that now provide improved coverage and a more comprehensive understanding of the area of investigation. The Project-specific surveys that are of direct relevance to the physical process environment are summarised in Table 9.4. More detailed information arising from these surveys is also provided in (Supporting Document: BTAL, 2015b).

Table 9.4: Project-specific surveys

Dataset	Methodology	Source
Bathymetry, shallow geology and seabed features	Single beam sonar transect survey.	Undertaken by Partrac in 2011 (no report available)
	Multi-beam echo sounder, side scan sonar, sub-bottom profiling and magnetometer survey within the AfL and within the Moodies Eddy and Aith Hope cable corridors (2012 – 2013).	Supporting Document: Osiris, 2014
	Multi-beam echo sounder survey within the Sheep Skerry cable corridor	(Supporting Document: Aquatera, 2015c)
Seabed sediments	ROV video footage collected to inform the preliminary seabed habitat assessment.	Undertaken by Aquatera in 2009 (no report available),
	Drop-down video camera survey.	Undertaken by Partrac in 2011 (no report available)
	ROV video footage.	Undertaken by Partrac in 2012 (no report available)
	ROV video footage within previously unsurveyed areas of seabed, namely the western area of the AfL and within the Moodies Eddy and Aith Hope cable corridors.	Aquatera, 2014
Metocean conditions (currents, waves, winds)	Bottom-mounted ADCP surveys at two locations (both east of the present AfL).	Partrac, 2011
	Vessel-mounted ADCP surveys (covering 6 locations) to inform on suitable locations for deployment of bed-frames.	Undertaken by Partrac in 2011 (no report available)
	Bottom-mounted ADCP surveys at two locations offshore from Brims Ness.	Partrac, 2011
	Bottom-mounted ADCP surveys at six locations offshore from between Brims Ness and Tor Ness.	Partrac, 2013

9.6 DATA GAPS AND UNCERTAINTIES

Given the extensive previous work undertaken specifically within The Crown Estate's Pentland Firth and Orkney Waters Strategic Area (PFOWSA) and the Project-specific geophysical, metocean and benthic surveys that have been undertaken, there are no significant identifiable data gaps. The Sheep Skerry export cable corridor and landfall option was only added to the design envelope after completion of the initial geophysical and benthic surveys, but information on the seabed bathymetry and surface sediments within this corridor has since been collected through additional surveys in 2015.

9.7 CONSULTATIONS

Feedback from consultations are summarised in Chapter 6 Consultation Process. An *Environmental Scoping Report* was produced for the Project in August 2013 (Supporting Document: BTAL, 2013). This contained a dedicated chapter (Chapter 7) on 'Possible impacts on the Physical Environment', with one section of this (Section 7.1) specifically focusing on 'Physical Processes'. The Scottish Government and Marine Scotland provided a *Scoping Opinion* by way of response in 2013. This provided advice on the content required in the ES and presented a collation of responses received from statutory and non-statutory consultees, including Orkney Islands Council, Scottish Environmental Protection Agency (SEPA) and Scottish Natural Heritage (SNH). Those comments were taken on board in the development of a *Physical Processes Method Statement* (BTAL, 2014) which was circulated to consultees by Marine Scotland. Responses were received from SNH and Marine Scotland Science (Marine Scotland, 2015). All responses of relevance to physical processes arising from consultation on the *Environmental Scoping Report* and the *Physical Processes Method Statement* are summarised in Table 9.5, with cross-references to where they have been incorporated into the assessment process.

Table 9.5: Key issues raised by stakeholder during consultation

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Env. Scoping: Physical processes	Marine Scotland Science	8.1.2 Potential Impacts: One potential impact not explicitly listed in Table 8.2 is the possible change in coastal process and beach morphology due to changes in tidal, and wave, dynamics (Marine Scotland, 2014).	This is an important issue that has been interpreted, using Expert Geomorphological Assessment (EGA), from outputs of assessments to changes in tidal, wave and sediment dynamics.	Section 9.10
Env. Scoping: Physical processes	Marine Scotland Science	8.1.2 Potential Impacts: Waves are also not mentioned in Table 8.2. It is acknowledged that this is a tidal site, but it is still possible that the presence of structures may change wave propagation through the site and wave current interactions. This is likely to be small, but should at least be considered in the ES (Marine Scotland, 2014).	Given the envisaged small scale and localised changes to the wave regime caused by the turbines and their associated TSS, EGA has been used to make the assessments of changes in wave propagation through the site. This qualitative assessment has been combined with the quantitative outputs from modelling the changes in tidal flow to assess, again using EGA, the potential for changes in wave-current interaction.	Section 9.10
Env. Scoping: Physical processes	Marine Scotland Science	8.1.3 Baseline Characterisation Strategy: The use of a hydrodynamic tidal model is strongly encouraged to understand the physical processes. It is suggested that some consideration be given to also using a wave model to better understand the wave-current interactions within the site. This could be done conceptually, but a model may provide more robust results and an enhanced understanding. There should at least be research into the wave climate at the site (Marine Scotland, 2014).	Monitoring of the wave climate at the site during the metocean campaign has indeed revealed some degree of wave-current interaction. The qualitative assessment of changes in wave climate due to reflections off the turbines has been combined with modelled outputs of changes in the tidal regime in a further qualitative assessment of the potential for changes in wave-current interaction.	Section 9.9
Env. Scoping: Physical processes	Marine Scotland Science	8.1.3 Baseline Characterisation Strategy: The location of sediment patches within the study site and close proximity should be identified with a survey. Beaches and other potentially vulnerable receptors should be identified (Marine Scotland, 2014).	The geophysical survey covers a suitable area of seabed and the beaches at the landfalls. Other potentially vulnerable (sedimentary) receptors have been identified from the survey, desk-study and existing maps and charts.	Section 9.9
Env. Scoping:	Marine Scotland Science	8.1.4 Impact Assessment Strategy: Table 8.4 mainly suggests using expert geological assessments (EGA) of the suspended sediment and bed morphology assessments. This may be	The greatest changes to the processes which drive sediment transport are envisaged to be the changes to the tidal regime (given that changes to the wave regime – and hence	Section 9.10

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Physical processes		acceptable, depending on the results of the baseline characterisation. If there are important beaches/receptors that may be changed due to changes in sediment transport forcing then some degree of modelling is recommended. There are a number of ways of doing this from a simplistic shear stress analysis (using model output) to using complex (coupled) sediment transport modules within the modelling software. A robust shear stress analysis of using sediment transport modules in an offline/decoupled mode are thought to be a good pragmatic way forward (Marine Scotland, 2014).	wave-driven sediment transport – are expected to be small in magnitude and localised in spatial extent). Changes in the tidal regime have been modelled and any associated changes in sediment mobilisation, transport and deposition have been inferred from these results using EGA and understanding of the thresholds of motion of appropriate sediment grain sizes (noting that in the limited areas where sediment cover exists, it is relatively coarse-grained sediment or boulders).	
Env. Scoping: Physical processes	Marine Scotland Science	Models should be run to characterise the baseline conditions and then rerun with tidal energy extraction implemented within the model. A comparison should then be made between any assessments made with the model output, i.e. changes to tidal currents, wave heights and sediment concentrations should be assessed (Marine Scotland, 2014).	This modelling has been undertaken for changes in the tidal regime, but changes in the wave regime and sediment transport have been interpreted using EGA. Wave modelling was considered when developing the Method Statement for this assessment, but was not taken forward on the basis that the changes in wave climate will be small in magnitude and localised in extent and would, therefore, not cause significant impacts. When considering the TSS within the Project Description the larger structures (e.g. GBS or SBS) are located near the seabed, where they would have minimum interaction with the waves, whilst those structures which occupy a greater height in the water column (e.g. tripods or monopiles) are slender in relation to the length of the wave trains and will not cause wave diffraction. However, it is acknowledged that wave-current interactions occur at the site and these could potentially be affected by changes associated with the Project, although these effects will be mostly due to changes in the tidal regime. This has been assessed using EGA and informed by the modelled changes in tidal regime.	Section 9.10

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Env. Scoping: Physical processes	Orkney Islands Council	Intertidal and Coastal This form of development will require assessment in view of its unique characteristics, the impacts on wave velocity as a consequence of the operation of the installed equipment should be identified along with any expected changes to coastal processes (e.g. coastal erosion, sediment flows and coastal deposits). This will also be required to include any expected changes to coastal process through cumulative impacts with other arrays in the area. The impacts of development(s) on the intertidal area and its habitats should be undertaken and the impacts on these areas should be included within the EIA. The Ayre which links South Walls to South Hoy is identified as being at significant risk of coastal erosion, an assessment should be undertaken to determine the likely effects of all aspects of the Project on this area of coast. The potential impacts on the array including the deployment, maintenance, servicing and decommissioning on recreational users of the coastal area should be assessed (Marine Scotland, 2014).	All of these aspects have been considered in the assessment, using a suite of tools and analytical approaches, including numerical modelling of changes in the tidal regime and EGA for other aspects.	Section 9.10
Env. Scoping: Physical processes	Orkney Islands Council	Geology A draft geological Local Nature Conservation Site, known as Melsetter Coast, is located on the South Hoy coast, to the west of the Area of Search for the cable landfall site. The site extends between Sheep Skerry and Sands Geo and consists of a restricted outcrop of the Hoy Lavas. The lava forms a distinctive coastal platform in front of a small dune system at Melberry. Further information on this site is available from Annex 1 Local Nature Conservation Sites which can be accessed from the Council's website at http://www.orkney.gov.uk/Service-Directory/R/naturalheritage.htm	This useful information has been incorporated into the above-mentioned assessments.	Section 9.10

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
		(Marine Scotland, 2014)		
Env. Scoping: Physical processes	Scottish Environmental Protection Agency	Alteration to coastal processes and wave regime (Marine Scotland, 2014).	These aspects have been considered in the assessment, using a suite of tools and analytical approaches, including numerical modelling of changes in the tidal regime and EGA for other aspects.	Section 9.10
Env. Scoping: Physical processes	Scottish Natural Heritage	Hydrodynamic effects of the tidal array are briefly considered in the scoping report but need to be assessed in greater detail for potential impacts on the near-field and far-field habitats and species. The ES should investigate and present information on all relevant changes to hydrodynamics (not just slowing of tidal flow, but lateral accelerations too, and any potential impacts on wave climate etc.). Crucially, however, any hydrodynamic changes should be considered in terms of direct and indirect impacts to species and habitats, and their conservation importance (Marine Scotland, 2014).	Outputs from the 'physical process' assessments have been interpreted by an oceanographer/geomorphologist (for changes in processes and morphology) and (in a separate chapter) a marine ecologist (for direct and indirect effects on habitats and species). It is a valid point that there will be lateral acceleration of flows around the devices and array as a whole and not just deceleration. The overall 'wake' effect (including any localised acceleration of flows) has been assessed using 2D numerical modelling. Potential changes to waves and sediment transport has been assessed using EGA and interpretation of outputs from modelling of tidal flow changes.	Section 9.10
Env. Scoping: Physical processes	Scottish Natural Heritage	At the potential landfall sites, greater consideration of the mobility, vulnerability and conversely natural protection that can be provided by a sensitive and informed choice of landfall site is required. Such an informed approach should extend throughout the design of the entire Project. Specific thought should be given to how to make all infrastructure 'future proof' with respect to climate change and this coastal location (Marine Scotland, 2014).	Likely future shoreline and seabed changes have been taken into consideration in the engineering design (including climate change effects).	Chapter 5 (Project Description)
Env. Scoping:	Scottish Natural Heritage	The scoping report has not outlined the position of the array within the Project site and the anticipated scale of hydrodynamic effects that may result from the array. We	Noted and agreed	Section 9.2 and 9.10

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Physical processes		recommend, therefore, that the boundaries of the numerical modelling exercise, the bathymetric and habitat surveys should be sufficiently broad to enclose the areas of change (Marine Scotland, 2014).		
Env. Scoping: Physical processes	Scottish Natural Heritage	The routing and positioning of all infrastructure should make best use of the geodiversity of the site. This could make best use of natural protection offered by the landforms, but could also avoid areas of increased vulnerability. We welcome the acknowledgement that correct placing of the export cable can avoid future damage and costly maintenance, and recommend this informed approach is extended to all components of the Project. If infrastructure passes through dynamic landforms (as is implied in the scoping report), like The Ayre, then specific investigations should be undertaken to appreciate the inherent dynamism of these features. Ayres in Orkney can be highly variable, whilst others can be largely stable. The use of historical map data will readily inform BTAL of the changes over the last 100 years (Marine Scotland, 2014).	Noted and agreed, these comments are relevant to both engineering design and EIA	Chapter 5 (Project Description) and Section 9.9.7
Env. Scoping: Physical processes	Scottish Natural Heritage	Table 7.4 of the scoping report considers '*Marine seabed habitat loss/change, due to turbine foundations and cable armouring'* but not marine seabed habitat loss/change due to hydrodynamic changes caused by the arrays. These are likely to be far greater in size and importance, and may have indirect impacts on other species which utilise these habitats. A robust assessment, informed by detailed numerical modelling, is necessary to establish potential changes on the potentially mobile habitats within and surrounding the array (Marine Scotland, 2014).	These have been investigated by means of numerical modelling of changes in tidal flow and the interpretation of the results by both an oceanographer/geomorphologist (for changes in processes and morphology) and (in a separate chapter) a marine ecologist (for direct and indirect effects on habitats and species).	Section 9.10
Env. Scoping:	Scottish Natural Heritage	Table 7.27 only anticipates the decrease in flow being of interest/concern. This is not the only concern. Tidal flows can	It is a valid point that there will lateral acceleration of flows around the devices and array as a whole and not just	Section 9.10

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Physical processes		be accelerated in the areas adjacent to the arrays. All hydrodynamic change should be investigated and their significance on the receptors and their conservation importance (Marine Scotland, 2014).	deceleration of flows. The overall 'wake' effect (including any localised acceleration of flows) has been assessed using 2D numerical modelling.	
Method Statement: Physical processes	Scottish Natural Heritage	In general the method statement is appropriate and provides a useful account of the impact assessment that will be undertaken (Marine Scotland, 2015).	The approaches described in the method statement have now been applied within this ES chapter to make a robust assessment of potential impacts on the physical process environment.	Chapter 9 Physical Processes
Method Statement: Physical processes	Scottish Natural Heritage	We welcome the use of the two dimensional hydrodynamic modelling to understand any potential impacts during the operational phase of the Project. The results of this modelling should be used to inform potential impacts on benthic habitats and any indirect impacts on marine wildlife (Marine Scotland, 2015).	Outputs from the two dimensional hydrodynamic modelling to understand any potential impacts during the operational phase of the Project have been used to inform potential impacts on benthic habitats and any indirect impacts on marine wildlife.	Chapter 9 Physical Processes
Method Statement: Physical processes	Scottish Natural Heritage	The 'zone of potential effects' (Figure 5 of the method statement) seems appropriate in area both as the minimum 'domain' for the modelling and for the impact assessment generally. It includes all of the coastline that could conceivably see significant effects (Marine Scotland, 2015).	The 'zone of potential effects' presented in the method statement has since been proven to be appropriate by the impact assessment undertaken in this ES chapter.	Figure 9.4 and Figure 9.5
Method Statement: Physical processes	Scottish Natural Heritage	In contrast, the area/extent of surveys may not be sufficient to inform the physical processes assessment, whether in terms of any effects on benthic habitats as a result of changes to the physical processes, or on near-shore/coastal sediment movement. Surveys mapped in Figures 3 and 4 are very limited in terms of coverage of the zone of potential effects. Table 2 includes a reference to "design of bathymetric and geophysical surveys to fill gaps and provide Project-level resolution" but this is not clarified in Section 2.5 Gaps Analysis. Without details on the nature of planned additional	Additional surveys have been extensive and together with considerable pre-existing information from earlier studies and investigations provide sufficient information to adequately characterise the baseline environment.	Section 9.5

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
		surveys and their resolution, we cannot be confident the assessment will be sufficient (Marine Scotland, 2015).		
Method Statement: Physical processes	Scottish Natural Heritage	The phrases "expert assessment" and "conceptual understanding" are short on detail with regard to effects of the landfall in particular (both construction and operational phases). Considering landfall will likely be at a 'soft' coastline, we reiterate two linked points from our scoping response: a. Need to consider natural dynamism, and thus vulnerability, of the affected coastal stretch over timescales ranging from individual events, to seasonal, to decades (e.g. any long-term changes apparent in historical mapping); b. Need to factor-in likely effects of predicted sea-level rise, including erosion, in order to 'futureproof' all elements of the landfall installation (Marine Scotland, 2015).	The baseline characteristics and natural variability of the shorelines at the three potential landfall sites has been considered in terms of both shoreline sediments and morphology and shoreline sediment transport. The proposals described in the Project Description for installation of cable at the landfall have taken into consideration shoreline dynamics and how this may be affected in the longer term by effects such as erosion and sea level rise.	Sections 9.9 and 9.10 Chapter 5 (Project Description)
Method Statement: Physical processes	Scottish Natural Heritage	In addition, we advise the expert assessment is informed by site visit(s) to develop 'micrositing' of landfall infrastructure, which should make maximum use of protection afforded by the detailed geomorphology, as well as minimising impacts on habitats and species (Marine Scotland, 2015).	During detailed design, site visits will be undertaken to develop 'micrositing' of landfall infrastructure to minimise potential adverse effects on habitats and species.	Section 9.11
Method Statement: Physical processes	Marine Scotland Science	The methods statement provides a good initial baseline description and highlights the assessments which will be required for the EIA. The level of suggested detail for the three phases, construction, operation, and decommissioning, are appropriate, with the most quantitative effort going into the assessments for the operational phase. The suggested use of a 2d hydrodynamic model is appropriate. The resolution of the model within the tidal array should be carefully considered, enabling near field effects of the turbines to be assessed (Marine Scotland, 2015).	Details of the 2d hydrodynamic modelling are provided in the assessment and a stand-alone Supporting Document (RHDHV, 2015b) the ES chapter.	Section 9.9, 9.12 and Supporting Document: RHDHV, 2015a

