Project Title	Seagreen Wind Energy Ltd
Document Reference Number	LF000009-CST-OF-REP-0021

Seagreen Alpha and Bravo Offshore Wind Farms

Alternative Landfall Cable Installation Marine Licence Application – Environmental Report

Rev	Date	Reason for Issue	Originator	Checker	Approver
1.0	21/06/2019	Approved for use	[Redacted]		

Table of Contents

Glossary

Term	Definition
AOD	Above Ordnance Datum
Cable	Seagreen Alpha and Seagreen Bravo Offshore Wind Farm's transmission high voltage (HV) alternating current (AC) 275 kV or Direct Current (DC) 220 kV subsea export cable.
HDPE Pipe	High-density polyethylene pipe. HDPE Pipes are laid in a trench, which is backfilled, before the export cable is pulled through them
EC1	Export cable 1
EC2	Export cable 2
EC3	Export cable 3
FRA	Flood Risk Assessment
GCR	Geological Conservation Review
Horizontal Directional Drilling (HDD)	A steerable, trenchless, method of installing an underground pipe, conduit or cable in a shallow area along a prescribed bore path by using surface-launched drilling equipment, with minimal impact on the surrounding area.
HRA	Habitats Regulations Appraisal
IHLS	International Herring Larvae Survey
Jointing bay / transition pit	The location at which the offshore cable joins the onshore cable, often within a pit excavated into the ground which is then backfilled once the join has been completed.
LAT	Lowest Astronomical Tide
MHWS	Mean high water spring tide mark is located part-way along the seaward face of the rock revetment.
MLWS	Mean low water spring tide mark.

Term	Definition
MS-LOT	Marine Scotland Licensing Operations Team
MSS	Marine Scotland Science
OTA	Offshore Transmission Asset
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PAC	Pre-Application Consultation
pSPA	proposed Special Protection Area
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SSC	Suspended Sediment Concentrations
SSSI	Site of Special Scientific Interest

1. Introduction

1.1 Overview

This Environmental Report has been prepared in support of a Marine Licence application by Seagreen Wind Energy Ltd (Seagreen) for an alternative landfall cable installation methodology. The alternative methodology is for ploughing or mechanical trenching (also termed 'open cut' trenching), which is being considered in addition to the already consented Horizontal Directional Drilling (HDD) installation methodology, although only one installation methodology will be implemented.

Under the Marine (Scotland) Act 2010, a Marine Licence is required if a person or organisation intends to carry out marine construction works within the Scottish marine area seaward of MHWS and therefore a Marine Licence is required for the alternative cable installation methodology up to the point of MHWS.

The Marine Licence application boundary for the alternative landfall cable installation methodology is shown in Figure 1.1, and includes the rock revetment and the intertidal and subtidal zones. The works landward of the rock revetment are subject to separate onshore planning approval from Angus Council and do not form part of this Marine Licence application.

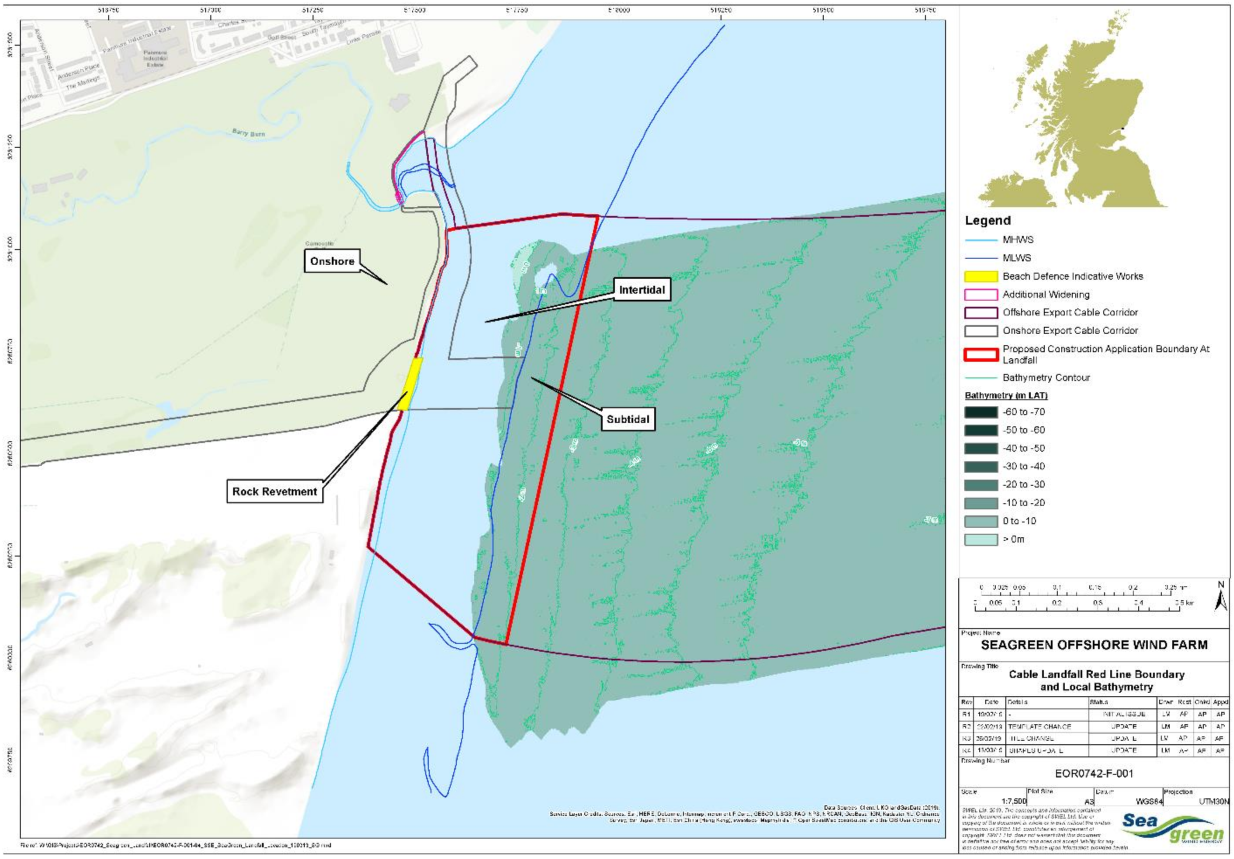


Figure 1.1: Cable Landfall Red Line Boundary and Local Bathymetry.

1.2 Background

Seagreen is developing the Seagreen Alpha and Seagreen Bravo offshore wind farms off the east coast of Scotland in the outer Firth of Forth and Firth of Tay area (Figure 1.2). The projects received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers in 2014 (the S.36 Consents) (subsequently varied to remove capacity limits, August 2018) and were granted three Marine Licences from the Scottish Ministers in 2014, one for Seagreen Alpha, one for Seagreen Bravo, and one for the Offshore Transmission Asset (OTA). The Onshore Transmission Asset (the onshore export cable from landfall at Carnoustie to a new substation at Tealing) was subject also to a separate planning application under the Town and Country Planning (Scotland) Act 1997 and was granted Planning Permission in principle by Angus Council in January 2013. This was extended by Angus Council in December 2016, following re-application by Seagreen.

Seagreen Alpha and Seagreen Bravo will together comprise up to 150 wind turbine generators (WTGs) with associated foundations, inter-array cables, offshore substation platforms (OSPs) and meteorological masts. The OTA cable corridor makes landfall at Carnoustie, in Angus (Figure 1.3).