Topic	Stakeholder	Comment	Response/Action taken	Section cross-reference
Method Statement: Physical processes	Marine Scotland Science	The decision not to explicitly perform sediment transport modelling is a good one, given the scarcity of soft sediments in the region. It might be useful to perform some quantitative assessment using the modelled results however, in addition to the proposed expert assessment. Consideration could be given to the changes in shear stress across the model domain, and particularly in areas where there are known to be sediments (Marine Scotland, 2015).	The model results (in terms of changes to baseline current velocities) have been considered in terms of both the spatial extent of change and the magnitude of the change at various points through the tidal cycle. These are deemed to be small in the context of causing significant changes to bed shear stresses and associated erosion, transportation and deposition of bed sediments.	Section 9.10
Method Statement: Physical processes	Marine Scotland Science	A validation of the baseline 2d model should also be performed and presented as part of the EIA. An interpretation of the baseline results should also be presented, including comments on whether the modelled results agree with the current qualitative understanding of sediment transport and deposition in the region (Marine Scotland, 2015).	Details of the 2d hydrodynamic modelling, including validation against previous modelling and measured metocean data are provided in a stand-alone Supporting Document (RHDHV, 2015b) the ES chapter. Baseline runs from the 2d hydrodynamic modelling have been used to inform the baseline description in Section 9.9.	Section 9.9, 9.12 and Supporting Document: RHDHV, 2015a

9.8 ASSESSMENT METHODOLOGY

9.8.1 Assessment Criteria

Guidance on the generic requirements, including spatial and temporal scales, for physical process studies associated with renewable energy developments is provided in several main documents. Although many of these documents relate specifically to offshore wind farm developments, they contain much useful information that is equally applicable for consideration during assessments of the effects of tidal energy developments on the physical environment. These documents are:

- Offshore windfarms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2' (Cefas, 2004);
- Coastal Process Modelling for Offshore Windfarm Environmental Impact Assessment' (COWRIE 2009);
- Review of Cabling Techniques and Environmental Effects applicable to the Offshore Windfarm Industry' (BERR 2008);
- General advice on assessing potential impacts of and mitigation for human activities on Marine Conservation Zone (MCZ) features, using existing regulation and legislation' (JNCC and Natural England 2011); and
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects' (Cefas 2011).

With the content of the above firmly in mind, a comprehensive and robust approach to the impact assessment has been adopted by following the general methodology summarised below:

- Review of existing relevant data and information sources;
- Acquisition of additional Project-specific data to fill any gaps;
- Formulation of a conceptual understanding of baseline conditions;
- Determination of the worst case assumptions;
- Consideration of mitigation measures; and
- Assessment of effects using analysis, empirical evidence, numerical hydrodynamic modelling and expert based judgements.

The assessment of effects on the physical processes is predicated on a source-pathway-receptor (S-P-R) conceptual model, whereby:

- The source is the initiator event;
- The pathway is the link between the source and the receptor impacted by the effect; and
- The receptor is the receiving entity.

The method for enabling assessments of the potential impacts arising from the Project on the receptors under consideration incorporates a combination of the sensitivity of the receptor, its value (if applicable) and the magnitude of the change in order to determine a significance of impact.

For the effects on physical processes and the associated geomorphology, a number of discrete receptors can be identified. These include certain features with ascribed inherent values, such as the:

- Offshore seabed – this plays an important role in influencing the baseline tidal, wave and sediment transport regimes; and
- Shoreline – the intertidal shore and backing cliffs/dunes.

However, in addition to these identifiable geomorphological receptors, there are other changes to the physical processes which may potentially be caused by the Project which in themselves are not necessarily 'impacts' to which significance can be ascribed. Rather, these changes (such as a change in the wave climate, a change in the tidal regime or a change in the suspended sediment concentrations in the water column) represent an 'effect' which may manifest as an impact upon other receptors, most notably water quality, benthic ecology, fisheries or navigation (e.g. in terms of increased suspended sediment concentrations or erosion or smothering of habitats on the seabed).

To this end, the assessment presented in this chapter follows two approaches. The first assessment approach is designed for situations where potential impacts can be defined as directly affecting receptors which possess their own intrinsic geomorphological value. In this case, the determination of significance of the impact is based on an assessment of sensitivity/value of the receptor and magnitude of effect by means of an impact significance matrix.

The second assessment approach is designed for situations where effects (or changes) in the baseline physical processes may occur which could potentially manifest as impacts upon other receptors. In this case, the magnitude of effect is determined in a similar manner to the first assessment method but the assessment of sensitivity of the other receptors and the significance of impacts on those other receptors is made within the relevant chapters of this ES pertaining to those receptors.

9.8.2 Sensitivity

The sensitivity of a receptor is dependent upon its:

- Tolerance to an effect (i.e. the extent to which the receptor is adversely affected by a particular effect);
- Adaptability (i.e. the ability of the receptor to avoid adverse impacts that would otherwise arise from a particular effect); and
- Recoverability (i.e. a measure of a receptor's ability to return to a state at, or close to, that which existed before the effect caused a change).

The sensitivity of discrete morphological receptors have been assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in Table 9.6. These expert judgements regarding receptor sensitivity are closely guided by the conceptual understanding of baseline conditions presented in detail in the Supporting Document (BTAL, 2015b) which is also summarised in Section 9.9 of this chapter.

Table 9.6: Definitions for sensitivity of physical process environment

Sensitivity	Criteria
High	Tolerance: Receptor has very limited tolerance of effect. Adaptability: Receptor unable to adapt to effect. Recoverability: Receptor unable to recover resulting in permanent or long-term (>10 years) change.
Medium	Tolerance: Receptor has limited tolerance of effect Adaptability: Receptor has limited ability to adapt to effect. Recoverability: Receptor able to recover to an acceptable status over the medium-term (5-10 years).
Low	Tolerance: Receptor has some tolerance of effect. Adaptability: Receptor has some ability to adapt to effect. Recoverability: Receptor able to recover to an acceptable status over the short-term (1-5 years).
Negligible	Tolerance: Receptor generally tolerant of effect. Adaptability: Receptor can completely adapt to effect with no detectable changes. Recoverability: Receptor able to recover to an acceptable status near instantaneously (<1 year).

As discussed above, in the context of the physical process environment, the geomorphological receptors that have been identified are the offshore seabed and the shoreline. As will be seen from the existing environment (see later section and Supporting Document: BTAL, 2015b) the offshore seabed is predominantly tide-swept bedrock that is bare of surficial sediment and therefore it is generally tolerant (i.e. negligible sensitivity) to changes in the physical process environment that may arise as a consequence of the Project. The shoreline is either likely to be remote from any changes in the physical process environment or, for elements which do affect the shoreline (e.g. cable landfall); the shoreline sediments are likely to be completely adaptable to, and fully recoverable from, the effects that are caused (i.e. negligible sensitivity). However, for each identified potential impact, a specific assessment of sensitivity of both the offshore seabed and the shoreline is provided in later sections of this chapter.

9.8.3 Magnitude

The magnitude of an effect is dependent upon it's:

- Scale (i.e. size, extent or intensity);
- Duration;
- Frequency of occurrence; and
- Reversibility (i.e. the capability of the environment to return to a condition equivalent to the baseline after the effect ceases).

The magnitude of effect has been assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in Table 9.7.

These expert judgements regarding receptor sensitivity are closely guided by the conceptual understanding of baseline conditions presented in detail in Supporting Document (RHDHV, 2015b), which is also summarised later in this chapter.

Table 9.7: Definitions for magnitude of effect for physical process environment

Magnitude	Criteria
High	Scale: A change which would extend beyond the natural variations in background conditions. Duration: Change persists for more than 10 years. Frequency: The effect will always occur. Reversibility: The effect is irreversible.
Medium	Scale: A change which would be noticeable from monitoring but remains within the range of natural variations in background conditions. Duration: Change persists for 5-10 years. Frequency: The effect will occur regularly but not all the time. Reversibility: The effect is very slowly reversible (5-10 years).
Low	Scale: A change which would barely be noticeable from monitoring and is small compared to natural variations in background conditions. Duration: Change persists for 1- 5 years. Frequency: The effect will occur occasionally but not all the time. Reversibility: The effect is slowly reversible (1- 5 years).
Negligible	Scale: A change which would not be noticeable from monitoring and is extremely small compared to natural variations in background conditions. Duration: Change persists for <1 year. Frequency: The effect will occur highly infrequently. Reversibility: The effect is quickly reversible (<1 year).

9.8.4 Impact Significance

Following the identification of receptor sensitivity and magnitude of the effect, it is possible to determine the significance of the impact. A matrix is presented in Table 9.8 as a framework to show how a judgement of the significance of an impact has been reached.

Table 9.8: Assignment of impact significance for physical process environment based on sensitivity of receptor and magnitude of effect

Sensitivity of Receptor	Magnitude of effect			
	High	Medium	Low	Negligible
High	*MAJOR*	*MAJOR*	*MODERATE*	*MINOR*
Medium	*MAJOR*	*MODERATE*	*MINOR*	*MINOR*
Low	*MODERATE*	*MINOR*	*NEGLIGIBLE*	*NEGLIGIBLE*
Negligible	*MINOR*	*NEGLIGIBLE*	*NEGLIGIBLE*	*NEGLIGIBLE*

Through use of this matrix, an assessment of the significance of an impact can be made in accordance with the definitions in Table 9.9.

Table 9.9: Definitions for significance

<table>
<tr><th>Significance</th><th>Definition</th><th>Significant/Insignificant</th></tr>
<tr><td>Major</td><td>Very large or large change in receptor condition which is likely to be an important consideration at a national or regional level.</td><td rowspan="2">Significant impact under EIA Regulations</td></tr>
<tr><td>Moderate</td><td>Intermediate change in receptor condition, which are likely to be important considerations at a local level.</td></tr>
<tr><td>Minor</td><td>Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.</td><td rowspan="2">Insignificant impact under EIA Regulations</td></tr>
<tr><td>Negligible</td><td>No discernible change (or no change) in receptor condition.</td></tr>
</table>

It should be noted that impacts may be deemed as being either positive (beneficial) or negative (adverse).

For the purposes of the EIA, 'major' and 'moderate' impacts are deemed to be significant. In addition, whilst 'minor' impacts are not significant in their own right, they may contribute to significant impacts cumulatively or through interactions.

Where applicable, embedded mitigation is referred to and included in the initial assessment of significance of an impact. If an identified impact requires further mitigation then the residual impact is evaluated. If no further mitigation is required, or is unlikely to have a positive ameliorating effect or if no further mitigation is practicably achievable, then the assessment of significance of an impact will remain as the initial assessment.

9.9 BASELINE DESCRIPTION

9.9.1 Introduction

The existing physical processes environment has been assessed in detail in supporting document (Supporting Document: BTAL, 2015b), and this represents the baseline against which any potential scheme impacts will be assessed. This baseline covers both the Project site (i.e. the seabed and shoreline directly within the AfL boundary of the Project site and associated export cable corridors) and the Project study site (i.e. the wider surrounding seabed and shoreline areas). This section provides an overview of the key information from this baseline assessment.

Given the extensive work that has previously been undertaken to characterise the existing physical process environment across the Pentland Firth and Orkney Waters strategic development area, the approach taken to the baseline description has been to:

- Collate and review existing relevant data and reports;
- Acquire additional data to fill any gaps, specific to the Project study site;
- Undertake numerical modelling of baseline tidal current flows; and
- Formulate a conceptual understanding of the baseline physical processes environment, specific to the Project study site, using Expert Geomorphological Assessment (EGA).

It is important to recognise from the outset that the baseline physical processes environment is not static, but instead will exhibit considerable variability due to cycles or trends of natural change. These can include the short-term effects of storms and surges, the well-observed patterns in the movement of tides during spring and neap cycles and the longer term effects of sea-level rise associated with global climate change, for example.

9.9.2 Seabed Geology

To the south of the Orkney Islands, bedrock outcrops occur on the seabed, which strongly influences the morphology of the seabed. The sea floor slopes away steeply from the west of Mainland and from the south west of Hoy and is typically comprised of exposed bedrock. In keeping with the above, more general, characterisation, the seabed of the BTAL site largely consists of exposed bedrock, comprising sandstone with subordinate conglomerate, siltstone and mudstone.

9.9.3 Shoreline Geology

The Orkney archipelago is formed largely of Middle and Upper Old Red Sandstone rocks of Devonian age (417-354 Million Years Before Present). Locally, older sedimentary rocks, basement igneous and metamorphic rocks, as well as younger lavas, volcanic plugs and numerous dykes (mostly of Carboniferous age) are present.

One local area of lava forms a distinctive coastal platform between Sheep Skerry and Sands Geo (to the immediate east of Melberry) and this is designated as a draft geological Local Nature Conservation Site, known as Melsetter Coast.

High-cliff coastlines are a feature of the south west tip of the island of Hoy, which provide some of the best examples in Europe of Old Red Sandstone cliffs and associated features. The rich variety of cliff and cliff-related forms along this coast include steep and overhung profiles; sea-stacks; arches; caves; and shore platforms, all reflecting the dominant geological control of horizontally bedded, fractured and faulted Devonian sandstone.

9.9.4 Bathymetry

Existing regional scale bathymetric data has been collated from various sources and interpreted. This information has been supplemented by two Project-specific surveys:

- A single beam bathymetric survey was undertaken in April 2011 (this was associated with the location of the original AfL, which has subsequently been revised through agreement with The Crown Estate).
- A more detailed multi-beam bathymetric survey was then undertaken in phases between August – October 2012 and April – May 2013 (this covers the revised AfL)

9.9.4.1 AfL

The Project-specific surveys show that within the AfL, water depths range from 60m below LAT at the north central inshore limit of the survey site (although this is not in an area where turbines are likely to be installed), to a maximum of 110m below LAT in the central section of the site. The seabed is characterised by exposed, differentially weathered bedrock across the majority of the AfL.

Distinctive faults, bedding, joints and fractures of this bedrock are clearly evident within the bathymetric data. These features locally influence the seabed gradients and depths.

A single north west to south east orientated sand wave is evident in the north west section of the AfL. The crest of this bedform lies approximately 10m above the surrounding seabed, with depths of 58m LAT along its crest. Megaripples associated with this feature are also evident in this area.

9.9.4.2 Export Cable Corridor – Sheep Skerry

Water depths within the Sheep Skerry corridor increase from the intertidal shore to 60m approaching the AfL area. Near the coast the seabed is predominantly irregular and rugged with pronounced geological fault line features and numerous igneous laval outcrops. However, areas of rippled sands are present in the sheltered area between Sheep Skerry and Tor Ness. The seabed in the southern part of the cable corridor is characterised by gently shelving mixed gravelly sediments and there is a large sandwave feature standing 6-8m above the surrounding seabed is present near the AfL boundary, 1km south east of Tor Ness.

9.9.4.3 Export Cable Corridor – Moodies Eddy

Water depths along the Moodies Eddy export corridor extend from the intertidal shore to approximately 36.0m below LAT, close to the end of the proposed cable route. The seabed initially dips steeply towards the south across an area of outcropping bedrock, at an average gradient of 10.0°. Then the bedrock surface becomes less irregular, dipping more gently southwards at an average gradient of less than 2.0°. In one location, the proposed route centre line crosses an area of sand waves and associated troughs, with the sand waves standing up to 12.5m above the surrounding seabed and exhibiting maximum slope gradients of 14.0°. Water depths within the associated seabed troughs deepen to approximately 32.0m below LAT. The proposed route crosses a localised trough feature, where water depths reach a maximum of 36.0m below LAT, before crossing a smaller, 4.0m high sand wave feature near the offshore end of the corridor.

9.9.4.4 Export Cable Corridor – Aith Hope

Water depths along the Aith Hope export cable corridor gradually increase from the intertidal shore to reach 40.0m below LAT further seaward, at an average gradient of approximately 2.1°, before dipping more steeply at a maximum gradient of 8.0°, to eventually reach 58.0m below LAT. A steeply-sided rock outcrop is present to the west of the corridor, where a minimum water depth of 19.6m below LAT was noted. Very steep localised gradients of up to 40° were noted across this rocky section.

9.9.5 Seabed Sediments and Bedforms

9.9.5.1 AfL

The 2012-2013 side scan sonar survey (Supporting Documents: Osiris, 2014) indicates that the seabed across most of the AfL comprises exposed and occasionally fragmented bedrock, with frequent isolated boulders and areas of gravelly sands/sandy gravels close to its northern boundary. Megaripples are evident across these areas of granular sediments, together with a single, distinct sand wave feature. Numerous sonar targets are present, and these are interpreted to comprise mainly boulders.

An area of gravel is present in the south west section of the survey site and this is associated with numerous sonar targets, mainly interpreted as boulders. Also, the deep gullies associated with faults in the bedrock are in-filled with coarsely granular sediments.

The results of the sub-bottom profiling survey show that the AfL consists predominantly of outcropping bedrock, with very little discernible sediment cover. Some areas of sediment cover are present along the northern boundary of the AfL, in particular where both the Moodies Eddy and Aith Hope cable route corridors enter the AfL, together with a localised sediment patch in the south western corner of the AfL.

ROV surveys undertaken by Aquatera over a broader area of survey indicate a number of large boulder fields in the west and centre of the AfL. Otherwise, sediment cover is sparse. Where sediment cover does exist, it is patchy, comprised of thin layers of sands and gravels. A grab sample containing only a very small quantity of coarse shell fragments collected by BGS supports sparse sediment deposition across the site and this is confirmed on nearby ROV footage taken by FRS (Halcrow, 2009).

A number of published sources document a sandwave field/transverse bedforms further to the west of the AfL (e.g. Holmes *et al*., 2003; Flinn, 1973). The Aquatera bathymetry dataset clearly shows large scale bedforms some 10km to the west of the AfL, with minor bedforms resolvable in the datasets between that point and around 3km from the AfL. These features are indicative of westward-directed net bedload sediment transport from a parting zone located beyond the east of the AfL.

A drop-down camera survey was undertaken in April 2011. Results show that, generally, the AfL comprises exposed bedrock, consisting mainly of Permo-Triassic sandstones, siltstones and mudstones, with patchy thin sands and gravels (especially deposited within open rock fractures). Along the tract lines, the solid geology comprises near-horizontally stratified sedimentary rock with only shallow titling.

9.9.5.2 Export Cable Corridor – Sheep Skerry

It is known from a draft geological Local Nature Conservation Site, known as Melsetter Coast, which extends between Sheep Skerry and Sands Geo (to the immediate east of Melberry) that the shoreline consists of a restricted outcrop of the Hoy Lavas. The lava forms a distinctive coastal platform in front of a small dune system at Melberry. It appears from the OS mapping that small deposits of sand exist at both Sheep Skerry and Melberry.

A video survey was undertaken by means of ROV and a diver in July 2015 to characterise the seabed within the Sheep Skerry cable corridor. Results were consistent with the data from the multibeam echo sounder bathymetric survey of the corridor from June 2015 (Supporting Document: Aquatera, 2015c) in that the relatively sheltered near-shore part of the cable corridor was mainly composed of areas of gently-shelving fine rippled sand with occasional rocky outcrops, whilst larger rocky outcrops and raised platforms become more prevalent as distance from the shore, and hence water depth, increased. In water depths of greater than 30m, the seabed was composed of mixed sediments, boulders and rock outcrops with the quantity of sand present generally decreasing with increasing water depth. The proportion of sandy sediment in the deeper water areas appeared to be greater along the more eastern of the two transects within the cable corridor, probably due to the closer proximity of major sand wave bedforms present to the east of the Sheep Skerry cable corridor.

9.9.5.3 Export Cable Corridor – Moodies Eddy

The seabed across the Moodies Eddy cable corridor is shown by the 2012-2013 side scan sonar survey (Supporting Document: Osiris, 2014) to comprise an irregular area of outcropping bedrock at its inshore limits. Then the bedrock surface becomes covered by a veneer of gravels for a short distance, and then by a large expanse of gravelly sands to the offshore end of the proposed corridor.

Based upon the sub-bottom profiling data from 2012-13, interpreted sediment thicknesses along the centre-line gradually increase from the edge of the area of outcropping bedrock, from a general thin veneer to approximately 2.0m, before increasing rapidly to more than 34m at the offshore end of the proposed route.

A further ROV video survey was undertaken along the Moodies Eddy cable corridor in 2014 (Aquatera, 2014). The seabed characteristics observed are fully consistent with the seabed types derived from analysis of the geophysical data collected in 2012-13. Gravelly sands, interspersed with rocky outcrops, were widespread. Increasing amounts of exposed bedrock and boulders were observed in the deeper water areas in the south of the cable corridor. The northern, near-shore, section of the cable corridor was characterised by uneven bedrock with water depths rapidly falling to around 20m within 200m of the coastline.

9.9.5.4 Export Cable Corridor – Aith Hope

A drop-down camera video survey was taken in April 2011 along the Aith Hope export cable corridor. Within the shallower region of the bay of Aith Hope, the imagery showed mainly coarse sand and broken shell. The survey indicated that, aside from an area of exposed bedrock at 24m depth, seabed sediment coverage was generally present and was noted in some areas as deep as 60m.

Further detail is available from the 2012-2013 side scan sonar survey (Supporting Document: Osiris, 2014), which indicates that the seabed across the Aith Hope cable corridor comprises mainly gravels or sandy gravels, with numerous boulders and irregular patches of finer grained sandy sediments near its inshore limits. Outcropping bedrock is present along the south western and north eastern edges of this near-shore section of the corridor. The rock outcrops become more extensive to the south east, crossing the proposed route centre-line. To the south east, the bedrock surface becomes covered by an irregular expanse of sandy gravels, with frequent boulders and patchy megaripples, with the proposed centre line turning sharply towards the south, then south west.

Based upon the sub-bottom profiling data from 2012-13, interpreted sediment thicknesses along the near-shore section of the proposed cable route vary between 1.0m and 5.0m. Along the central section of the proposed route, sediment thicknesses are generally less than 1.0m, with intermittent areas of outcropping bedrock. Along the offshore section, sediment thicknesses increase to between 2.0m and 4.0m.

A further ROV video survey undertaken was undertaken along the Aith Hope cable corridor in 2014 (Aquatera, 2014). The seabed characteristics observed are fully consistent with the seabed types derived from analysis of the geophysical data collected in 2012-13. Gravelly sands, interspersed with rocky outcrops, were widespread. Increasing amounts of exposed bedrock and boulders were observed in the deeper water areas in the south of the cable corridor and approaching the Brims Head headland. The northern part of the cable corridor was characterised by a gently shelving sandy seabed.

9.9.6 Shoreline Sediments and Morphology

In Orkney, sand deposits are a coastal feature within the larger bays. They are often associated with dune systems and a machair type hinterland. Two documented dune systems are noted in close proximity to the landfall of the three potential cable corridors of the Project, namely the bay-dune system of The Ayre (at the shore within the Aith Hope cable corridor) and the dune-machair system of Melberry (at the shore within the Sheep Skerry cable corridor and less than 1km to the west of the Moodies Eddy cable corridor).

Existing Ordnance Survey 1:25,000 scale mapping denotes the intertidal zone of the Sheep Skerry cable corridor to be rock outcrop fronting the Melberry dune and machair system, with small deposits of sand at both Sheep Skerry and

Melberry. Within the Moodies Eddy cable corridor the intertidal is characterised as rock outcrop with, in places, occasional boulders. The Aith Hope cable corridor is predominantly characterised by rock outcrop at either end, with a short (250m) sandy beach and dune ridge frontage at The Ayre in between.

Due to the particular interest in the dune systems at The Ayre and Melberry, further consideration in Table 9.11 shows the extent of different habitats, both derived from the *Sand Dune Vegetation Survey of Scotland* (Dargie, 1988).

Table 9.10: Land uses within the dune systems at Aith Hope and Melberry (source: Dargie, 1988)

Land Use	Area (ha)	
	The Ayre	Melberry
Beach above MHWS	0.32	2.25
Bare sand	-	0.45
Vegetated sand	0.24	41.16
Arable and fallow	-	3.61
Buildings, roads, gardens, etc.	-	2.15
Total (excluding beach above MHWS)	0.24	47.38
Total (including beach above MHWS)	0.57	49.63

Table 9.11: Habitats within the dune systems at Aith Hope and Melberry (source: Dargie, 1988)

Habitat	Area (ha)	
	The Ayre	Melberry
Beach and strand	0.57	2.25
Mobile dune		1.27
Semi-fixed dune		2.25
Fixed dry calcareous dune		0.5
Dune slack and wet grass		1.94
Mire and swamp		0.36
Arable and fallow		3.61
Improved grassland		35.25
Other		2.46
Total	0.57	49.89

9.9.7 The Ayre

The Ayre of Hoy forms the road link between Hoy and South Walls. It is flanked by the bays of North Bay (to the north) and Aith Hope (to the south). The beach is a consequence of the construction of the road in its present alignment at the beginning of the 20th century. The original ayre consisted of two shingle spits building out towards each other, hinged on shore platforms at either end, and with an intervening narrow channel which was flooded at high tide. When the road was constructed, the natural throughway for sand transport into North Bay through this channel was closed and thus a sand beach began to accumulate on the Aith Hope side of The Ayre.

The Ayre is 0.4km long and is mostly a shingle-based feature, but with the sandy beach and dune present on the Aith Hope flank. The beach has a gradient of ~8° and the backing dune ridge remains low in height, typically at around 4mOD (i.e. only around 2mOD above the general road level). It is also relatively narrow, at its minimum only 2m wide. This has allowed sand to be blown across the road in places. The beach is relatively stable and the dune system is actively building up in general, although is constrained in developing beyond its embryonic character into a full dune-machair system by the presence of the backing road and North Bay.

The dune area is small (0.24ha), comprising only a dune ridge directly adjacent to the road, and contains an area near the strandline colonised by sea lyme grass. The vegetation is of virtually no nature conservation interest (Dargie, 1988) but is considered a successful stabiliser of the dunes (Mather *et al.,* 1973).

9.9.8 Melberry

Melberry Links is situated on the south coast of Hoy in the lee of the promontory formed by the localised outcrop of the Devonian lavas, which form a small headland. This is the largest dune site on Hoy (47.4ha) and is exposed to a short (24km) south west fetch across the Pentland Firth to the north coast of the Scottish Mainland. Two bays are present, one facing south west and the other facing south, with sand blown over the intervening headland and inland. It is therefore a bay-dune and climbing dune complex of moderate size. There are small areas of mobile dune and modest amounts of semi-fixed dune. Most of the interior is improved grassland, which dominates the site, plus some arable ground. Overall nature conservation interest is moderate to low (Dargie, 1988).

The south western exposed shore is characterised by a fringing beach which has a steep gradient (~8°) and partially overlies the lava platform. It is characterised by a break-point bar near the high water mark, indicating the high energy environment within which it is set. Deep water lies relatively close inshore. Further east of the fringing beach the coastline is a low cliff coast of less than 10m in height, with a fragmented shore platform and cobble geos. The cliffs carry a capping of blown sand which is fixed by vigorous Marram grass growth and which, in turn, overlies a thin capping of till.

The foredune itself is relatively high, frequently exceeding 18m, with a gentle landward slope. Helped by the vigorous growth of Marram grass, it remains relatively stable despite the high energy exposure. The landward elements of the dune and machair system are extremely stable despite being heavily modified by agricultural practices and sand extraction.

The south facing shore is characterised by a thin veneer of sand coving a small area, typically associated with slumping and downcombing of the dune sands during storm conditions, but with outcrops of lava platform, a massive boulder beach and offshore rock skerries being the more extensive features.

9.9.9 Tidal Regime

The tides around Orkney are the result of the interaction of two independent tidal systems, in the North Atlantic and the North Sea. The tidal waves of both systems have anti-clockwise rotations and the systems reach the Orkney coastline with similar strengths but moving in opposite directions. This produces a net flow of water from west to east and complex interactions among the island sounds and in Scapa Flow.

Tidal currents can be significant and highly variable, particularly within the Pentland Firth where they can run at up to 5m/s on both the flood and ebb tide. Large eddies form in the lee of islands and can be sudden and extremely variable. However, the main tidal flows tend to be pushed offshore by the rocky headlands which occur around much of the southern Hoy coastline.

The sea region offshore from between Brims Ness and Tor Ness in the Pentland Firth is exposed and consequently complex in terms of the principal oceanographic dynamics. The interaction of strong tidal currents through the seabed region with the hard coastline and rapidly shelving bathymetry develops both broad-scale and localised water circulation patterns. To further investigate the tidal regime within the AfL, a series of metocean surveys were undertaken at eight locations within the Project site.

At all locations, there was a clear correlation between tidal phase and measured currents through the water column. Additionally, current velocities were lowest at the bed and generally highest a few metres below the free water surface at all locations. Peak current speeds measured at 15m above the seabed (a typical turbine hub height) were of the order of 3.20 – 3.86m/s on spring tides and 2.36 - 2.66m/s on neap tides and were aligned strongly W-E at most sites (the exceptions being where the tidal dynamics on the flood tide were complicated by the actions of the tide running along the south west coast of Hoy). Figure 9.3 shows the current roses from three deployment locations within the AfL indicating a strong W-E alignment of the principal flow axis.

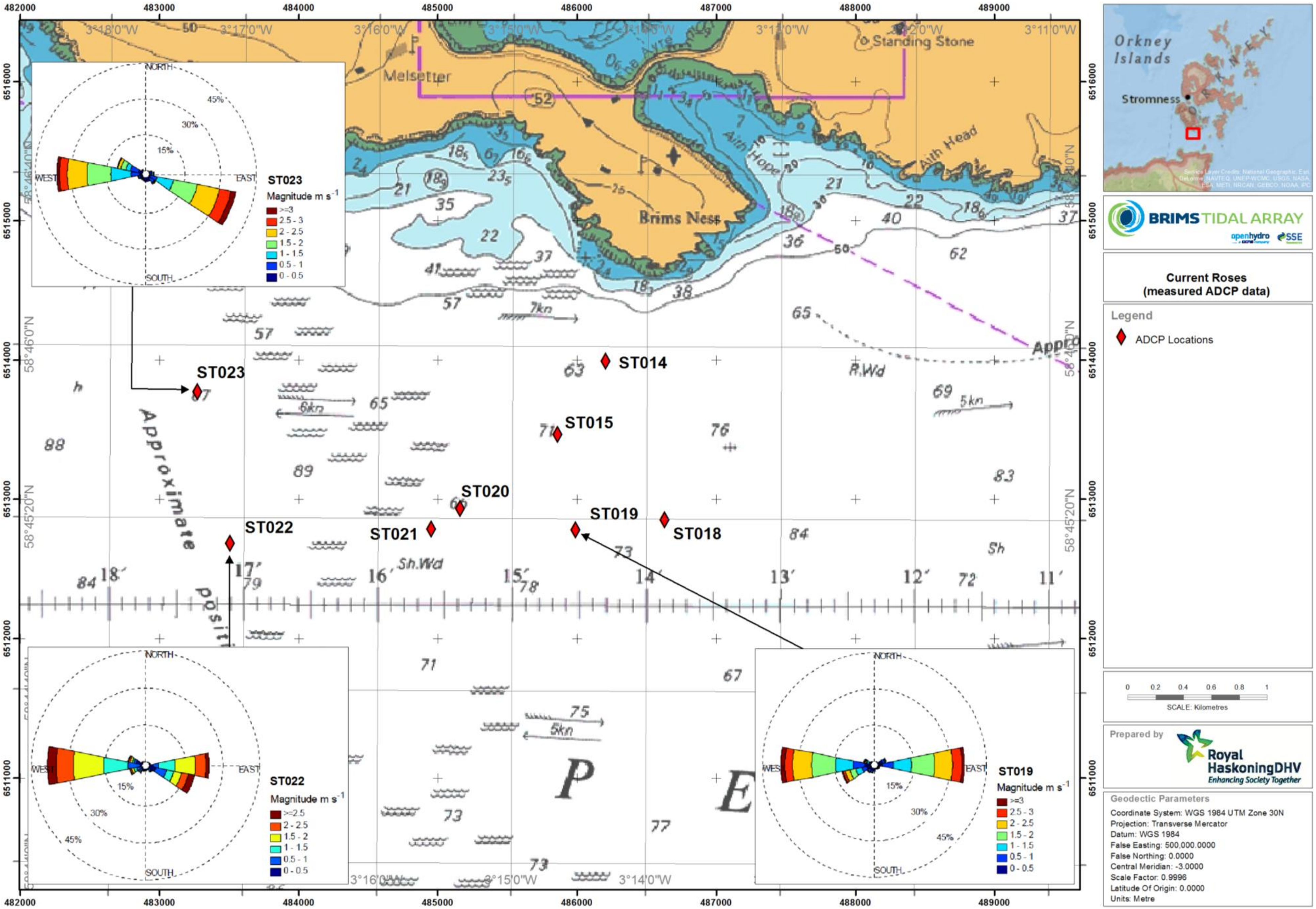

Figure 9.3: Current roses from measured ADCP data

Table 9.12: Measured tidal range from metocean surveys

Parameter	Measured value from metocean survey					
	Phase 2		Phase 3			
	Site 14	Site 20	Site 19	Site 21	Site 22	Site 23
Max range during spring (m)	3.80	3.90	3.93	4.41	3.94	-
Max range during neap (m)	2.80	2.80	2.44	2.75	2.61	-

Table 9.13: Measured tidal currents from metocean surveys

Parameter	Measured value from metocean survey					
	Phase 2		Phase 3			
	Site 14	Site 20	Site 19	Site 21	Site 22	Site 23
Peak spring current (m/s)	3.20	3.27	3.63	3.87	3.45	3.86
Peak neap current (m/s)	2.45	2.36	2.61	2.91	2.36	2.66
Mean spring current (m/s)	1.58	1.92	1.90	1.93	1.75	2.04
Mean neap current (m/s)	1.15	1.37	1.42	1.29	1.33	1.50
Mean spring ebb to flood ratio	>1.0	>1.0	1.03	1.30	1.20	1.06
Mean neap ebb to flood ratio	>1.0	<1.0	0.94	1.18	0.99	1.17
Principal current axis on flood (°N)	~90	~90	91.7	96.4	104.3	111.3
Principal current axis on ebb (°N)	~270	~270	271.8	270.8	277.5	281.1

Short-term fluctuations in tidal stream flow resulting from turbulence are site-specific and temporally-variable phenomena. Nonetheless, they are important issues to consider for robust evaluation of the performance of a tidal turbine. At all sites, the turbulent kinetic energy gradient was relatively small in general, except for close to the seabed and near the free water surface, probably due to shear effects and wave-current interactions, respectively.