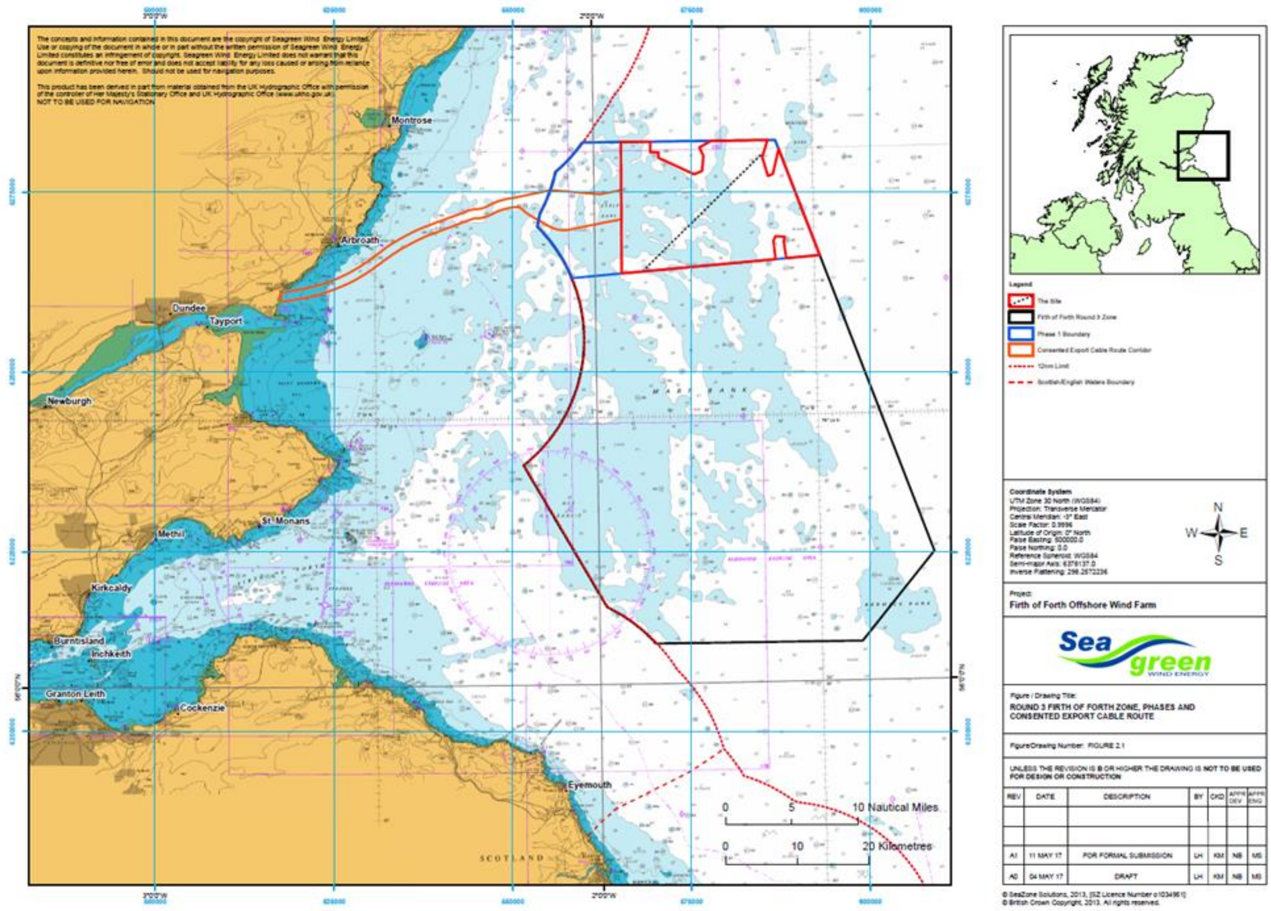


Figure 1.2: Firth of Forth Zone, Seagreen Alpha and Seagreen Bravo Offshore Wind Farms and the Export Cable Route Corridor.

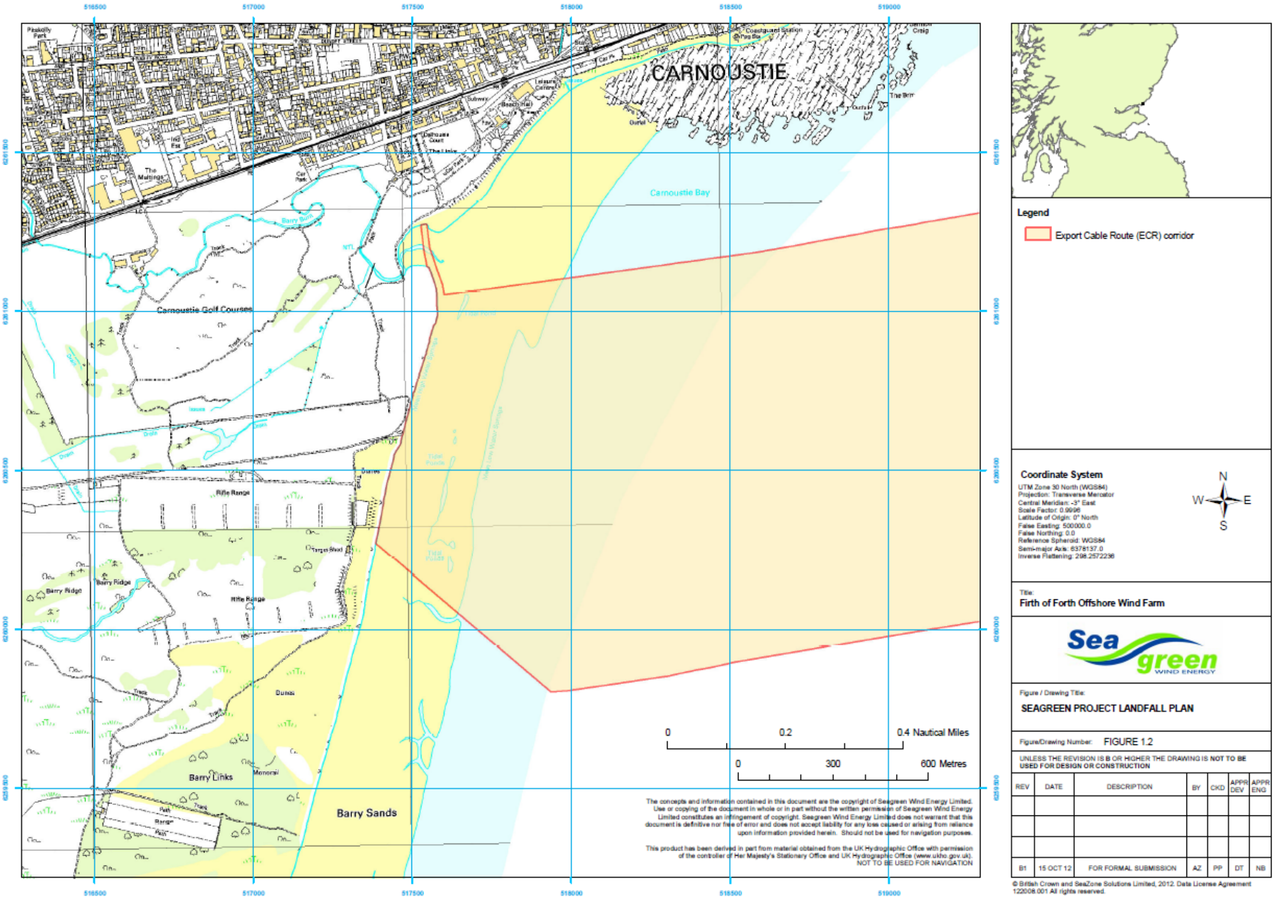


Figure 1.3: Seagreen Export Cable Route Corridor Landfall

The landfall at Carnoustie consists of a sandy beach backed by a rock revetment. The rock revetment was installed as a coastal defence measure along the coast from Carnoustie, to just north of Buddon Ness to the south. The rock revetment is approximately 3.5 km in length and 30 m wide. The distance between the charted Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS) is approximately 250 m (Figure 1.1 and see also further discussion in Section 2.2).