Table 9.14: Measured turbulence from metocean surveys

Parameter	Measured value from metocean survey					
	Phase 2		Phase 3			
	Site 14	Site 20	Site 19	Site 21	Site 22	Site 23
Peak total kinetic energy (m^2 s^2)	-	-	0.60	N/A	0.51	0.59
Relative turbulence intensity (%)	-	-	11.51	10.57	13.17	11.23

Results from the metocean surveys indicate that whilst the broad-scale tidal circulation patterns are predictable, given the dominance of the tidal signal at the site, shorter and more localised circulation patterns can be caused by more random water column structures. There is an unusual multiple peak in currents during the ebb phase in particular which indicates the energetic and unsteady nature of the regional flows.

To provide further characterisation of the tidal regime at the AfL and surrounding seabed areas and adjacent shorelines, a MIKE21 hydrodynamic model was set up and run to simulate a spring – neap cycle. Modelled outputs were compared against measured data from the metocean surveys to ensure adequacy of the calibration in terms of water level, current speed and current direction. Figure 9.4 and Figure 9.5 show the current velocities (speeds and directions) on a spring tide at the times of high water and low water and at times of peak ebb and peak flood.

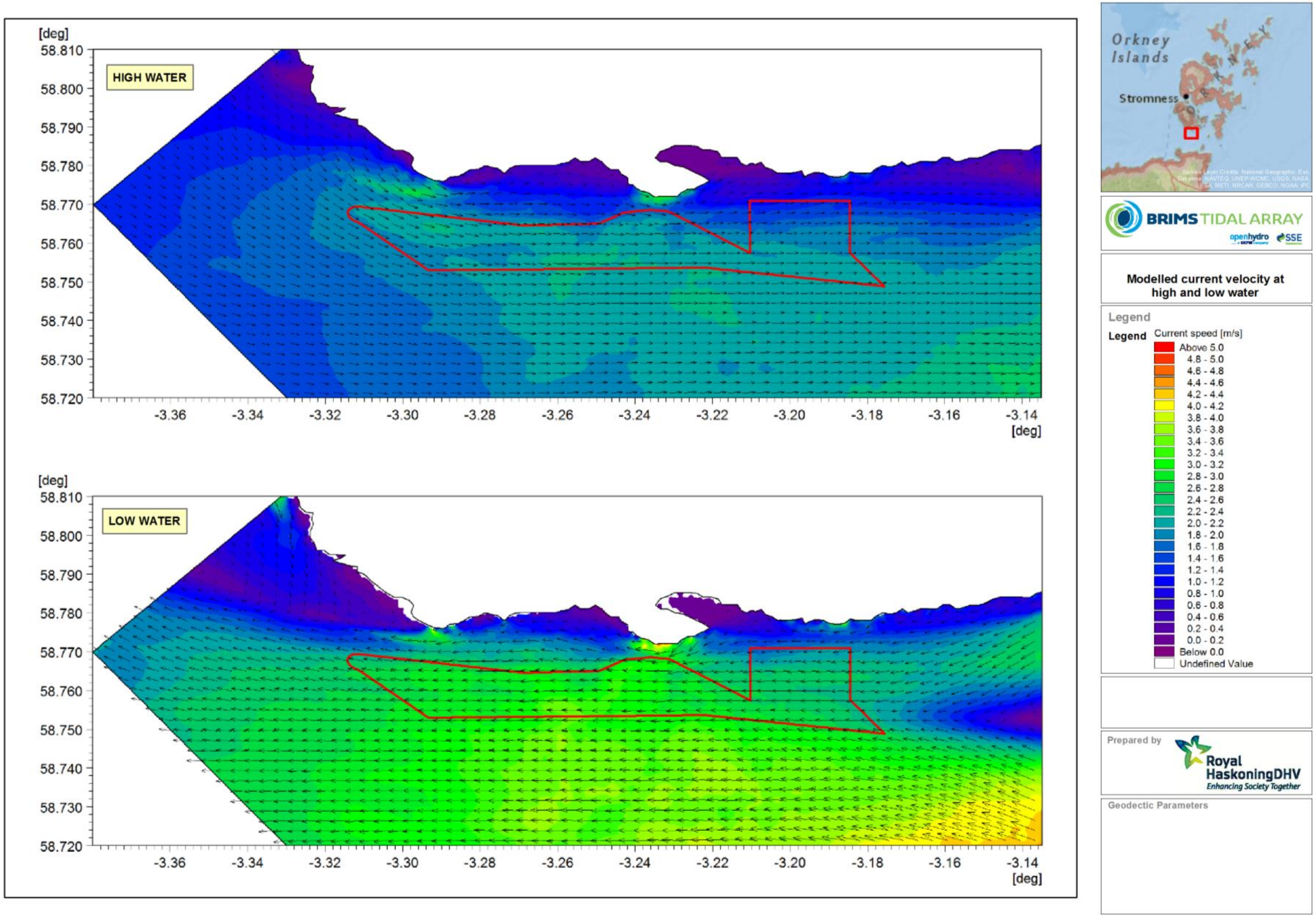

Figure 9.4: Modelled current velocity at high and low water

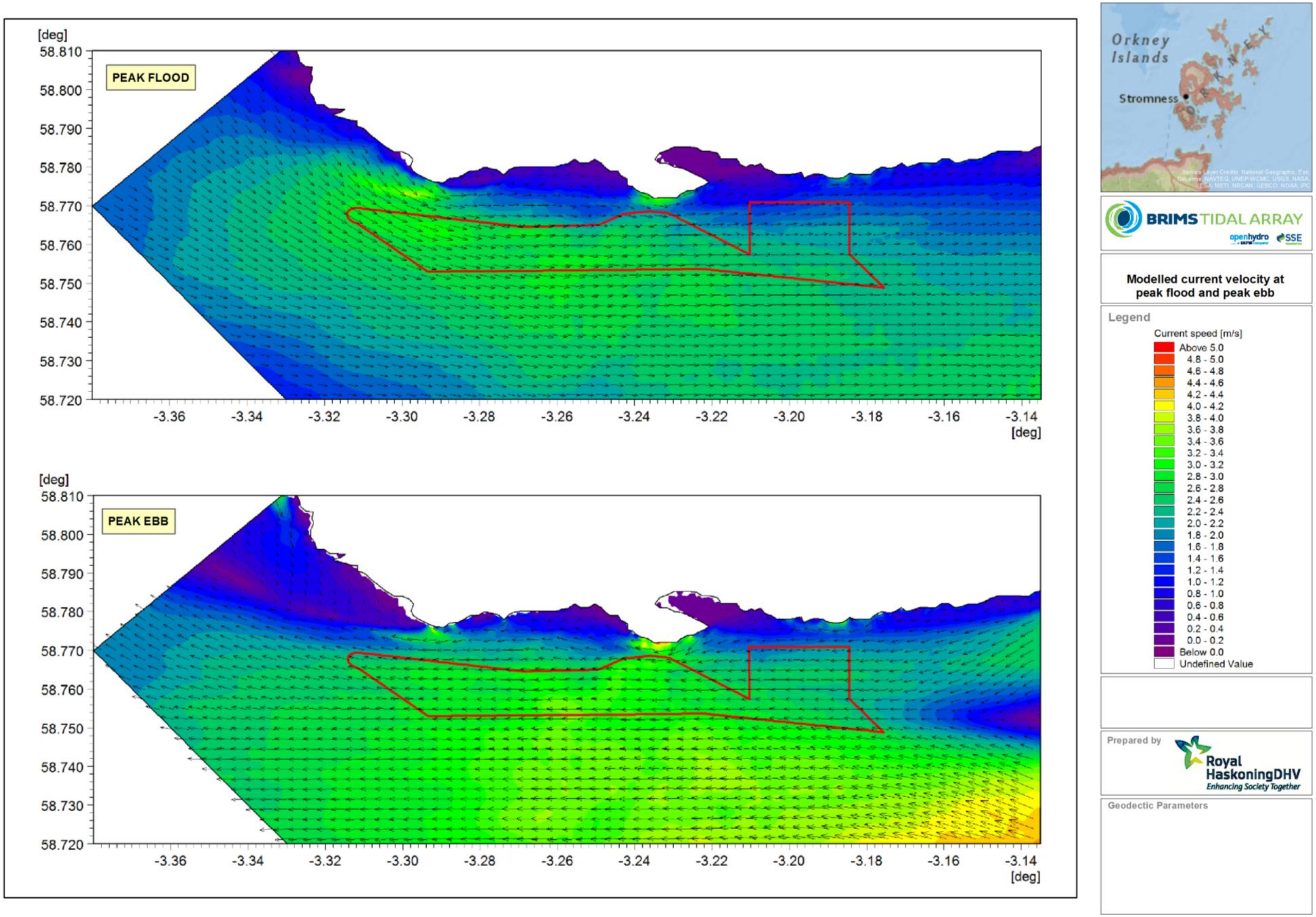

Figure 9.5: Modelled current velocity at peak flood and peak ebb

In keeping with earlier metocean measurements, flows are aligned strongly W-E within the AfL and peak ebb flows are generally greater than peak flood floods, peaking within the AfL in excess of 3m/s but wider across the Pentland Firth exceeding 5m/s in places. There are notable exacerbations in flow around headlands, especially at the time of peak ebb and peak flood flows.

9.9.10 Wave Regime

Along the south west coast of Hoy, a combination of deep open water and exposure to prevailing winds produces a high-energy wave climate, especially during north and north west incident storms. Since the sea floor falls steeply away from the west to 60m, the coast is exposed to relatively high wave energies.

Severe offshore wave conditions (>8m) can be incident from any sector, excluding the south east. Extreme offshore significant waves heights and associated return periods, calculated using data from the Met Office model are presented in Table 9.15. It should be noted, however, that the Met Office model has a coarse grid and therefore the results at this point may not take full account of local bathymetry and local current effects.

Table 9.15: Total extreme significant wave heights

Return Period (years)	Significant wave height (m)
1	10.65
10	12.79
100	14.82

During the aforementioned Project-specific metocean surveys, wave heights, periods and directions were also measured by the ADCPs at eight sites to help characterise the wave climate within the AfL (rather than further offshore as described above). Wave heights reached a maximum of 4.81m, with a mean wave height value of 0.66 – 1.20m (depending on location). Peak wave periods ranged from a minimum of 4.8 s to a maximum of 16.4 s. As can be seen from Figure 9.6, the predominant wave direction was from the West, with the greatest storm waves approaching from between North West and South West. However, some storm waves also approach from between South East and East. The wave field changes according to the tidal phase (ebb or flood).

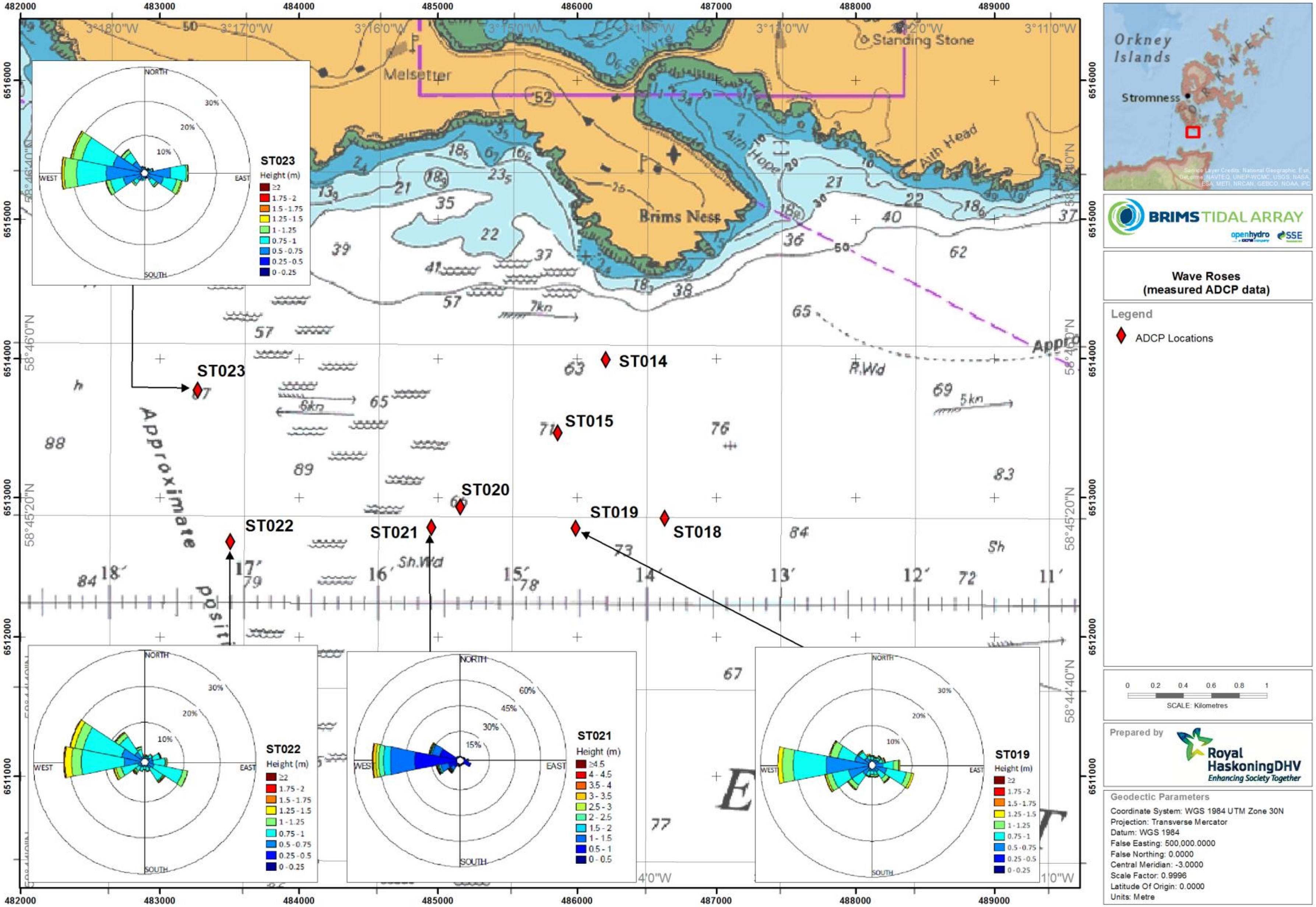

Figure 9.6: Wave roses from measured ADCP data

Table 9.16: Measured wave heights, periods and directions from metocean surveys

Parameter	Measured value from metocean survey					
	Phase 2		Phase 3			
	Site 14	Site 20	Site 19	Site 21	Site 22	Site 23
Max wave height, H_{m0} (m)	2.00	2.48	1.72	4.81	1.98	1.58
Mean wave height, H_{m0} (m)	0.83	0.66	0.84	1.20	0.88	0.80
Modal peak wave direction (°N)	~270	~270	269	271	270	269
Max peak wave period, T_p (s)	13.8	16.4	15.0	15.0	13.4	15.0
Max mean wave period, T_m (s)	4.8	4.8	9.1	10.6	7.0	7.1

Results from the metocean surveys show that waves are strongly modified by the tidal phasing. During the ebb tide, wave heights are seen to increase by up to 1m due to the tidal currents moving directly against the dominant wave direction, casing waves to steepen. This shows a degree of wave-current interaction, although such modulation of the waves is not evident during the flooding phase of the tide.

9.9.11 Sediment Transport Regime

Unconsolidated sediments laid down at the seabed since the sea transgressed across the area following the early Holocene rise in sea level have the potential to be transported as either bedload (‘rolled’ along the seabed) or suspended load (mobilised into the water column). Typically coarser sediment will be transported as bedload and finer sediment as suspended load, but this depends upon the grain size of the particles and the forces exerted on them by the combined *effects of wave-induced currents and tidal currents.*

9.9.12 Seabed Sediment Transport

As has been previously stated, the AfL consists predominantly of outcropping bedrock, with very little discernible sediment cover. This is due to the very strong tidal currents which sweep mobile sediment away, unless it becomes deposited within faults and crevices in the rock structure. There are, however, some identifiable patches of sediment cover within the AfL, especially along the northern boundary of the AfL, in particular where the cable route corridors enter the AfL and within a localised sediment patch in the south western corner of the AfL.

Importantly, it should also be recognised that the AfL is located within a broader-scale bedload sediment transport regime which covers a regional area of seabed, i.e. the wider Pentland Firth. This has previously been investigated based upon the collation and interpretation of existing data and information (Halcrow, 2009). It is important to understand this broader scale sediment transport regime since any significant change in the tidal or wave regimes could, potentially, have knock-on effects in terms of sediment transport within the regional scale context. There are several key components to this broader-scale system.