The existing OTA Marine Licence (Licence Number 04678/14/0) as updated in 2019 (Licence Number 04678/19/0) (in Part 2, Section 2.2) permits the installation of up to six export cables between the Seagreen Alpha and Seagreen Bravo OWFs and the landfall. The OTA Marine Licence states the following in relation to the landfall:

> ‘*Export cable installation at intertidal area will be by Horizontal Directional Drilling (“HDD”) under the coastal defence from above MHWS and continued by ploughing or mechanical trenching across the intertidal area to meet the offshore works.*’

The alternative method is for ploughing or mechanical trenching (also termed ‘open cut’ trenching), between the original proposed landward entrance points of the HDD (approximately 100 m above MHWS), through the rock revetment, down to a depth of 2.5 m (LAT) (approximately 190 m below charted MLWS). It should be noted that the key changes between the alternative methodology and the consented methodology is that the works will undertake trenching through the revetment as opposed to HDD under the revetment and that an additional option is being proposed to excavate a single trench, to accommodate up to three cables (as opposed to installation of up to six cables as consented).

This Environmental Report aims to address potential impacts related to these changes while also considering the potential impacts of activities associated with construction of the landfall. This approach is being taken in order to ensure that a holistic and robust assessment of potential effects is undertaken.

1.3 Consultation

Marine Scotland Licensing Operations Team (MS-LOT) was notified of the intention to submit a Marine Licence application for the alternative methodology at the end of 2018, and regular bi-weekly calls have been held subsequently with MS-LOT regarding the Seagreen project.

In March 2019, Seagreen undertook consultation with MS-LOT on the approach to gaining consent for the alternative landfall cable installation method through the development of a Consenting Approach document (Seagreen, 2019a) which was submitted on 18th March 2019. The Consenting Approach document described Seagreen's intended approach for preparing a Marine Licence application and set out the proposed scope of an Environmental Report to be submitted in support of the application. Following the submission of the Consenting Approach document a meeting was held with MS-LOT on 20th March 2019. The Consenting Approach document and the overall approach to undertaking the licence application was discussed with MS-LOT during the meeting. At the meeting it was agreed that with reference to the relevant criteria under the Marine Licencing (Pre-application Consultation (PAC)) (Scotland) Regulations 2013, PAC would not be required. It was also agreed at the meeting that the scope of the Environmental Report presented in the Consenting Approach document was likely to be appropriate. The requirement for Environmental Impact Assessment (EIA) was also discussed and while it was considered that EIA under the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended) ("the 2017 MW Regulations") was unlikely to be required, MS-LOT stated that this position would be confirmed in writing following the meeting. Following this meeting, MS-LOT advised Seagreen to submit a request for an EIA Screening Opinion under Regulation 10(1) of the 2017 EIA Regulations. Seagreen submitted the EIA Screening Request on 4th April 2019 and received an EIA Screening Opinion from Marine Scotland on 22nd May 2019. The response indicated that based on a review of the relevant criteria under Paragraph 13 of Schedule 2 of the 2017 MW Regulations Scottish Ministers were in agreement with Seagreen that an EIA was not required to support the Marine Licence application.

Given the location of the works, in close proximity to the Barry Links Special Area of Conservation (SAC)/Site of Special Scientific Interest (SSSI)/ Geological Conservation Review (GCR), the Firth of Tay and Eden Estuary SAC, Special Protection Area (SPA) and Ramsar site and the Outer Firth of Forth and St Andrews Bay Complex proposed SPA (pSPA) (see Figure 3.1), consultation was undertaken with Scottish Natural Heritage (SNH). SNH agreed with Seagreen that an EIA was not necessary, but also stated that while the proposed works lie outside of designated sites that are in the vicinity of the works, the consideration of potential impacts to relevant sites is still required.

However, SNH concluded that it was unlikely that the proposed works would have significant effects on the qualifying features of the sites identified in the SNH response. SNH recommended that the potential risk of trenched cable(s) being re-exposed by storm erosion should be considered in the ER and that consideration should be given to any potential beach lowering over the design life of the cable. Seagreen has conducted this assessment and the results are provided in Appendix B and summarised in Section 5.2.

Consultation with the Scottish Environment Protection Agency (SEPA) and Angus Council was also undertaken, due to the proposal to remove and replace a small section of the rock revetment during trenching operations. The rock revetment was installed as a coastal defence measure and there is the potential for a water breach of the revetment during trenching operations. Given this potential and with consideration of SEPA's lead role in the implementation of the EU Floods Directive and specifically the Flood Risk Management (Scotland) Act 2009, a call was held on the 3rd of April 2019 with SEPA and Angus Council, to discuss any requirements in relation to the application. The meeting highlighted the need for a desk-based Flood Risk Assessment (FRA) to be undertaken. The results of the FRA are provided in Appendix A and summarised in Section 5.2. It was agreed that other than the requirement for an FRA desk study the proposed scope of the Environmental Report covered all the aspects SEPA required.

Angus Council is also being consulted with separately in relation to the works landward of the rock revetment in respect of submitting an application for a new onshore planning permission. A meeting was held with Angus Council on 14th March 2019 to agree the application type and the content of the proposed strategy document. The strategy document was submitted to Angus Council on the 22nd March 2019 and is due to be discussed with the council and the relevant consultees at a meeting in early May.

Table 1.1 below provides a summary of the key points raised during consultation and the responses received to the EIA Screening Request submitted on the 4th of April 2019.

Table 1.1: Consultation Responses

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
Marine Scotland	Meeting 20th March 2019	Highlighted SEPA's standing advice for projects and recommended referring to this advice with respect to deterioration to any bathing waters.	Section 5.2
		Also queried the identified source of the rock material to be used in reinstating the revetment.	Section 4, Table 4.1.
		Confirmed PAC would not be required	N/A
	E-mail 29th March 2019	Marine Scotland advise Seagreen to submit a request for a screening opinion under regulation 10(1) of the 2017 Marine Works Regulations.	Section 1.3, Table 1.1
	EIA Screening Response 22nd May 2019	The Scottish Ministers consider that the Proposed Works constitute a change to an authorised project and therefore they are considered to fall under the description of the projects provided at Paragraph 13 of Schedule 2 of the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended) ("the 2017 MW Regulations").	N/A
		Based on the information provided, the Scottish Ministers are of the opinion that the characteristics of the works are unlikely to have significant effects on the environment.	Section 5

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
		Effects on the environment as a result of the location of the Proposed Works will be considered within the scope of an Environmental Report to support the forthcoming marine licence application.	Section 5
		Potential impacts on the environment associated with the Proposed Works will be identified within the Environmental Report.	Section 5
		Scottish Ministers are of the opinion that the Proposed Works are not an EIA project under the 2017 MW Regulations and, therefore, an EIA is not required to be carried out in respect of the Proposed Works.	N/A
SEPA	Meeting 3rd April 2019	SEPA confirmed that a desk study FRA would be sufficient.	Section 5.2
	Letter dated 3rd May 2019	No explanation has been provided for the proposed change of method for laying the cables in this area. Using HDD will avoid any increased flood risk in the area for the duration of the works.	Section 2.1.4 has been updated to provide more information on the reasons for an alternative method.

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
			A FRA has been undertaken for the alternative cable landfall and is presented in Section 5.2 and Appendix A.
		SEPA would not object to the proposed trenching on flood risk grounds.	Section 5.2
		Provided that SEPA advice is followed SEPA are of the opinion that there are unlikely to be significant environmental effects.	N/A
		OS maps indicate that the land behind the rock revetment, which is golf course and therefore low vulnerability, lies at an elevation of over 5mAOD. For information, a predicted 1 in 200-year still water level at this location is 3.79mAOD (+/- 0.3m).	Section 5.2, Appendix A
		Given the temporary nature of the works, that the land behind the revetment is golf course and therefore considered low vulnerability, and the land levels are higher than the predicted still water levels, we have no objection to the proposals.	Section 5.2

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
		SEPA support the recommendations to reduce potential flood risk through monitoring the forecast and ensuring works do not take place during storm events.	Section 4
		SEPA need to ensure that there will be no impact during the bathing water season (the pre-season period, 15 to 31 May, should be included as part of the bathing water season (1 June to 15 September) as we take compliance samples and it counts towards the classification. A key concern in relation to the bathing water would be an increase of faecal coliforms from large scale sediments and sand /silt disturbance. We therefore request the work is NOT carried out between the 15 May and 15 September.	Section 4, Section 5.2
		SEPA Flood Maps have been produced following a consistent, nationally-applied methodology for catchment areas equal to or greater than $3km^2$. For further information please visit http://www.sepa.org.uk/environment/water/flooding/flood-maps/	Section 5.2
		Vehicle movements and machinery work should be kept at a minimum over the beach area and best practices adhered too.	Section 2.3, Section 4, Section 5.3

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
Dundee City Council	E-mail dated 17th April 2019	Agree that an EIA is not required	N/A
Angus Council	Letter dated 23rd April 2019	The scale, location and potential impacts arising from the alternative cable installation would be unlikely to have significant effects on the environment. This is based on the proposed works taking place within the existing consented Offshore Transmission Works corridor. Although the Firth of Tay and Eden Estuary SAC, SPA and Ramsar site or the Barry Links SAC, SSSI and GCR sites fall within the application boundary, there would be no excavation required through these sites. A full EIA is not required in this instance as it is considered that any potential impacts can be identified and mitigated without requiring the support of a full EIA.	N/A
SNH	Letter dated 23rd April 2019	Agree that an EIA is not required	N/A
		The proximity and nature of the proposed works are such that consideration of potential impacts to European and nationally designated sites is necessary. The designated sites include: • Barry Links SSSI • Barry Links GCR	Section 7

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
		• Barry Links SAC • Firth of Tay and Eden Estuary SAC • Firth of Tay and Eden Estuary SPA • Firth of Tay and Eden Estuary Ramsar site • Outer Firth of Forth and St Andrews Bay Complex pSPA In our view, it is unlikely that the marine works will have significant effect on Barry Links or Firth of Tay and Eden Estuary SAC qualifying habitats. Similarly, it is unlikely that the proposal will have a significant effect on any of the features of Firth of Tay and Eden Estuary SPA/Ramsar and Outer Firth of Forth and St Andrews Bay Complex pSPA due to the short term temporary nature of the marine works.	
		SNH recommend that the potential risk of trenched cable(s) being re-exposed by storm erosion should be considered. Any future risk of cable re-exposure could potentially affect the viability of the landfall installation and general management of the shore. As such, this potential re-exposure needs to be assessed to understand whether the proposed burial depth is sufficient. Consideration should be given to potential beach lowering over the design life of the cable landfall.	Section 5.2
		The vibro-piling needed to install the temporary sheet piling does not require any specific marine mammal mitigation. Our advice is that the marine works will not have a significant effect on the Harbour seal qualifying feature of Firth of Tay and Eden Estuary SAC.	Section 5.5

Consultee	Date of Discussion / Comment	Summary of Response / Discussion	Comment / Relevant Section Response Addressed
		We also advise, that due to the low risk of disturbance, an EPS licence is not, in our view, required.	
East Lothian Council	E-mail dated 24th April 2019	No comment	N/A

1.4 Structure of Report

The structure of this Environmental Report is as follows:

Section 2, Project Description: this section outlines the need for the alternative methodology and provides a description of the methodology and the licensable marine activities that are the subject of the application;

Section 3, Existing Environment: this section provides an overview of the key receptors that may potentially be affected by the alternative cable landfall installation methodology;

Section 4, Management Measures: this section sets out the management measures which have been designed-in to the methodology, to reduce potential effects on the environment;

Section 5: Assessment of Effects: this section provides an assessment of the potential environmental impacts of the alternative landfall cable installation activities, in relation to each environmental topic;

Section 6: Cumulative Effects: this section considers the potential for cumulative effects arising from the alternative landfall cable installation activities alongside other activities;

Section 7: Inter-related Effects: this section considers the potential for inter-related effects arising from the alternative landfall cable installation activities upon identified receptors;

Section 8: Consideration of Likely Significant Effect: this section considers the potential for Likely Significant Effects on the European sites scoped into the assessment.

Section 9: Summary: Provides a summary of the conclusions of the report.

2. Project Description

2.1 Background

The following sections provide an overview of the consented Seagreen Alpha and Seagreen Bravo projects, an outline of the consented cable landfall installation methods, and a comparison of the consented landfall installation method with the proposed alternative cable landfall installation method that is the subject of this application.

2.1.1 Seagreen Alpha and Seagreen Bravo Overview

The Seagreen Alpha and Seagreen Bravo offshore wind farms will together comprise up to 150 WTGs with associated foundations, inter-array cables, OSPs and meteorological masts. The OTA export cable route corridor extends from the offshore wind farm project areas to the landfall at Carnoustie, approximately 27 km and 38 km from the Seagreen Alpha and Seagreen Bravo project areas respectively. The original application provided for up to six export cables to be installed within the offshore export cable route corridor between the Seagreen Alpha and Seagreen Bravo project areas and the landfall (Seagreen, 2012, Chapter 5: Project Description).

2.1.2 Existing Offshore Consent relevant to the Landfall

The original application specified that HDD would be used to install ducts from the transition pit location (located above MHWS) under the rock revetment. In the intertidal area or the shallow subtidal water, the application noted that a backhoe excavator may be used to dig a trench at each duct entrance, with the cables installed in the trenches up to the entrance to the ducts, and then drawn through the ducts to the transition pit by winches. The cables would be pulled to shore through the ducts from an offshore vessel (Seagreen, 2012, Chapter 5: Project Description). The application noted that beach access may be required for the works to be undertaken particularly for trench excavation (Seagreen, 2012, Chapter 5: Project Description).

As noted in Section 1.2, the OTA Marine Licence specifies that export cable installation within the intertidal area will be by HDD under the rock revetment from above MHWS and continued by ploughing or mechanical trenching across the intertidal area to meet the offshore works.

2.1.3 Existing Onshore Consent relevant to the Landfall

The Planning Permission in Principle received from Angus Council in January 2017 allows for the direct burial of up to six cables (in ducts) from MLWS using jetting, ploughing or trenching, up to the point where it connects with the HDD that will be used to cross the rock revetment and to connect with the transition joint bays located above MHWS. The consented landfall installation method between the transition joint bays and MLWS therefore comprised a combination of HDD (from the transition joint bays through the rock revetment) and jetting/trenching/ploughing through the intertidal to the point where it connects with the offshore cable.

2.1.4 Proposed Alternative Cable Landfall Methodology

As noted in Section 2.1.2, the existing OTA Marine Licence specifies that export cable installation at the landfall will be by HDD under the rock revetment and by ploughing or trenching across the intertidal and nearshore subtidal zones to meet the offshore works. Seagreen wishes to consent an alternative cable installation method that will permit open cut trenching through the rock revetment and will continue through the intertidal and nearshore subtidal zones (either as a single trench accommodating all three cables or a total of three trenches accommodating one cable per trench) to meet the offshore works. This alternative is being progressed to provide Seagreen with flexibility in installing the landfall and to ensure that an alternative is available should, during the course of detailed design, it be determined that the chosen methodology is not suitable. Only one of the HDD option or the open cut option will be utilised during installation.

The alternative methodology represents a change to the consented methodology and to the number of cables that are to be installed. This alternative method is for open cut trenching between the original proposed landward entrance points of the HDD (approximately 100 m above MHWS, through the rock revetment, the intertidal and nearshore subtidal zones, down to a depth of 2.5 m LAT (which is reached at approximately 190 m below MLWS, see Figure 1.1). The proposal is to excavate up to three trenches (instead of up to six) in which up to three high-density polyethylene (HDPE) pipes (800 mm Outside Diameter) will be installed (see Figure 2.1), from the original HDD landward entrance points down to the subtidal area.