- There is a field of sandwaves/transverse bedforms further to the west of the AfL. These are reported as being most identifiable at around 10km to the west, but minor bedforms are resolvable in the datasets between that point and around 3km to the west of the AfL. These features are indicative of westward-directed net bedload sediment transport from a seabed parting zone (described below);

- There is a large sandbank with three topographic highs on the seabed offshore from, and to the east of, South Ronaldsay, with sandy gravel or, especially, gravelly sand sediment cover over extensive areas of the seabed further to the east. There is a postulated eastward-directed net bedload sediment transport from a seabed parting zone (described below) to these areas of seabed; and
- Between these two sedimentary zones, there is a wide area within the Pentland Firth (including the seabed covered by the AfL) with no significant sediment cover and instead extensive areas of tide-swept exposed bedrock are evident. This area of seabed is characterised as a bedload sediment parting zone, with any sediment being rapidly transported either to the west or to the east from this parting.

9.9.13 Shoreline Sediment Transport

The existing beach sediments (where present over bedrock) around the Orkney Islands (in general) are derived from a combination of eroded glacial till, erosion of sandstone cliffs and from shell material. Sands and gravels forming the sea-bed sediments around the Orkney Islands (where present over bedrock) are notable for their high biogenic carbonate content. Much of the gravel around the islands, particularly to the north and east, is composed predominantly of shell debris. These carbonate deposits reflect the rich littoral and sublittoral fauna that exists around the Orkney Islands.

There is little documented detail on bedload transport patterns at the shoreline. The coastline is a high energy environment dominated by wave processes. In the south, the isles are rocky and subject to harsh wave conditions. Consequently most beaches experience long-term coastal and cliff erosion.

The shoreline at the landfall of the Sheep Skerry cable corridor is characterised as an outcrop of lava fronting a dune and machair system. Due to the paucity of shoreline sediment along adjacent cliff frontages, there is likely to be little alongshore sediment movement, but there may be measurable onshore-offshore sediment movement as a consequence of storms, although during calmer wave conditions sediment is likely to progressively return to the beach to slowly naturally replenish the foreshore and dunes over time.

The shoreline at the landfall of the Moodies Eddy cable corridor is characterised as rock outcrop with, in places, occasional boulders. As a consequence, there is no significant bedload sediment transport along this frontage, other than the movement of occasional boulders during storms. Importantly, there is no sediment present on the shoreline at this location that is transported to feed the bay-dune and machair system of Melberry (located less than 1km to the west of the Moodies Eddy cable corridor).

The shoreline at the landfall of the Aith Hope cable corridor is predominantly characterised by rock outcrop at either end, with a short (250m) sandy frontage at The Ayre in between, which is backed by sand dunes. Given that the beach-dune system at The Ayre is confined between the rock outcrops at either end and, further, is protected against waves approaching from all directions except south easterlies by the rocky land masses of Brims Head and South Walls, the beach sediment is considered relatively stable, except under south easterly storms when foreshore lowering and dune front erosion is expected to occur. There is likely to be little alongshore sediment movement, but measurable onshore-offshore sediment movement as a consequence, although during calmer wave conditions, sediment is likely to progressively return to the beach to slowly naturally replenish the foreshore and dunes over time.

9.9.14 Suspended Load Transport

During the metocean surveys undertaken within the AfL, turbidity in the water column was measured by turbidity sensors at four sites. Sensors measured the turbidity of the water column at a distance of 0.7m off the seabed, recording raw data as Normal Turbidity Units (NTU). These values were converted into suspended sediment concentrations (SSC) through statistical calibration using sediment captured from the sediment traps on each bed-frame.

Table 9.17: Measured total suspended sediments from metocean surveys

Parameter	Measured value from metocean survey					
	Phase 2		Phase 3			
	Site 14	Site 20	Site 19	Site 21	Site 22	Site 23
Min total suspended sediments (mg/l)	-	-	0	0	16	0
Mean total suspended sediments (mg/l)	-	-	2	9	21	20
Max total suspended sediments (mg/l)	-	-	104	*	63	109

* Data became affected by biofouling towards the end of the survey period

9.9.15 Summary

The baseline conditions represent the ranges and interactions of naturally occurring physical properties (e.g. geology, bathymetry, bedforms), physical processes (e.g. water levels, tidal currents, waves, wave-current interactions, sediment transport) and morphological responses (e.g. erosion, accretion) across the seabed and shoreline prior to the installation of the Project. Accordingly, the potential effects of natural dynamism and climate change are also considered as part of the baseline conditions.

The key sensitivities in terms of the baseline conditions relate principally to the areas of more mobile sediment, such as sands and gravels, where processes of erosion, sediment transport and deposition *may* become affected by any changes to the baseline tidal or wave regimes. In most locations within the AfL and cable corridors, the seabed is sparsely covered or entirely devoid of such sediments and, due to this, the baseline conditions are relatively insensitive to potential changes of this nature. There are, however, some seabed and shoreline areas with patches or more distinct deposits of sands or gravels, including the particularly sensitive sand dune systems at The Ayre and Melberry. Due to this, the impacts assessment has considered the potential effects of changes to the baseline conditions on these areas as a keen focus.

Within the context of the Project proposals, the baseline conditions may potentially be affected during any or all of the construction, operation and maintenance, and decommissioning (including potential for repowering) phases. These issues are considered in further detail in Section 9.10.

9.10 POTENTIAL IMPACTS

Potential effects on, or changes to, the baseline physical processes environment may arise during the life-cycle of the Project, including through the:

- Construction and installation phase;
- Operation and maintenance phase; and

- Decommissioning phase.

The potential impacts on the physical processes environment have been derived based upon:

- the design envelope considerations contained within the Project Description;
- the legal framework and policy context which applies in general to assessment of effects from energy schemes and renewable energy schemes on the physical processes environment;
- consultation with the Licensing Authority during the EIA Scoping phase; and
- Consultation with the Licensing Authority during preparation of the bespoke methodology used with the ES for the assessment of effects of the Project on the physical processes environment of the Pentland Firth.

The potential impacts on the physical processes environment during the three stages of the Project's life-cycle are summarised below and then assessed in more detail in following sections.

9.10.1 Construction and Installation Phase

Impacts potentially arising as a consequence of the construction phase are typically likely to be associated with the installations of turbine support structures (TSS), turbines and electrical connector hubs (and their support structures), and the laying of inter-array or export cables and the installation of any required export cable protection works.

The greatest potential impacts during the construction phase are likely to be in the form of:

- enhanced suspended sediment concentrations in the water column; and
- Consequential sediment deposition arising from seabed disturbance.

However, these impacts are mainly expected to arise only locally around the source of the effect and persist for short timescales (order of hours to days at any one location) during the construction period.

In addition, the presence of installation vessels and equipment will have the following localised and temporary potential impact:

- Changes to the tidal, wave and sediment transport regimes.

9.10.2 Operation and Maintenance Phase

Impacts during this phase are most likely to be associated with the physical presence of turbines, TSS and electrical connector hubs (and their support structures) throughout the 25 year operational lifetime of the Project, causing potential:

- Changes to the baseline flow regime;
- Changes to the baseline wave regime;
- Changes to the baseline sediment transport regime (arising as a consequence of any changes to the tidal and/or wave regimes) and, if sufficient in magnitude and extent, potentially lead to morphological change across a wider area of seabed or adjacent shore; and
- Changes to the seabed morphology due to the physical footprint of the infrastructure.

In addition, the presence of maintenance vessels and equipment will have the following localised and temporary potential impact:

- Changes to the tidal, wave and sediment transport regimes.

9.10.3 Decommissioning Phase

The intended Project lifetime is 25 years and, after such time, the Project will either be decommissioned, involving the full or partial removal of certain offshore elements, or repowered.

Any decommissioning or repowering programme will cause effects that are similar in type and similar or, more likely, lower in magnitude to those potentially experienced during the construction and installation phase, namely:

- Enhanced suspended sediment concentrations in the water column;
- Consequential sediment deposition arising from seabed disturbance; and
- Changes to the tidal, wave and sediment transport regimes arising from the presence of decommissioning vessels and equipment.

Any repowering programme will additionally have cause effects that are similar in type and magnitude to those potentially experienced during the operation and maintenance phase. However, the repowering option has not been considered further and instead would be subject to a separate Environmental Impact Assessment at the time.

These effects (or changes) in the baseline physical processes environment during the construction and installation, operation and maintenance or decommissioning phases may become manifest as potential impacts if they directly affect receptors which possess their own intrinsic geomorphological value, such as the shoreline or the seabed. In these cases both the magnitude of effect and the significance of the potential impact on morphological receptors is assessed in this chapter of the ES. However, effects (or changes in baseline conditions) may also become manifest as potential impacts upon other receptors such as the benthic ecology or marine water quality. In such cases, the magnitude of effect on the baseline physical processes environment is determined in this chapter, but the significance of potential impacts upon those other receptors arising from these effects is made within the relevant chapters of this ES pertaining to those receptors.

9.11 MITIGATION MEASURES

9.11.1 Project Design Mitigation and General Mitigation

All Project Design and General Mitigation measures are set out in Chapter 5 Project Description, Table 5.15 and Table 5.16 respectively. These are standard practice measures based on specific legislation, regulations, standards, guidance and recognised industry good practice that are put in place to ensure significant impacts do not occur.

The assessment of each potential impact in this chapter has been based on a bespoke ‘worst case’ for that particular issue. This is because the design envelope is purposefully sufficiently wide to encompass all possible technological, engineering and design options that will be considered as the Project continues to evolve. It is highly unlikely in practice, for example, that all turbines will be installed on monopile TSS (which represent the worst case sub-surface sediment spill considered in impacts). Similar situations exist for all other potential impacts that have been considered, where a bespoke worst case scenario has been selected (e.g. use of GBS as TSS, use of 23m diameter turbine rotors, etc.). Through the design process, therefore, a combination of approaches will be selected which best suit the physical environment in which they will be located and hence the actual impact will be within the bounds of those assessed in this chapter.

Furthermore, the detailed programming of construction, maintenance and decommissioning (or repowering) works will be designed so that there is maximum cost-effectiveness, whilst minimising potential impacts, for example through the phased installation of TSS or the phased maintenance of turbines over a period of time.

9.11.2 Specific Mitigation

The assessment of the potential effects on the baseline physical processes environment has revealed that no potentially significant impacts will arise to the identified shoreline geomorphology and seabed geomorphology receptors. Due to this, no specific mitigation measures have been identified for these receptors other than 'micrositing' of landfall cables and infrastructure during detailed design to minimise potential adverse effects on morphology, habitats and species, as requested by SNH. Consequently, the following mitigation measure will be implemented specifically to minimise the impacts on physical processes.

Table 9.18 Mitigation Measures specific to Physical Processes

Mitigation Measures Specific to Receptor		
PP01 (physical processes)	Micrositing of landfall cables and infrastructure	A landfall installation plan will be developed in consultation with SNH and Marine Scotland which will help minimise potential adverse effects on morphology, habitats and species at the shore.

9.12 RESIDUAL EFFECTS

9.12.1 Construction and Installation

9.12.1.1 Changes in suspended sediment concentrations due to installation activities

During the construction phase there is potential for installation activities to disturb sediments, either from the seabed surface or from below the seabed, and release them into the water column as a plume. This will enhance the baseline suspended sediment concentrations in the water column, making the water column more turbid, until the plume becomes dispersed by tidal current action and the sediments settle once again on the seabed. To provide context, the baseline suspended sediment concentrations measured during within the AfL during the metocean surveys are typically low (often only 3mg//l but can become enhanced temporarily to around 60 – 110mg/l during storm events. However, following the storms, suspended sediment concentrations return rapidly to background levels due to the strong tidal currents which prevail.

Seabed sediment disturbance

The installation activities that may lead to disturbance effects of sediments from the seabed surface (as opposed to sediments from below the bed) include:

- the placement of seabed-mounted turbine support structures (TSS) (e.g. GBS or SSB) or seabed-mounted electrical hub support structures on the seabed (although note that no seabed preparation will be required);
- the surface laying and anchoring of inter-array or subsea export cables
- the installation of cable at the cable landfall (three potential landfall locations are under consideration);
- the placement of export cable protection works on the seabed, where required; and

- deployment of anchors or jack-up legs of specialist vessels during the installation of the above Project infrastructure.

Throughout the proposed AfL the seabed comprises mostly outcropping bedrock with very little discernible sediment cover. Where sediment does exist in these areas, it is predominantly isolated rock boulders or boulder fields, which are not of grain size that can be suspended in the water column and therefore these will not form part of a sediment plume even if disturbed during installation. Some of the deep gullies are infilled with coarse sediments, but these areas would not be suitable for placement of Project infrastructure. The only exceptions within the AfL exist in the south west section, where an area of gravel is present, and along parts of the northern boundary where areas of gravelly sands and sandy gravels are present. However, given the overall propensity for the presence of tide-swept bedrock across most of the AfL and given the temporary short-term and localised disturbance in the local areas where coarse sediment cover does exist, the changes in suspended sediment concentration during the installation of Project infrastructure within the AfL for Phase 1 only and for Stages 1 and 2 combined will be low or negligible in magnitude, temporary in duration, caused by infrequent activities and will be reversible within a very short time period.

The export cable corridors represent a slightly different case because whilst there remain areas of outcropping bedrock with very little discernible sediment cover along parts of each cable corridor, there are also some sections where the seabed is covered by sands or gravels as either veneers or deposits of substantially greater thicknesses. However, other than in areas closest to shore (see below), the export cables will be surface laid and protected with rock, concrete mattresses or grout bags rather than being buried and therefore the changes in suspended sediment concentration during Stage 1 only and during Stages 1 and 2 combined will be low or negligible in magnitude, temporary in duration, caused by infrequent activities and will be reversible within a very short time period.

At the three potential landfall sites the worst case installation technique (in the context of suspended sediment concentrations) would be open trenching since there will be direct physical disturbance during both trenching and back-filling operations. However, the length of cable to be trenched at the landfall will be relatively short (i.e. across the intertidal and possibly the shallow near-shore zones only) and the shores are characterised by high energy exposure conditions, meaning that any temporary short-term and localised increases in suspended sediment concentrations during Stage 1 only and during Stages 1 and 2 combined would be within the bounds of natural fluctuations during storm events. Therefore the changes in suspended sediment concentration will be low in magnitude, temporary in duration, caused by infrequent activities and will be reversible within a very short time period.

Sub-seabed sediment disturbance

There also exists a potential for the release of sediments from depths below the seabed (as opposed to sediments released from the seabed) during installation activities. This would occur during the drilling of any monopiles or pin piles associated with TSS that may be required within the AfL. Sediments released from such installation activities would be generally finer than surface sediments (as the drilling would extend through the sub-surface rock formations) and possibly would be released at the water surface (where tidal currents are strongest) rather than at the seabed. The worst case sediment spill for TSS would be associated with drilling a monopile, with 117.6m^3 released per installed structure. If it is assumed that up to 30 turbines are installed during Stage 1, then a total volume of 3,528m^3 will be released. For Stages 1 and 2 combined, involving up to 200 turbines, a total volume of 23,520m^3 will be released. These volumes are relatively small in comparison to the area of the AfL over which they will be released. Furthermore, these volumes will not be released instantaneously into the water column but instead will be released in a phased manner as construction progresses. Given the high tidal currents (aligned strongly east-west) and the likely finer-grained nature of drilled sub-surface sediments, any sediment released into the water column will be widely transported by tidal currents, becoming rapidly dispersed. Therefore the changes in suspended sediment concentration during Stage 1 only and during Stages 1 and 2 combined will be low or negligible in magnitude, temporary in duration, caused by infrequent activities and will be reversible within a very short time period.

Table 9.19 Summary of Residual Effects on Seabed or Shoreline Morphology Arising From Changes in Suspended Sediment Concentrations due to Installation Activities

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
GBS or SSB types of TSS	Seabed	Negligible	PD01-04 GM01-04	Negligible	Project design and general mitigation	Negligible*
Monopile or pin pile TSS	Seabed	Negligible	PD01-04 GM01-04	Low	As above	Negligible*
Export cables	Seabed	Negligible	PD05 & GM05	Negligible	As above	Negligible*
Cable landfall	Shoreline	Low	PD05, GM05 & PP01	Low	As above plus micro-siting of landfall cables	Negligible*

* Changes in the suspended sediment concentrations do not directly have impacts on the identified shoreline or seabed geomorphological receptors *per se* (they simply affect turbidity in the water column), but these effects are important to consider because they inform subsequent assessment of impacts arising from sediment deposition (see following section).

These effects on suspended sediment concentrations are also important to consider in the assessment of impacts on other receptors, especially marine water quality (see Chapter 8), Benthic Ecology (see Chapter 11), Fish Ecology (see Chapter 12), Shipping and Navigation (see Chapter 15) and Commercial Fisheries (see Chapter 16).

9.12.1.2 Changes in sediment deposition due to installation

Any sediment that becomes suspended within the water column and entrained within a plume (see previous section) will have the potential to subsequently become deposited on the seabed at some distance from its point of disturbance or release as it settles through the water column to the seabed.