The HDPE pipes will be installed in the trenches, which will be backfilled, and left in situ until the cable pull-in at a later date. It is anticipated that the three cables will be pulled through the three HDPE pipes in a similar manner to that proposed in the original application, however for completeness cable pull-in is also included in the scope of this document. A spare HDPE pipe will be installed within the rock revetment (i.e. four in total under the rock revetment) to avoid any future disturbance to the rock revetment in the event of cable failure. All other areas (including landward of the rock revetment, intertidal and subtidal zones) will have three HDPE pipes installed.

Figure 2.1: Trench Installation of Landfall HDPE Pipes into which Cables will be Pulled.

The key differences between the alternative methodology and the consented methodology are the reduction in the number of cables from up to six to up to three, the change from HDD to trenching through the rock revetment and the inclusion of an option to install all three cables within a single trench across the intertidal and subtidal zones down to the 2.5 m LAT depth contour. For completeness the application also covers excavation of up to three individual trenches (one for each cable) across the intertidal and subtidal zones, down to the 2.5 m LAT depth contour. Onshore consent approvals are being progressed separately.

2.2 Site Visits

The distance between the charted MHWS and MLWS at the cable landfall location (based on OSOpen data) is approximately 250 m (Figure 1.1). However, during a site visit to the landfall location shortly after low tide on 20 February 2019, the intertidal area was observed to be much narrower. This can be seen in Figure 2.2 and was estimated to be between 10 m and 20 m from the toe of the rock revetment, 29 minutes after low tide[1]. This affects the assessment of the alternative methodology in terms of understanding the length of the intertidal zone and in determining a potential worst case scenario for assessment. For the purposes of this document, the charted data is used with commentary provided where the observed situation (assuming a distance of up to 20 m) has the potential to influence the assessment undertaken. This approach has been utilised in Section 5.

Figure 2.2: Photo of Low Water at Landfall Location 9.13am 20th February 2019, 29 minutes after Low Water (8:44am) at 0.78 m above CD.

[1] Tide data taken from https://www.tidetimes.org.uk/river-tay-bar-tide-times-20190220

A second site visit was undertaken on 29 April 2019 to inform the FRA and to understand how the rock revetment and the land behind the rock revetment were connected. The site visit was to provide the study with context and to provide a better understanding of what might potentially occur in the event of a breach of the rock revetment leading to a flooding event. The site visit demonstrated that at MHWS, the tide was some way up the face of the rock revetment and that the rock revetment was in a state of disrepair and may have slumped over time (see Figure 2.3). The site visit also confirmed that landward of the rock revetment, the land was initially just below the level of the top of the rock revetment (above the MHWS line) and then gently sloped away to the west as it moved further inshore. Carnoustie golf course is 10 to 20 m behind the rock revetment (see Figure 2.4).

Figure 2.3: Photos of High Water at Landfall Location 11:50 am 29th April 2019, 18 minutes after High Water (11:32am) at 4.10 m above CD.

Figure 2.4: Aerial Photo of the Landfall Location showing Carnoustie Golf Course behind the Rock Revetment.

2.3 Alternative Cable Installation Methodology

The following sections consider the full extent of the cable installation methodology, with the worst case scenario presented in Table 2.1 and details of the vessels and plant that may be utilised set out in Table 2.2. Section 2.4 then considers which of these activities are licensable under the Marine (Scotland) Act 2010 and hence the subject of the Marine Licence application.

The alternative methodology is for open cut trenching between the original proposed landward entrance points of the HDD (approximately 100 m above MHWS), through the rock revetment, down to the 2.5 m (LAT) depth contour (approximately 190 m below MLWS).

The open cut trenching will cover four distinct zones (see Figure 1.1), namely onshore (landward of the rock revetment, covered by terrestrial planning consents); the rock revetment (MHWS is approximately half way up the face of the rock revetment, covered by both terrestrial planning consents and the proposed Marine Licence application); intertidal zone (covered by both terrestrial planning consents and the proposed Marine Licence application) and the subtidal zone (covered by the proposed Marine Licence application). The entire length from the toe off the rock revetment to the 2.5m LAT depth contour based on charted data is 360 m. From that point, the trenching will continue offshore under the existing OTA Marine Licence.

2.3.1 Rock revetment

The proposal is to excavate a single open trench through the rock revetment, into which up to four HDPE pipes will be installed (see Figure 2.1 for an example of an HDPE pipe). It should be noted that the fourth pipe will be installed to provide a spare should a further cable need to be pulled through at a later date (e.g. in the event of a cable failure), to avoid further removal of, or disturbance to, the rock revetment. All other areas will only have three HDPE pipes installed (e.g. onshore, intertidal and subtidal).

Open cut trenching will require temporary removal of a section of the rock revetment, so that the HDPE pipes can be installed underneath. The trench will be up to 70 m in width at the top, 32 m in length, 30 m at base (a trapezoid trench to provide stability); and 10 m deep with a 1 in 3 gradient and is likely to be excavated using a rock grapple (see Table 2.2). A width of 70 m is required, based on installation of the four HDPE pipes at suitable separation distance, to avoid electrical interference while also reducing environmental impact where possible; and a length of 32 m is based on the length of the revetment from onshore to the toe of the rock revetment in the intertidal zone. Temporary sheet piling may be required to maintain safe working conditions until the trench work is completed. A further 2 m below the base of the rock revetment will be excavated into which the pipes will be placed within the trench at 5 to 10 m spacing. The pipes will have 1 m cover below the rock revetment base. Following placement of the pipes, concrete will be poured over the pipes for stabilisation underneath the rock revetment.

The rock revetment will then be reinstated using the material originally removed for the trenching works. Initial inspection has determined that some of the rock may need to be replaced due to deterioration of material since the rock revetment was installed. Therefore, up to a maximum of 6,000 m^3 of additional rock may be required in order to reinstate the rock revetment. Rock may be delivered to the landward side of the rock revetment for use in reinstatement activities. However, due to the narrow intertidal area identified during site visits, it is likely that rock is delivered by sea using a barge. Rock material would then be moved onto the rock revetment using a crane mounted on the barge. Rock materials removed from the rock revetment will, where practicable, be reused during reinstatement.

Material excavated from the rock revetment that is suitable for re-use will be stockpiled onshore until the rock revetment is reinstated. Alternatively, the material may be crushed for re-use on site. Where the material is not suitable for re-use it will be transported to a licenced onshore disposal site. Storage, crushing activity and any transport to a licenced disposal site will be covered by the onshore planning approval process being progressed with Angus Council. Removal and reinstatement of the rock revetment is being covered by this Marine Licence application and the onshore planning approval process.

The temporary removal and reinstatement of a section of the rock revetment is anticipated to be undertaken in the following order:

- Remove rock armour;
- Remove Geofabric rock under layer;
- Excavate cable pipe trench;
- Install sheet piling;
- Install HDPE pipes;
- Install concrete cap over HDPE pipes at rock revetment toe;
- Remove sheet piles;
- Replace Geofabric rock under layer; and
- Replace and reinstate rock armour.

The removal of the rock revetment will be designed to prevent breach by seawater. Additional mitigation may include measures such as monitoring the storm surge forecast and weather forecast prior to and during construction activity, to prevent surges from breaching the rock revetment during construction. Once reinstated the rock revetment will be returned to the same profile as found prior to commencement of the Seagreen works.

It should be noted that access to the intertidal and rock revetment areas for vehicles and materials is limited by tidal conditions, therefore equipment and materials are likely to be transported by sea.

2.3.2 Landward of the rock revetment (Onshore)

Landward of the rock revetment, the proposal is to install three HDPE pipes, one pipe in each of three trenches. The trenches will be excavated to provide a minimum of 2 m cover to the pipes using an excavator. The HDPE pipes will be surrounded with predefined quality sand wrapped in geotextile. Working areas of up to 30 m width will be established running parallel to each side of the cable pipe trench, from the onshore pipe ends to the rock revetment, including vehicle access and any storage.

To aid successful reinstatement of the as found soil layers, each layer of material will be removed and stored in a designated area, marked and kept separate from mixing with other layers.

Tarpaulin or similar cover will be laid down prior to storing material. The trench will be backfilled with each layer in reverse order to which it was removed, to maintain any original soil type layering and profile. For each layer or for each 0.5 m depth, the material will be compacted to reduce subsidence.

The cable pipe trenches will interface with the land cable at a cover depth of around 1.2 m at the three interface joints located onshore above MHWS. Each interface joint will require a joint pit 10 m x 5 m x 2 m deep. Pipe trenches will need to pass under the existing sewer and mains water services landward of the rock revetment.

Onshore planning approvals for the landward portion of the works will be progressed separately with Angus Council.

2.3.3 Intertidal and subtidal to 2.5 m (LAT)

From the toe of the rock revetment, up to three HDPE pipes will be installed across the intertidal and subtidal zones down to the 2.5 m (LAT) depth contour (total length of section 360 m) in either a single trench (Option 1) or up to three trenches (Option 2), as follows:

1. **Option 1:** installation of up to three HDPE pipes within a single trench excavated to 3 m deep, 20 m wide at base and 30 m wide at top. The trench will be excavated to provide a minimum of 2 m cover to the three HDPE pipes at 5 m minimum spacing. Option 1 may require approximately 200 m of sheet piling either side of the trench (400 m in total) in the subtidal zone (which may also extend into the intertidal zone) and working areas 30 m wide either side of the trench (60 m wide in total); or

2. **Option 2:** installation of up to three HDPE pipes within up to three trenches excavated to 3 m deep, 2 m wide at base and 3 m wide at the top. The trenches will be excavated to provide a minimum of 2 m cover to the three HDPE pipes at 25 m spacing. Option 2 may require approximately 200 m of sheet piling either side of each trench (400 m per trench, 1,200 m in total) in the subtidal zone (which may also extend into the intertidal zone) and working areas 30 m wide on the outer trenches only with 25 m working areas in between each trench (110 m wide in total).

The trench(es) will be excavated by elevated or barge/jack-up mounted backhoe excavators allowing excavation work to be carried out at all states of the tide. In some cases (i.e. within areas permanently submerged), temporary sheet piling may be required to maintain safe working conditions until the trench work is completed and backfilled. Sheet piling will be installed using vibro-piling (as opposed to impact piling). For the sections of trench which are dry at low tide, excavation could be undertaken with the trench sides supported using trench boxes. Trench boxes are used as a temporary earth retaining structure to shore up the sides of a trench while material is excavated from within and can allow the sides of a trench to be cut vertical or near vertical.

During excavation of the trenches within the intertidal zone, to aid successful reinstatement of the as found sediment layers, each layer of material will be removed and stored in berms to the side of the trench with individual layers kept separate to aid reinstatement once works are complete. The berms created to the side of the trenches will be flattened on a regular basis to ensure they do not become too high.

HDPE pipe sections will be preassembled and floated to site, lowered into position in the trench and then joined to the previous section. The pipes may then be secured using concrete collars before the trenches are backfilled to ensure the HDPE pipes stay in position and are buried at the correct depth. In the intertidal zone, the trench section will be backfilled using the excavated material maintaining any original sediment layering and profile, as far as reasonably practicable and compacted where necessary to avoid subsidence. In the subtidal zone, the trench will be allowed to backfill naturally.

On completion, the seaward end of the pipes (at a depth of 2.5 m LAT, approximately 190 m from MLWS) will be fitted with a messenger line and left temporarily capped on the seabed to allow cable pull-in later. Temporary ballast (e.g. concrete bags/clamps or rock nets/bags of gravel) may be attached to the pipe ends for stabilisation. The pipe ends will be fully buried to a depth allowing 2 m of material above the top of the pipe following cable pull-in and completion of cable installation.

2.3.4 Cable Pull-In

The cable pull-in will be conducted both onshore and offshore. It is currently anticipated that a winch will be installed at the landward end of the HDPE pipes and attached to the messenger line with the temporary cap on the seaward end of the HDPE pipes removed. The messenger line will then be attached to the end of the cable which is stored on an offshore vessel. The cable will then be pulled through the HDPE pipe by the winch until the cable reaches the jointing bay.

2.3.5 Post-installation surveys

To ensure the HDPE pipes are buried to the desired depth, a survey of the HDPE pipe depths will be carried out within all four zones (onshore, rock revetment, intertidal and subtidal) prior to backfilling of the trenches. Following reinstatement, a topographical survey will be carried out to identify and map the contours of the ground/seabed and to confirm reinstatement to the correct profile, again within all four zones.

Table 2.1: Worst case scenario[2] (Source, Seagreen, 2019b, Seagreen 2019c).

Description	Details	Comments
Number/Quantity		
Number of interface joint pits – onshore	3	Pipes for Export Cable 1 (EC1), Export Cable 2 (EC2) and Export Cable 3 (EC3)
Number of trenches – onshore	3	

[2] Note the durations, depths and widths in the table are approximates at this stage and subject to change.

Description	Details	Comments
Number of trenches through rock revetment	1	
Number of HDPE pipes through rock revetment	4 (3 plus 1 spare)	
Number of trenches: intertidal and subtidal (**Option 1**)	1	Will contain all three cables EC1, EC2 and EC3 in a single trench, each cable within its own HDPE pipe
Number of trenches: intertidal and subtidal (**Option 2**)	3	Three individual trenches each containing one cable (EC1, EC2 or EC3) within its own HDPE pipe
Dimensions		
Dimension of trenches – onshore	EC1: 1 m x 100 m x 3 m EC2: 1 m x 100 m x 3 m EC3: 1 m x 100 m x 3 m	Width (at top) x length x depth Based on each trench being ~100 m long from MHWS to interface joint pits. Length subject to location of interface joint pits Depth 3 m to provide 2 m cover to pass under existing services.
Dimension of trench – rock revetment	EC1, EC2 and EC3: 70 m x 32 m x 10 m Note: Bottom width = 30 m (trapezoid trench to avoid slippage of trench sides) 70 m width includes working areas	Width x length (at top) x depth Pipes at 5-10 m spacing Concrete encased at toe of rock revetment. HDPE Pipes 2 m deep. Re-use of removed materials. Potential for additional rock (6,000 m^3) imported for rebuild to 1 in 3 gradient.
Dimensions of trench: intertidal and subtidal (**Option 1**)	Trench for EC1, EC2 and EC3: 30 m x 360 m x 3 m Note: Bottom width = 20 m (trapezoid trench to avoid slippage of trench sides) Subtidal Only 30 m x 190 m x 3 m	Width (at top) x length x depth To provide a minimum 5 m spacing of HDPE pipes and 2 m cover. Up to 400 m sheet piling required. Subtidal distance from MLWS to 2.5 m LAT = 190 m

Description	Details	Comments
Dimensions of trenches: intertidal and subtidal (**Option 2**)	EC1: 3 m x 360 m x 3 m EC2: 3 m x 360 m x 3 m EC3: 3 m x 360 m x 3 m Note: Bottom width = 2 m (trapezoid trench to avoid slippage of trench sides) Subtidal only EC1: 3 m x 190 m x 3 m EC2: 3 m x 190 m x 3 m EC3: 3 m x 190 m x 3 m	Width (at top) x length x depth To provide a minimum 25 m spacing of HDPE pipes and 2 m cover. Up to 400 m sheet piling per trench required, 1,200 m in total. Subtidal distance from MLWS to 2.5 m LAT = 190 m
Area (m^2)		
Plan area of joint pits – onshore	EC1: 50 m^2 EC2: 50 m^2 EC3: 50 m^2	Three joint pits each 10 m x 5 m
Plan area of trenches – onshore	EC1: ~100 m^2 EC2: ~100 m^2 EC3: ~100 m^2	Subject to final location of interface joint pits.
Plan area of rock revetment trench	2,100 m^2	
Plan area of trench: intertidal and subtidal (**Option 1**)	10,800 m^2 Subtidal only = 5,700 m^2	Trapezoidal trench for 3 HDPE pipes minimum 5 m spacing, 2 m cover. Values for intertidal and subtidal (trapezoidal trenches) have taken the width at top to estimate the volume. The width of trench at the base will be less than at the top. Therefore, the greater value has been used to provide a slight overestimate.
Plan area of trenches: intertidal and subtidal (**Option 2**)	EC1: 1,080 m^2 EC2: 1,080 m^2 EC3: 1,080 m^2 Subtidal only EC1: 570 m^2 EC2: 570 m^2 EC3: 570 m^2	