However, the total quantities of sediment released into the water column from installation activities will be very small in magnitude (compared to dredging overspill or volumes released from seabed preparation for GBS installation in areas of sandwaves, for example) and will persist locally for only a very short duration (due to high tidal currents causing rapid dispersion) and hence will cause a negligible effect in terms of enhanced suspended sediment concentrations (see previous section). Due to this, there will similarly be only very limited potential for any sediment to become deposited on the seabed in any measureable quantities. Rather, deposited sediments would very quickly become re-suspended and redistributed across a wide area in low (immeasurable) quantities.

Table 9.20 Summary of residual effects on seabed or shoreline morphology arising from changes in sediment deposition due to installation activities

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
GBS or SSB types of TSS	Seabed	Negligible	PD01-04 GM01-04	Negligible	Project design and general mitigation	Negligible
Monopile or pin pile TSS	Seabed	Negligible	PD01-04 GM01-04	Low	As above	Negligible
Export cables	Seabed	Negligible	PD05 & GM05	Negligible	As above	Negligible
Cable landfall	Shoreline	Low	PD05, GM05 & PP01	Low	As above plus micro-siting of landfall cables	Negligible

Changes in sediment deposition are also important to consider in the assessment of impacts on Benthic Ecology (see Chapter 11), Fish Ecology (see Chapter 12), Commercial Fisheries (see Chapter 16) and Shipping and Navigation (see Chapter 15).

9.12.1.3 Changes in tide, wave and sediment regimes due to presence of installation vessels

During the construction phase, a number of specialist vessels will be used for installation activities. While these are present at the site, their jack-up legs, anchors and hulls will exert influences on the baseline physical processes and (in the case of the legs / anchors) the seabed geomorphology.

Due to the predominance of exposed bedrock, with occasional boulders across much of the AfL and parts of the cable corridors, the legs / anchors of installation vessels will cause no change to the seabed geomorphology. Where veneers or deeper sequences of coarse-grained sediments are present in local areas, there will be small ‘footprints’ created in the seabed, but given the coarse-grained nature of the sediments, these will become infilled and/or re-worked by natural processes once the loading forces are removed.

Due to the temporary and highly localised presence of the vessels at any one location within the Project site and subsea cable corridor, the installation vessels will not cause significant effects on the wave, tide and sediment regimes.

Table 9.21 Summary of residual effects on seabed or shoreline morphology arising from changes in tide, wave and sediment regimes due to the presence of installation vessels

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Installation vessels	Seabed	Negligible	PD01-04 GM01-04	Negligible	Project design and general mitigation	Negligible
Installation vessels	Shoreline	Low	PD05, GM05 & PP01	Negligible	As above plus micro-siting of landfall cables	Negligible

Changes in the tide, wave and sediment regimes due to presence of installation vessels are also important to consider in the assessment of effects on marine water quality (see Chapter 8), Coastal and Terrestrial Ecology, Benthic Ecology (see Chapters 10 and 11), Fish Ecology (see Chapter 12), Commercial Fisheries (see Chapter 16) and Shipping and Navigation (see Chapter 15).

9.12.2 Operation and Maintenance

9.12.2.1 Changes in tidal regime due to the presence of Project infrastructure

Once installed within the AfL, turbines will extract energy from the baseline hydrodynamic current flow and this will have the potential to affect the tidal regime due to the formation of wakes. The TSS will also present a local blockage to flow, partially within the water column, although this is expected to be a considerably lesser effect than that caused directly by the turbine through tidal energy extraction. The overall effect will be to (mainly) pacify the existing regime downstream of the tidal devices, when compared to the pre-existing (baseline) situation. Such wake effects can be visually observed at the water surface on existing turbine deployments (e.g. SeaGen deployment in Strangford Lough, Northern Ireland). There could also be some (less significant) local increases in current speed between the wakes of adjacent tidal devices and/or around some of the TSS and connecting hubs within the Project site and/or around the 'edges' of the array (especially if constrained on one side by its proximity to the shoreline).

The changes invoked by the turbines and their TSS (and also to a lesser extent by the connecting hubs and their support structures) could therefore lead to a modification of the tidal regime within the array (near-field scale) or downstream of the array beyond the AfL (far-field scale).

To investigate this issue, numerical modelling has been used to determine the magnitude and spatial extent of changes in the tidal regime arising from the worst case considerations for turbines, TSS and connecting hubs. This has been based on a two-dimensional hydrodynamic model of the AfL, surrounding seabed areas and adjacent shoreline. The two-dimensional hydrodynamic modelling approach has previously been successfully used within the following major projects within the tidal energy sector:

- SMARTtide, (Simulated Marine Array Resource Testing), commissioned and funded by the Energy Technologies Institute (ETI) to investigate the interactions between tidal energy systems around the UK, including how they combine to form an overall effect of tidal range and flow velocity; and
- Pentland Firth and Orkney Waters (PFOW) Marine Modelling Enabling Action (MMEA), commissioned and funded by The Crown Estate to deliver a live marine modelling facility on behalf of, and for use by, PFOW project developers to support the ongoing work in wave and tidal energy development within the PFOW strategic area.

In addition, two-dimensional hydrodynamic modelling has also been used on numerous other tidal energy developments, including MeyGen Tidal Energy in the Pentland Firth (Scotland), Copeland Islands (Northern Ireland), The Skerries (Wales), the Shannon Estuary (Republic of Ireland) and the Bristol Channel (England/Wales).

Given the nature of the design envelope under consideration, there could potentially be a wide range of types, dimensions and ratings of turbines, with various TSS employed. It would not be practicable to undertake numerical modelling of every potential combination that may exist. Rather, this numerical modelling of one particular arrangement is intended to provide a quantitative assessment of a reasonably conservative worst case assumption that can lead to an informed qualitative judgement regarding the potential impacts arising from other arrangements within the AfL.

Similarly, the modelling has been based on an indicative layout of 30 turbines and 4 subsea connecting hubs for Stage 1 and 200 turbines and 8 subsea connecting hubs for Stages 1 and 2 combined. The turbines have been spaced within this indicative layout in accordance with the spacing rules defined in Chapter 5 Project Description, but again this numerical modelling of one particular (indicative) layout is intended to provide a quantitative assessment of a realistic arrangement that can lead to an informed qualitative judgement regarding the potential impacts arising from other arrangements within the AfL.

The principal parameter which influences the potential impact on the baseline hydrodynamics from a turbine is the size of its rotor. The greatest effect arises with the greatest rotor diameter (and hence greatest swept area) within the design envelope; this being 23m. As a conservative approach, all 30 turbines in the Stage 1 array and all 200 turbines in the combined Stage 1 and 2 arrays were represented by 23m diameter turbines. In practice, this may not be the case and either a smaller number of these turbines or up to this number of smaller turbines may instead be selected for use. In such cases, the effects would be within the range covered by the impact modelling of the worst case.

The principal parameter which influences the potential impact on the baseline hydrodynamics from a TSS is its cross-sectional area, which creates a physical blockage effect in the water column. It was therefore considered that of the different TSS being considered, gravity base structures (GBS) would have the greatest potential blockage effect. Although some alternative TSS being considered occupy a greater height in the water column, they present only a slender obstacle to flow. GBS on the other hand present a considerably greater obstacle, although only near the seabed. Similarly, the principal parameter which influences the potential impact on the baseline hydrodynamics from a subsea cable connecting hub (and its associated support structure) is its cross-sectional area, which creates a physical blockage effect in the water column.

The approach of quantitatively assessing a conservative worst case assumption and applying qualitative judgement in consideration of alternative arrangements is therefore considered a pragmatic and proportionate approach to the assessments given the nature of the design envelope presently under consideration.

Details of the numerical modelling, including model set-up, baseline verification, and outputs are presented in Supporting Document: Physical Processes Modelling (RNDHV, 2015b). The indicative layout that was modelled is shown in Figure 9.7 and the worst case assumptions used in the modelling are shown in Table 9.22.

Table 9.22 Worst case assumptions for modelling

Project parameters relevant to the impact assessment	Maximum Project parameters for the impact assessment
General arrangement: Turbine numbers	Stage 1: 30 turbines Stages 1 and 2: 200 turbines
General arrangement: Turbine spacing	Minimum cross-flow spacing: 80m Minimum down-flow spacing: 150m
General arrangement: Turbine layout	Turbines will be arranged in rows perpendicular to the direction of the prevailing tidal flow, with 2 – 15 turbines per row and between 10 and 40 rows in total.

Project parameters relevant to the impact assessment	Maximum Project parameters for the impact assessment
	An indicative layout has been defined in the Project Description based upon these maximum Project parameters and this has been used as the basis for the impact assessment. It is acknowledged that the final arrangements will depend on the turbine type, rating and numbers, resource availability and seabed conditions.
Specific element: Turbine	Rotor diameter: 23m Total swept area: 415m^2
Specific element: Turbine support structure (TSS)	Type: GBS supporting a central supporting column Seabed contact: flat bottom Dimensions: 30 x 40 x 2.5m
Specific element: Cable connecting hubs	Stage 1: 4 subsea hubs Stages 1 and 2: 16 subsea hubs Hub dimensions: 15m length x 7m diameter Support structure: subsea base

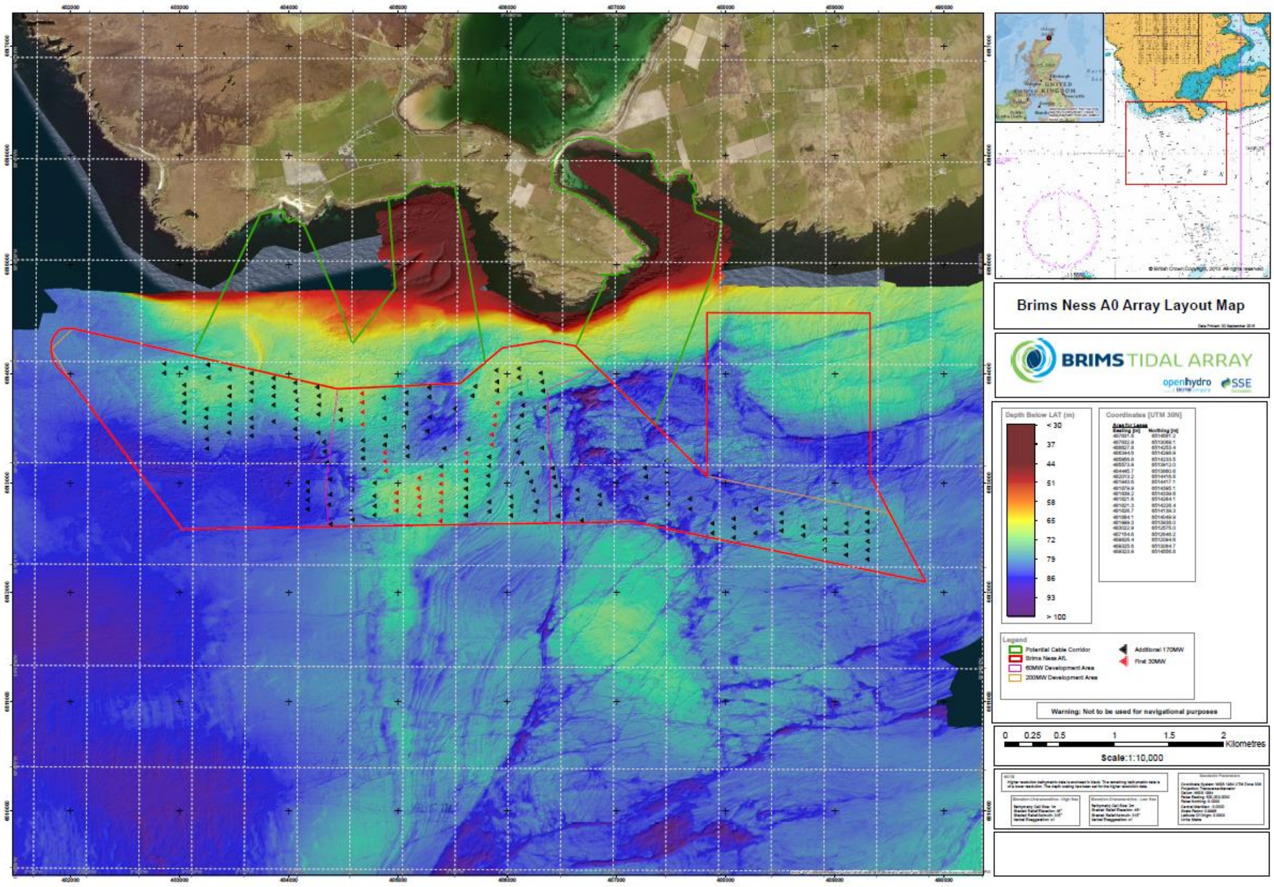

Figure 9.7 Indicative Project layout

Results from the worst case tidal regime modelling for Stage 1 only are shown in Figure 9.8 and Figure 9.9 for a spring tide (at times of high water and low water and at times of peak ebb and peak flood, respectively). The maximum modelled differences in current speed at any time during the tidal cycle are shown in Figure 9.10.