Description	Details	Comments
Volume (m^3)		
Volume of material excavated	Onshore joint pits 2 m deep to include concrete plinth: EC1: 150 m^3 EC2: 150 m^3 EC3: 150 m^3	All values rounded to nearest whole cubic metre.
	Onshore trenches: EC1: 300 m^3 EC2: 300 m^3 EC3: 300 m^3	
	Rock revetment: 22,400 m^3	Includes rock materials replenishment up to 6,000 m^3. Up to 23,000 m^3 temporary storage onshore required.
	Intertidal and subtidal: (**Option 1)** 32,400 m^3	Includes side slopes – final volumes subject to ground conditions but within the estimate provided.
	Intertidal and subtidal: (**Option 2**) 9,720 m^3	Includes side slopes – final volumes subject to ground conditions but within the estimate provided.
	Subtidal only (**Option 1**) 17,100 m^3	Subtidal distance from MLWS to 2.5 m LAT = 190 m
	Subtidal only (**Option 2**) 5,130 m^3	

Description	Details	Comments
Working Areas		
Working area onshore	(30 m + 30 m) x 100 = 6,000 m^2 Including working areas total plan area affected onshore = 6,450 m^2	30 m either side of the trench
Working area rock revetment	70 m width of rock revetment trench includes working areas	
Working areas intertidal	(30 m + 30 m) x 170 m = 10,200 m^2 (**Option 1**) (30 m + 25 m + 25 m + 30 m) x 170 m = 18,700 m^2 (**Option 2**).	30 m either side of the single trench (60 m width in total, 90 m width including trench) (**Option 1**). 30 m either side of the outer two trenches with 25 m working areas between trenches one and two and between trenches two and three (110 m width in total, 119 m width including trenches) (**Option 2**).
Total area temporarily disturbed (intertidal and subtidal)	Including working areas, total plan area temporarily affected = 21,000 m^2 (**Option 1**) or 21,940 m^2 (**Option 2**).	Conservative estimate, with working area running parallel to either side of the trench. Working areas not considered for subtidal as cables installed via offshore vessel. However, there may be some additional disturbance through jack up vessel/barge spud cans and other vessel moorings.
Storage areas onshore (landward of MHWS) (covered by onshore application)	Two 30 m x 30 m areas.	Approximate estimate.

Table 2.2: Vessels and Plant.

Type	Description
Backhoe excavators, dumpers, crane/long reach excavator with rock grapple (onshore (except backhoe excavators) and rock revetment)	 Whilst the exact details will not be known until contractors have been appointed, it is likely that backhoe excavators (shown in the diagram below), dumpers and cranes/long reach excavators would be required.
Elevated backhoe excavator and barge/jack-up mounted backhoe excavator (subtidal)	In the subtidal zones elevated excavator and/or a barge-mounted backhoe excavator. The images below show examples of an elevated backhoe excavator (left) and a barge-mounted backhoe excavator (right).  
Crawler crane and clamshell bucket / rock grapple (rock revetment)	 Due to the limited reach of a long reach excavator, it may be necessary for some rock removal and placement to be carried out using a crawler crane and clamshell bucket or rock grapple (shown in the photo, courtesy of Arch Henderson).
Barge	The delivery method for any additional rocks for the rock revetment is to be determined. One option is to use a barge at high tide to deliver the rock material to the rock revetment and crane off rock material to be used on the rock revetment.

2.4 Licensable marine activities

The alternative cable landfall installation activities which are licensable marine activities under the Marine (Scotland) Act 2010 are summarised below. These include activities within the rock revetment, intertidal and subtidal zones only. These activities form the focus of this Environmental Report. However, as certain non-licensable activities can increase the duration and extent of the impact (e.g. use of vessels/plant and presence of human activity during surveys leading to disturbance effects), these wider activities are also considered in the overall assessment presented in this Environmental Report, where relevant. The following activities are considered to be licensable under the Marine (Scotland) Act 2010 and are therefore considered within this Environmental Report:

- Temporary removal and reinstatement and, if necessary, additional deposit of material at the rock revetment;
- Temporary removal and storage of material in the intertidal and subtidal zones;
- Creation of working areas on the rock revetment;
- Creation of working areas in the intertidal zone;
- Open cut trenching and HDPE pipe installation through the rock revetment;
- Open cut trenching and HDPE pipe installation in the intertidal and subtidal zones;
- Backfilling of the trench(es) in the intertidal and subtidal zones; and
- Cable pull-in.

2.5 Timescales and duration

Indicative timescales for the alternative cable landfall works are provided below in Figure 2.5.

The activities listed in Section 2.4 including installation of the HDPE pipes from the onshore joint pits, through the rock revetment, intertidal and subtidal zones to a depth of 2.5 m LAT is expected to take place over a period of up to four months (excluding any weather downtime e.g. due to storms or adverse weather). The works to remove, trench through and install the HDPE pipes within the rock revetment, including reinstatement will take approximately eight weeks. A further eight weeks will then be required to trench through the intertidal and subtidal area, including excavation of material, installation of sheet piling, laying of HDPE pipes, backfilling and reinstatement of the site.

Sheet piles will be installed using vibropiling techniques. Sheet piling activities would likely require one week (seven days) to install the sheet piles in the rock revetment trench, with seven days also required to install the 400 m of sheet piles required for Option 1. Up to 21 days may be required to install the 1,200 m of sheet piles for the three trenches for Option 2. It should be noted that installation periods for sheet piling are not continuous piling days but are installation periods within which piling will take place and during sheet pile installation there will be periods when piling is not taking place (e.g. piling will only occur during daylight hours).

The pull-in operations of the three cables is expected to take place over a period of two to three weeks working time, with the actual pull-in of the cables from a vessel offshore to the onshore cable jointing bays lasting approximately two days per cable (6 days in total). However, the period between HDPE pipe installation and the pull-in of the cable lengths is subject to seasonal conditions (e.g. weather) and the availability and delivery time of the cable lengths from the cable manufacturer. The cable pull-in will be undertaken separately to the installation of the HDPE pipes through which the cables will be pulled.