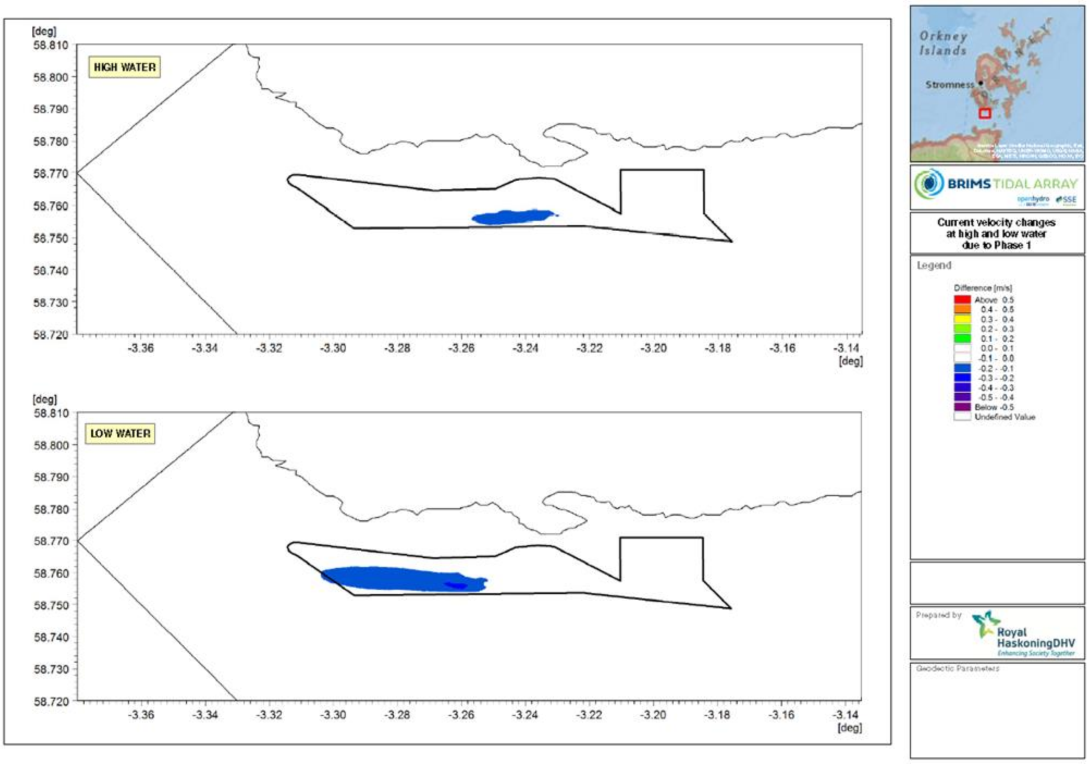

Figure 9.8 Current velocity changes at high and low water – Stage 1

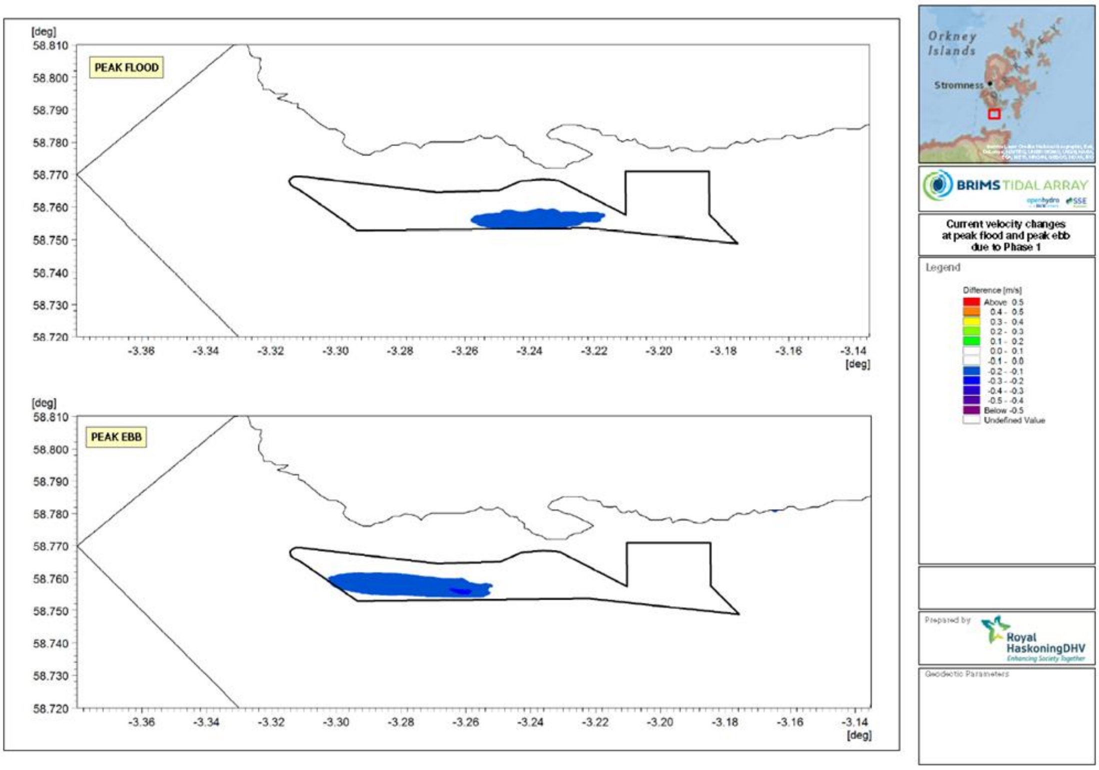

Figure 9.9 Current velocity changes at peak flood and ebb - Stage 1

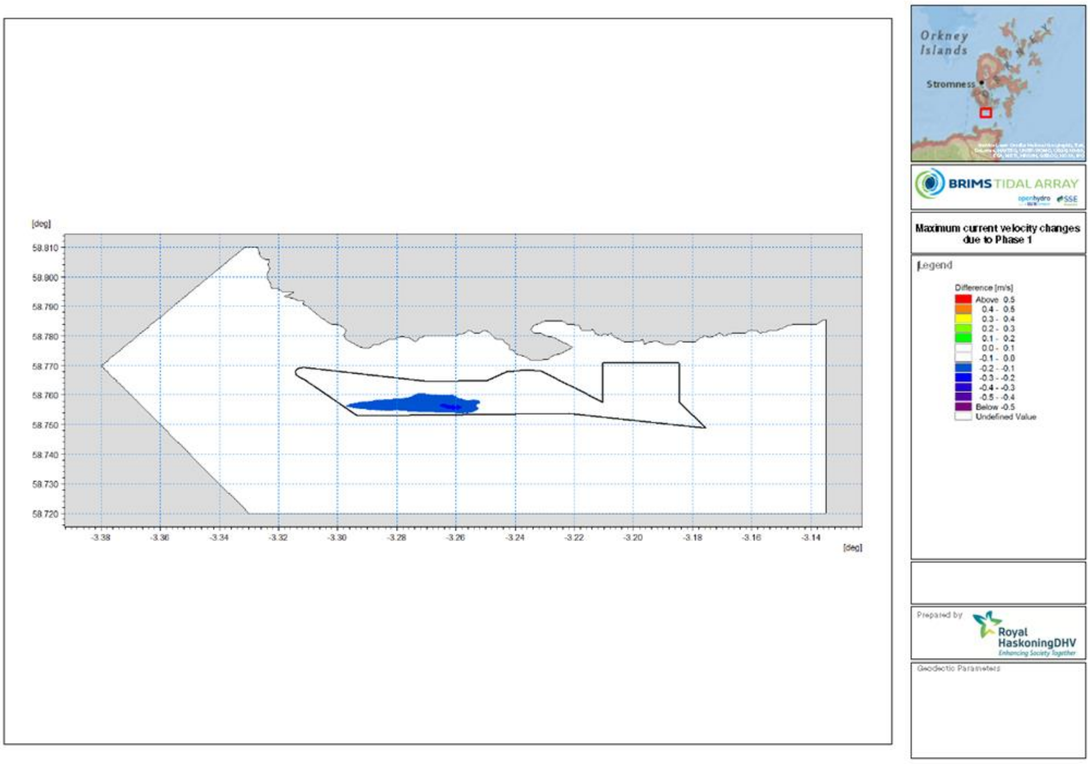

Figure 9.10 Maximum current velocity changes - Stage 1

Similar results for a spring tide are shown for Stages 1 and 2 combined in Figure 9.11 and Figure 9.12 (at times of high water and low water and at times of peak ebb and peak flood, respectively), with the maximum modelled differences in current speed at any time during the tidal cycle shown in Figure 9.13.

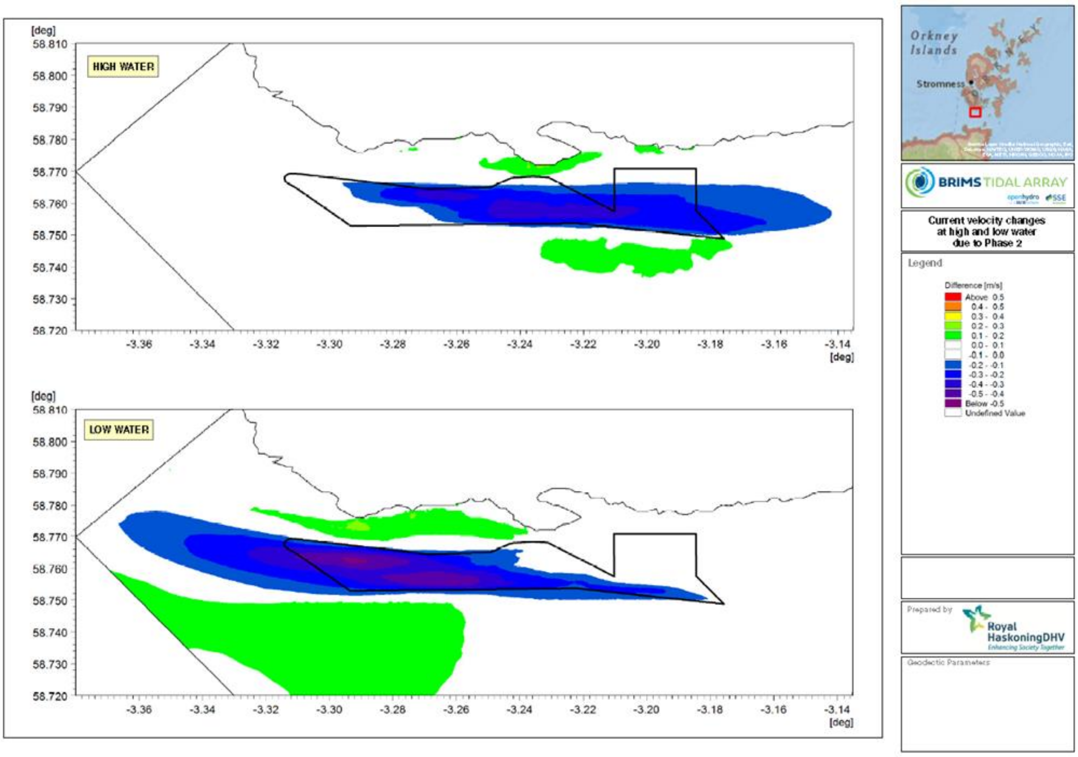

Figure 9.11 Current velocity changes at high and low water - Stage 1 and 2

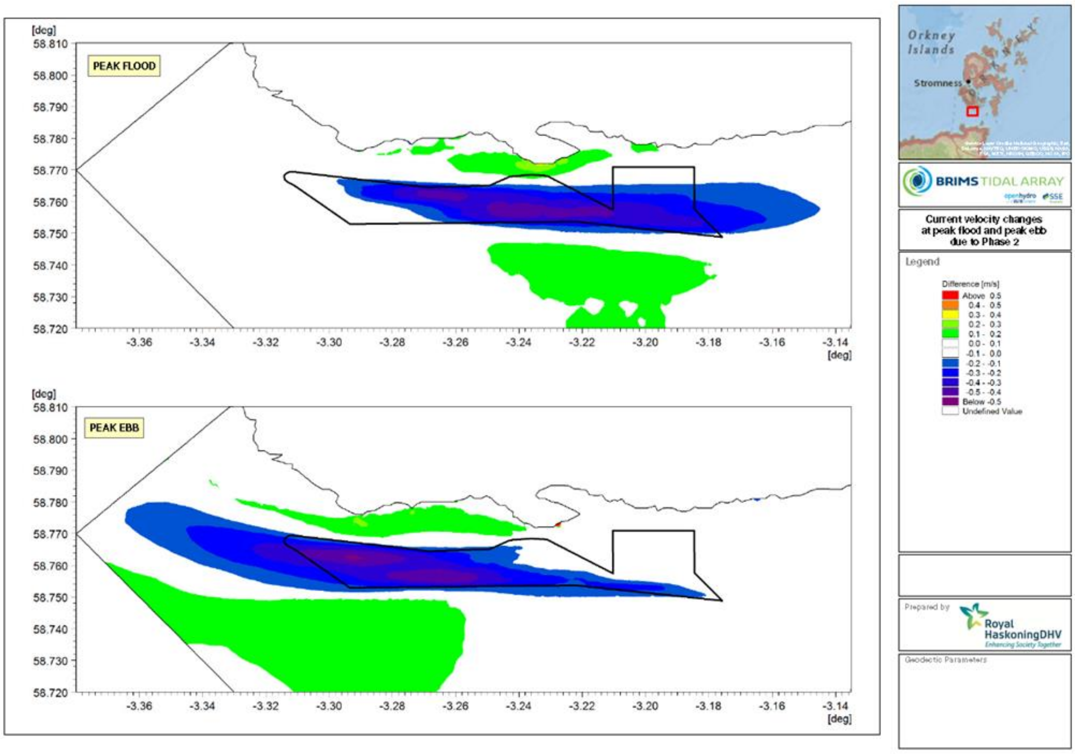

Figure 9.12 Current velocity changes at peak flood and peak ebb - Stage 1 and 2

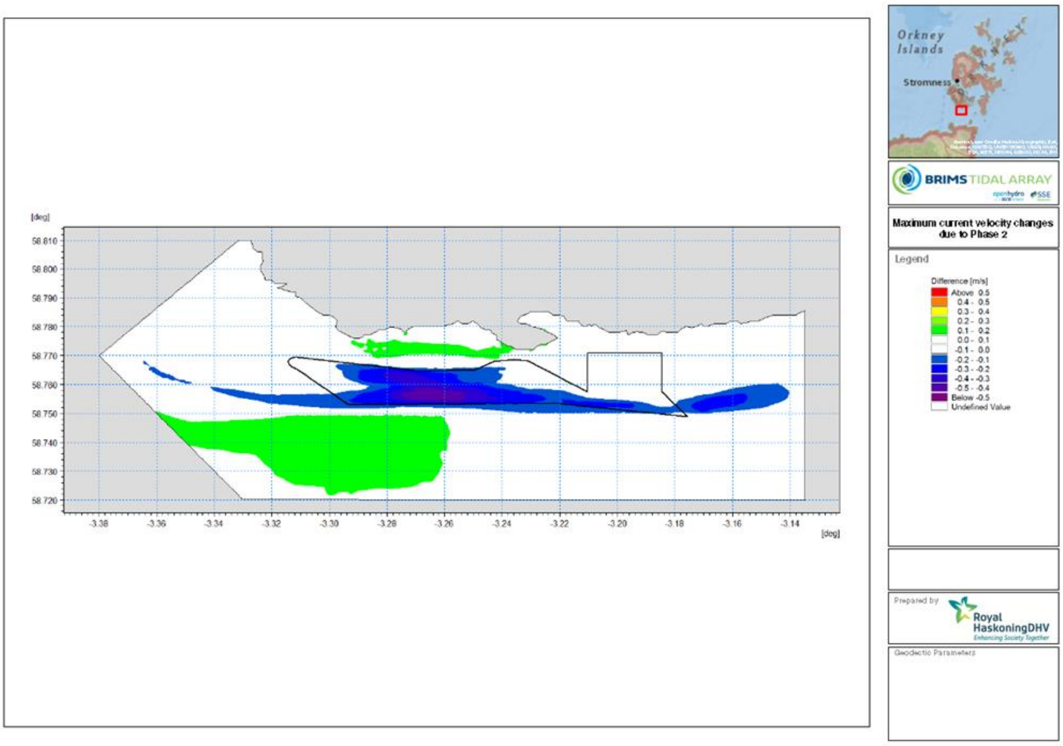

Figure 9.13 Maximum current velocity changes - Stage 1 and 2

Generally, the model outputs show a zone extending from the AfL directly along the west-east aligned flow-axis in the direction of the dominant tidal state (i.e. flood or ebb direction). Within this zone the baseline currents are reduced in the form of a wake.

For Stage 1 only, the wake remains within the boundaries of the AfL and typically causes a reduction in baseline flow of between 0.1 – 0.2m/s. This is within a baseline tidal regime which experiences peak currents in excess of 2m/s during neap tides and in excess of 3.5m/s during spring tides.

For Stages 1 and 2 combined, both the spatial extent of the wake and the magnitude of reductions in baseline currents are greater. Despite some localised higher reductions in baseline currents immediately adjacent to some individual turbines (e.g. of the order of 0.5m/s locally), the magnitude of the wake variation remains relatively small beyond the boundaries of the AfL (typically <0.3m/s). This change represents a relatively small percentage reduction in the generally high baseline flow conditions and the wake effect dissipates to baseline conditions within 3km of the boundary of the AfL.

For Stage 1 only and for Stages 1 and 2 combined, the spatial extent of the wake is highly restricted in lateral expansion (i.e. the wake is restricted to within the northern and southern boundaries of the AfL due to the strongly west-east aligned baseline currents that prevail).

The modelling results also show that for Stages 1 and 2 combined, the larger wake effect is also associated with an acceleration of flow around the edges of the combined arrays. The magnitude of change in baseline currents is relatively small compared to baseline values (with accelerations typically of 0.1 – 0.2m/s). At the time of peak ebb, the zone affected by these changes approach the shoreline between The Mares (west of Brims Ness) and Tor Ness (and the near-shore zone further west of Tor Ness), while at the time of peak flood the zone affected by these changes extends from around Tor Ness further east, past Brims Ness. In both situations, there are no changes within Aith Hope or at the shoreline of The Ayre beach and dune system. However, at both peak flood and especially at peak ebb, the zone of accelerated flow does extend very close to shore (although not directly to the shoreline itself) at both the Sheep Skerry landfall location and the Melberry beach and dune system and it also affects the shore at the Moodies Eddy landfall location. The Sheep Skerry and Melberry sites contain some sand overlying bedrock outcrops at the shore, with a dune and machair system landward. The changes in tidal regime are small in magnitude (compared to natural variability within the tidal regime which can range from near zero at slack water to peak currents in excess of 3.5m/s), located slightly offshore of the sites, and are confined to particular phases of the tide. Therefore such changes are not expected to cause measureable changes in beach levels at these sites. At the Moodies Eddy landfall, the shore is characterised by coarser material (e.g. boulders) overlying bedrock and hence the small magnitude changes, occurring only for part of the tidal cycle, will not cause measureable changes in beach levels.

Modelling was also undertaken to assess the relative contributions to the changes in tidal regime arising from the turbines and the TSS. This revealed that the changes due to the TSS only were less than ±0.1m/s (i.e. immeasurable change). Consequently, the turbines contribute the greatest proportion of the change.

The maximum changes that are observed by the modelling under a conservative worst case assumption are relatively modest beyond the immediate confines of the AfL. Directly at the location of each turbine and foundation the effects are greatest, but these diminish rapidly with distance downstream. In all cases the wake effects fully dissipate within a few kilometres of the AfL. Localised accelerations in flow also occur around the AfL, potentially affecting parts of the shoreline and parts of the seabed further offshore of the AfL.

Table 9.23 Summary of residual effects on seabed and shoreline morphology arising from changes in tidal regime during the operation and maintenance phase

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Turbines, TSS and hubs	Seabed	Negligible	PD01-04 GM01-04	Medium (near-field)	Project design and general mitigation	Negligible
Turbines, TSS and hubs	Shoreline	Low	PD01-04 GM01-04	Low (far-field)	As above	Negligible

Changes in the tidal regime are also important to consider in the assessment of effects on Coastal and Terrestrial Ecology and Benthic Ecology (see Chapters 10 and 11) and Shipping and Navigation (see Chapter 15).

9.12.2.2 Changes in wave regime due to the presence of Project infrastructure

Once installed within the AfL, turbines and their associated TSS as well as connecting hubs and their support structures will have the potential to affect the wave regime. This effect will be most notable for either: (1) turbines with TSS or connecting hubs and support structures that occupy a sufficient height within the water column to interact with the wave base; or (2) turbines with TSS or connecting hubs and support structures that present the greatest cross-sectional area as a solid mass, albeit closer to the seabed, causing greatest potential for blockage (depending on water depth).

The changes invoked by the turbines and their TSS as well as connecting hubs and their support structures could lead to a modification of the wave regime within the array (near-field scale) or down-wave of the array beyond the AfL (far-field scale).

In defining a worst case assumption, consideration was given to: (i) the turbine and TSS types considered as being representative of those which may potentially be used within the AfL; (ii) the typical water depths across the site; and (iii) the characteristics of the baseline wave regime (especially wave height, wave period and wavelength).

Structures that extend through all, or a notable part of, the water column (such as monopiles and pin piles) may cause diffraction of the wave trains if they are sufficiently large in diameter with respect to the wavelengths that prevail in the baseline wave climate. To investigate this issue, consideration was given to wave theory which relates the pile diameter (D) to the wavelength (L) of the incident waves. Diffraction effects become important when $D/L \geq 0.2$. Using the maximum monopile diameter described in Chapter 5 Project Description (2.8m), diffraction effects would become important when the wavelength is very short (14m or less). Wave heights typical of the AfL are in the range 1.72 – 2.48m with corresponding wave periods of 4.8 – 16.4 s (as measured during the metocean survey) and due to this wavelengths are a minimum of 35m and a maximum of several hundred metres. Consequently, wave diffraction is not induced by a worst case monopile foundation of 2.8m in diameter (which in any case does not extend through the whole water column and therefore is unlikely to interfere with the wave base), confirming that effects on the wave regime from these types of TSS or hub support structures will be confined to local scale reflections and blockage, but that the wave trains will regroup and return to baseline values within a short distance of each TSS or hub support structure.

Structures that present the greatest cross-section area as a solid mass are generally bed-mounted GBS. The largest GBS dimensions (30 x 40m base by 2.5m height above the seabed) are associated with TSS. These structures could potentially interact with the base of a wave as it passes the structure, depending on the water depth (d) and wavelength (L). In situations where $d < L/20$, there will be considerable interaction between the wave and the seabed (including the base of the GBS). If $d > L/2$ there will be no interaction as the water depth is sufficiently great with respect to the wavelength. In intermediate situation ($L/20 < d < L/2$) there may be some interaction between the wave and the seabed. For the range of water depths (60 -110m) and wavelengths (36 – 420m) measured during the metocean survey within the AfL, there will be no (or only very limited) interaction between the wave and the seabed under mean measured conditions, but some (very limited) interaction under peak measured conditions (when wavelengths could reach hundreds of metres). This natural interaction between the wave and the seabed under peak measured conditions will be accentuated by the presence of the GBS, and whilst there potentially could be a relatively large number of these within the AfL each one remains relatively small in base size (compared for example to GBS used for offshore wind farms which can be of the order of 70m in diameter at the base) and they protrude only a small height off the seabed, thus limiting their ability to cause significant change to the passing wave trains. It is expected that whilst under some stormier conditions there will be a local-scale (and small magnitude) interaction between the waves and the TSS, any far-field changes will be immeasurable.

Since there is presently a degree of wave-current interaction occurring within the AfL, whereby wave heights can become increased during the ebbing phase of the tide by the interaction between the prevailing wave trains and the strong ebb tide currents, there is also the potential for the wave regime to be affected indirectly, i.e. as a consequence of alterations to the tidal regime. As previously mentioned, the currents within the AfL will generally be reduced by a small magnitude and, for Stages 1 and 2 combined, there will also be a slight increase in currents (including during the ebbing tide) around the sides of the AfL boundary. Due to this, there is potential for slightly reduced wave-current interaction within the AfL and slightly increased wave-current interaction in some areas of the seabed, including close to shore, to the north and south of the AfL. However, the changes in current are small in magnitude and their effect on wave-current interactions will be well within the bounds of naturally occurring behaviour at different stages of the tide.

Table 9.24 Summary of residual effects on seabed and shoreline morphology arising from changes in wave regime during the operation and maintenance phase

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Turbines, TSS and hubs	Seabed	Negligible	PD01-04 GM01-04	Low (near-field)	Project design and general mitigation	Negligible
Turbines, TSS and hubs	Shoreline	Low	PD01-04 GM01-04	Negligible (far-field)	As above	Negligible

Changes in the wave regime are also important to consider in the assessment of effects on Coastal and Terrestrial Ecology and Benthic Ecology (Chapters 10 & 11) and Shipping and Navigation (Chapter 15).

9.12.2.3 Changes in sediment regime due to the presence of Project infrastructure

Changes in the sediment regime will arise either: (i) as an indirect effect, consequent upon changes in the tidal and/or wave regimes; or (ii) as a direct effect due to blockage of bedload sediment transport by the foundations, connecting hubs, surface-laid cables and export cable protection works on the seabed.

As the effects arising from changes to the tidal regime and wave regime (both previously assessed) are at worst of negligible significance (no discernible change), then so the associated knock-on effects on prevailing sediment transport conditions will be of negligible significance (no discernible change).

The worst case for potential direct blockage of (bedload) sediment transport by TSS is associated with a GBS measuring 30 x 40m (and 2.5m height off the seabed), used for each turbine. There may also be up to 8 subsea connecting hubs within the AfL (up to 4 of which would be installed during Stage 1) which may also be founded on GBS (although these would be likely to be of considerably smaller dimensions). However, bedload sediment transport is not expected to be a significant issue within the AfL because the seabed is largely swept-clear of sediments by the strong tidal currents. Where sediment is located within crevices in the bedrock it does not form part of an active transport system. In the small number of locations where some sediment cover is present, namely where the export cable corridors enter the AfL and in a localised patch in the south west corner, there may be some localised interruption to bedload transport but this is expected to be negligible in the context of the overall Stage 1 (only) and Stages 1 and 2 (combined) seabed areas.

Surface-laid inter-array and subsea export cables, together with the export cable protection works, will present an obstacle to bedload sediment transport up to a short height off the seabed. However, within the AfL and across many parts of the three potential export cable corridors, there is little mobile sediment available for bedload transport. Where the export cable corridor (and in particular any export cable protection works) cross patches of surficial sediment, there is expected to be a greater interaction with the baseline sediment transport regime. However, if bedload transport processes are active in these areas (i.e. in situations when an impact would potentially occur), then it would be expected that a ‘ramp’ of sediment would rapidly form against the surface-laid cable or export cable protection works and ongoing bedload transport process would then occur across the ramp. Such processes are commonly observed across gas pipelines on the seabed in areas of active sediment transport.

Given that there is so little mobile sediment potentially available for bedload transport within the AfL, the potential for interruption of sediment transport by the TSS, connecting hub support structures and surface-laid array cables is extremely limited. The greatest potential effect on sediment transport will arise in parts of the three potential export cable corridors where sediment cover is present, but there the effect will only occur until a ramp of sediment forms to enable 'bypassing' over the obstruction.

Since there is a field of sandwaves on the seabed several kilometres west of the AfL that are indicative of westward-directed bedload transport, there is theoretically a potential for either direct or indirect changes in the tide, wave or sediment transport processes to affect the sediment regime extending to this area of the seabed. However, the changes in tide, wave or sediment transport processes are small in magnitude and relatively localised to within, or just beyond the AfL and therefore no significant effects on the seabed several kilometres west of the AfL are envisaged.

Table 9.25 Summary of residual effects on seabed and shoreline morphology arising from changes in sediment regime during the operation and maintenance phase

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Turbines, TSS and hubs	Seabed (near-field effects)	Negligible	PD01-04 GM01-04	Medium (near-field)	Project design and general mitigation	Negligible
Turbines, TSS and hubs	Shoreline (far-field effects)	Low	PD01-04 GM01-04	Low (far-field)	As above	Negligible
Inter-array cables	Seabed	Negligible	PD05, GM05	Negligible	As above	Negligible
Export cables and cable protection	Seabed	Negligible	PD05, GM05	Low	As above	Negligible
Export cables landfall	Shoreline	Low	PD05, GM05 & PP01	Negligible (cable buried)	As above plus micro-siting of landfall cables	Negligible

Changes in the sediment regime are also important to consider in the assessment of effects on marine water quality (see Chapter 9), Coastal and Terrestrial Ecology and Benthic (see Chapters 10 and 11), Fish Ecology (see Chapter 12), Commercial Fisheries (see Chapter 16) and Shipping and Navigation (see Chapter 15).

9.12.2.4 Changes in morphology due to the footprint of Project infrastructure

The physical presence of TSS, connecting hub support structures, surface-laid cables and export cable protection works will create a 'footprint' imposed on the seabed that will directly cover the seabed morphology.

The worst case footprint for TSS is associated with GBS. If it is assumed that all 30 turbines in Phase 1 use GBS and all 200 turbines in Stages 1 and 2 combined use GBS, then the total seabed footprint from TSS is 36,000m^2 for Stage 1 only and 240,000m^2 for Stages 1 and 2 combined. These worst case values represent 0.3% and 2% respectively of the total seabed area within the AfL (11.1km^2). When inter-array cables, export cables and export cable protection works are also considered, the total areas affected increase, but remain within relatively small percentages of the total seabed area within the AfL.

The export cables will be buried (through open cut trenching, short HDD or long HDD) at their landfall and it is therefore expected that export cable protection works will not be required in any significant extent within the ‘closure depth’ of the active beach profile at any of the potential landfall locations and therefore the effects on shoreline morphology due to physical footprints of export cable protection works (or indeed indirectly due to effects on shoreline sediment transport) will not be applicable.

Table 9.26 Summary of residual effects on seabed and shoreline morphology arising from changes due to the footprint of the Project infrastructure

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
GBS type of TSS	Seabed	Negligible	PD01-04 GM01-04	Low (up to only 2% of seabed affected)	Project design and general mitigation	Negligible
Inter-array cables	Seabed	Negligible	PD05, GM05	Low (small direct footprint)	As above	Negligible
Export cables and cable protection	Seabed	Negligible	PD05, GM05	Low (small direct footprint)	As above	Negligible
Export cables landfall	Shoreline	Low	PD05, GM05 & PP01	Negligible (cable buried)	As above plus micro-siting of landfall cables	Negligible

Changes in morphology due to the footprint of the Project infrastructure is also important to consider in the assessment of effects on Coastal and Terrestrial Ecology and Benthic Ecology (see Chapters 10 and 11).

9.12.2.5 Changes in tide, wave and sediment regime due to the presence of maintenance vessels

During the operation and maintenance phase, a number of specialist vessels will be used for maintenance activities. While these are present at the site, their jack-up legs, anchors and hulls will exert influences on the baseline physical processes and (in the case of the legs / anchors) the seabed geomorphology.

Due to the predominance of exposed bedrock, with occasional boulders, across much of the AfL and parts of the cable corridors, the legs / anchors of installation vessels will cause no change on the seabed geomorphology. Where veneers or deeper sequences of coarse-grained sediments are present in local areas, there will be small ‘footprints’ created in the seabed, but given the coarse-grained nature of the sediments, these will become infilled and/or re-worked by natural processes once the loading forces are removed.

Due to the temporary and highly localised presence of the vessels at any one location within the Project site and subsea cable corridor, the maintenance vessels will not cause significant effects on the wave, tide and sediment regimes.

Table 9.27 Summary of residual effects on seabed and shoreline morphology arising from changes in tide, wave and sediment regimes due to the presence of maintenance vessels

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Installation vessels	Seabed	Negligible	PD01-04 GM01-04	Negligible	Project design and general mitigation	Negligible
Installation vessels	Shoreline	Low	PD05, GM05 & PP01	Negligible	As above plus micro-siting of landfall cables	Negligible

Changes in the tide, wave and sediment regimes due to the presence of maintenance vessels are also important to consider in the assessment of effects on marine water quality (see Chapter 9), Coastal and Terrestrial Ecology and Benthic Ecology (see Chapters 10 and 11), Fish Ecology (see Chapter 12), Shipping and Navigation (see Chapter 15) and Commercial Fisheries (see Chapter 16).

9.12.3 Decommissioning

9.12.3.1 Changes in suspended sediment concentrations due to removal activities

During the decommissioning phase there is potential for removal activities to disturb sediments and release them into the water column as a plume. This will enhance the baseline suspended sediment concentrations in the water column, making the water column more turbid, until the plume becomes dispersed by tidal current action and the sediments settle once again on the seabed.

The decommissioning activities that may lead to such disturbance effects of sediments from the seabed surface include:

- the activity of removal of turbines, TSS, hubs, hub support structures, navigation buoys, inter-array cables, export cables and export cable protection works from the seabed; and
- deployment of anchors or jack-up legs of specialist vessels during the removal of the above Project infrastructure.

The effects on suspended sediment concentrations arising during the decommissioning phase would be likely to be less in magnitude than those identified for the construction phase, since mostly (limited) surficial sediment would be disturbed, rather than sub-seabed sediment that was considered as arising from drilling during the construction phase. To consider a worst case, however, it has been assumed in these assessments that the magnitude of effect during decommissioning will be similar to that arising during construction.

Based on the previous construction phase assessments, it is concluded that the sediment plumes resulting from the decommissioning phase will be low in concentration and temporary in nature due to the highly limited presence mobile seabed sediments and the high tidal currents which prevail.

Table 9.28 Summary of residual effects on seabed or shoreline morphology arising from changes in suspended sediment concentrations due to decommissioning activities

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Turbines, TSS and hubs	Seabed	Negligible	PD01-04 GM01-04	Medium (near-field)	Project design and general mitigation	Negligible
Turbines, TSS and hubs	Shoreline	Low	PD01-04 GM01-04	Low (far-field)	As above	Negligible

Changes in the suspended sediment concentrations do not directly have impacts on the identified shoreline or seabed geomorphological receptors per se (they simply affect turbidity in the water column), but these effects are important to consider because they inform subsequent assessment of impacts arising from sediment deposition (see below).

These changes in suspended sediment concentrations are also important to consider in the assessment of effects on marine water quality (see Chapter 9), Coastal and Terrestrial Ecology and Benthic Ecology (see Chapters 10 and 11), Fish Ecology (see Chapter 12), Shipping and Navigation (see Chapter 15) and Commercial Fisheries (see Chapter 16).

9.12.3.2 Changes in sediment deposition due to removal activities

Any sediment that becomes entrained within a plume during the decommissioning phase will have the potential to become deposited on the seabed at some distance from its point of disturbance or release as it settles through the water column to the seabed.

In keeping with changes in suspended sediment concentrations (discussed above) the effects on sediment deposition during the decommissioning phase would be likely to be less in magnitude than those identified for the construction phase, since mostly (limited) surficial sediment would be disturbed, rather than sub-seabed sediment that was considered as arising from drilling during the construction phase. To consider a worst case, however, it has been assumed in these assessments that the magnitude of effect during decommissioning will be similar to that arising during construction.

Based on the previous construction phase assessment, it is concluded that the sediment deposits on the seabed resulting from the decommissioning phase will be very low in magnitude (immeasurable using conventional survey techniques). Any deposits will be temporary in nature due to the high tidal currents which prevail that will re-suspend and further disperse any deposited sediments.

Table 9.29 Summary of residual effects on seabed or shoreline morphology arising from changes in sediment deposition due to decommissioning activities

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
GBS or SSB types of TSS	Seabed	Negligible	PD01-04 GM01-04	Negligible	Project design and general mitigation	Negligible
Monopile or pin pile TSS	Seabed	Negligible	PD01-04 GM01-04	Low	As above	Negligible
Export cables	Seabed	Negligible	PD05 & GM05	Negligible	As above	Negligible
Cable landfall	Shoreline	Low	PD05, GM05 & PP01	Low	As above plus micro-siting of landfall cables	Negligible

Changes in sediment deposition are also important to consider in the assessment of effects on Coastal and Terrestrial Ecology and Benthic Ecology (see Chapters 10 and 11), Fish Ecology (see Chapter 12), Shipping and Navigation (see Chapter 15) and Commercial Fisheries (see Chapter 16).

9.12.3.3 Changes in tide, wave and sediment regimes due to the presence of decommissioning vessels

Similar specialist vessels will be used for the decommissioning phase as were assessed during the construction phase and therefore the magnitude of effects will be similar.

While these specialist vessels are present at the site, their jack-up legs, anchors and hulls will exert influences on the baseline physical processes and (in the case of the legs/anchors) the seabed geomorphology.

Due to the predominance of exposed bedrock, with occasional boulders, across much of the AfL and parts of the cable corridors, the legs / anchors of installation vessels will cause no change on the seabed geomorphology. Where veneers or deeper sequences of coarse-grained sediments are present in local areas, there will be small ‘footprints’ created in the seabed, but given the coarse-grained nature of the sediments, these will become infilled and/or re-worked by natural processes once the loading forces are removed.

Due to the temporary and highly localised presence of the vessels at any one location within the Project site and subsea export cable corridor, the specialist vessels will not cause significant effects on the wave, tide and sediment regimes.

Table 9.30 Summary of residual effects on seabed or shoreline morphology arising from changes in tide, wave and sediment regimes due to the presence of decommissioning vessels

Technology Option	Receptor	Sensitivity	Mitigation	Residual Magnitude	Summary	Residual Significance
Vessels	Seabed	Negligible	PD01-04 GM01-04	Negligible	Project design and general mitigation	Negligible
Vessels	Shoreline	Low	PD05, GM05 & PP01	Negligible	As above plus micro-siting of landfall cables	Negligible

Changes in the tide, wave and sediment regimes due to presence of specialist vessels are also important to consider in the assessment of effects on marine water quality (see Chapter 9), Coastal and Terrestrial Ecology and Benthic Ecology (see Chapters 10 and 11), Fish Ecology (see Chapter 12), Shipping and Navigation (see Chapter 15) and Commercial Fisheries (see Chapter 16).

9.13 SUMMARY

The principal effects on the baseline physical processes environment are of negligible, low or medium magnitude only. However, due to their relative low (shoreline) or negligible (seabed) sensitivities to changes of the magnitudes expected, the proposed Project will have effects of negligible significance on the seabed and shoreline morphology.

The effects on the baseline physical processes environment may in turn have impacts on other receptors (such as benthic ecology, fish ecology, commercial fisheries and shipping and navigation) and these are assessed in the respective chapters of this ES.

In terms of the physical processes environment, there are no cumulative or in-combination effects that could potentially arise between the proposed Project and other seabed activities in the vicinity.

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