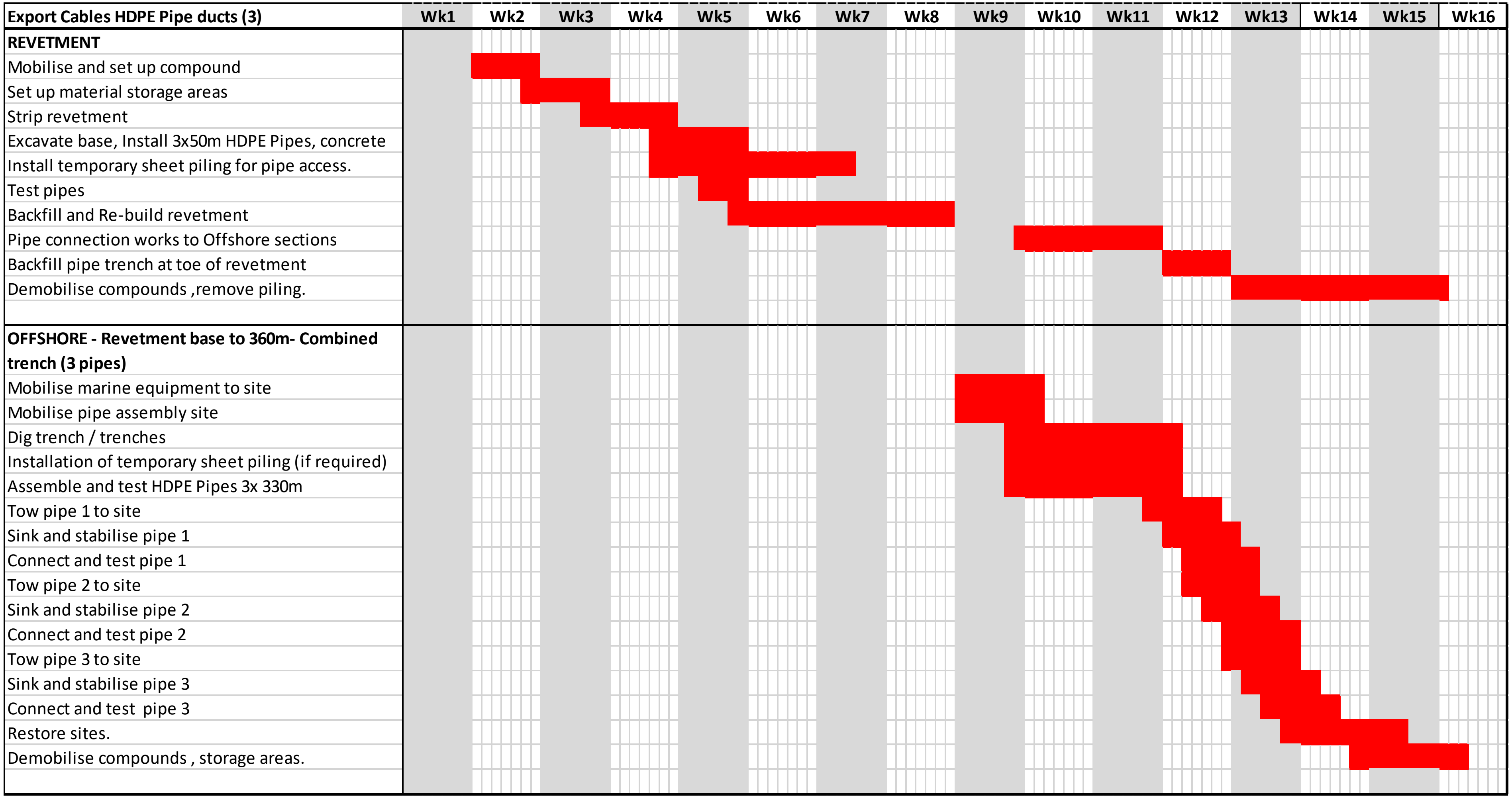


Figure 2.5: Indicative Programme. NOTE: Indicative only - season and delivery times of pipes and cables will significantly affect work progress. Offshore and onshore works can be concurrent.

3. Existing Environment

3.1 Overview

A detailed description of the baseline environment for each environmental parameter is available from the Seagreen Alpha and Seagreen Bravo Environmental Statement (ES) (Seagreen, 2012), the ES Addendum (Seagreen, 2013a), the Seagreen Habitats Regulations Appraisal (HRA) report (Seagreen 2013b), HRA report for the optimised design (Seagreen, 2018b) and the ES for the optimised design (Seagreen, 2018a). The following sections provide an overview of the key receptors that may potentially be affected by the alternative cable landfall installation method. The receptors included in this section were presented and discussed with MS-LOT at the meeting on 20th March 2019. The information utilised to provide details of the key receptors has been drawn from the Seagreen Alpha and Seagreen Bravo ES (Seagreen, 2012), the ES Addendum (Seagreen, 2013), the ES for the optimised design (Seagreen, 2018a), the Seagreen Habitats Regulations Appraisal (HRA) report (Seagreen, 2013b), HRA report for the optimised design (Seagreen, 2018b), other Seagreen project documents and other publicly available information, as set out in the Consenting Approach document (Seagreen, 2019a).

3.2 Nature Conservation Designations

A summary of the designated sites that have been screened into the assessment as having the potential to interact with the licensable marine activities is provided in Table 3.1 and presented in Figure 3.1 and Figure 3.2. The screening of sites has further been informed by the EIA Screening Response received from SNH (SNH, 2019a) which identified a number of key sites for consideration. In addition to the sites in close proximity to the landfall and identified by SNH sites have also been screened into the assessment for mobile species. These include SACs for marine mammals as these may be present in the vicinity of the landfall during foraging and SACs for Atlantic salmon which may pass close to the proposed works during migrations to and from their home rivers. The sites were screened in on the basis of the known foraging habits of the bottlenose dolphins *Tursiops truncatus* from the Moray Firth SAC (Cheney *et al*., 2013), the distances over which grey seals *Halichoerus grypus* forage (Marine Scotland, 2018) and that the potential migratory routes of Atlantic salmon *Salmo salar* to and from their natal rivers (Malcolm *et al*., 2010) may bring them close to the shore during these works either as smolts or as adults.

The alternative cable landfall application boundary overlaps with the Outer Firth of Forth and St Andrews Bay Complex pSPA and the subtidal section of the works will occur within the pSPA boundary. The Outer Firth of Forth and St Andrews Bay Complex pSPA is proposed to be designated for a variety of bird populations of European importance including Arctic tern *Sterna paradisaea*, Atlantic puffin *Fratercula arctica*, common tern *Sterna hirundo*, Manx shearwater *Puffinus puffinus* and northern gannet *Morus bassanus* during the breeding season; black-headed gull *Chroicocephalus ridibundus*, common eider *Somateria mollissima*, common goldeneye *Bucephala clangula*, common gull *Larus canus*, common scoter *Melanitta nigra*, little gull *Hydrocoloeus minutus*, long-tailed duck *Clangula hyemalis*, razorbill *Alca torda*, red-breasted merganser *Mergus serrator*, red-throated diver *Gavia stellata*, Slavonian grebe *Podiceps auritus* and velvet scoter *Melanitta fusca* during the non-breeding season; and guillemot *Uria aalge*, European shag *Phalacrocorax aristotelis*, herring gull *Larus argentatus* and kittiwake *Rissa* *tridactyla* during the breeding season and non-breeding season. The pSPA is an extensive proposed marine protected area off the south-east coast of Scotland stretching from Arbroath in the north to St Abb's Head in the south, encompassing the Firth of Forth, the outer Firth of Tay and St Andrews Bay, and covers an area of 2,721 km^2 (SNH, 2016).

In addition, the southern section of the alternative cable installation works application boundary overlaps the Firth of Tay and Eden Estuary SAC, SPA and Ramsar site. However, given the location of the proposed breach of the rock revetment and the location of the offshore export cable corridor, as shown in Figure 3.1, it is likely that the works themselves will not take place within the designated sites. The Firth of Tay and Eden Estuary SAC is designated for the Annex I habitats Estuaries, Sandbanks which are slightly covered by sea water all the time, and Mudflats and sandflats not covered by seawater at low tide; and the Annex II species harbour seal *Phoca vitulina*. The Firth of Tay and Eden Estuary SPA and Ramsar site is designated for supporting populations of European importance of little tern *Sterna albifrons* and marsh harrier *Circus aeruginosus* during the breeding season; bar-tailed godwit *Limosa lapponica* in the over-wintering period; migratory greylag goose *Anser anser*, pink-footed goose *Anser brachyrhynchus* and redshank *Tringa totanus* in the over-wintering period; and is designated as a wetland of international importance and for supporting a waterfowl assemblage.

The southern section of the alternative cable installation works application boundary also overlaps with the Barry Links SSSI and GCR site, and the Barry Links SAC, although for the same reasons noted above it is unlikely that the works themselves will take place within the designated sites. The Barry Links SSSI and GCR site is designated for its sand dunes, vascular plants, bryophytes, invertebrates, breeding birds and landforms. The Barry Links SAC is designated for embryonic shifting dunes, shifting dunes along the shoreline with *Ammophila arenaria*, fixed coastal dunes with herbaceous vegetation, Atlantic decalcified fixed dunes and humid dune slacks. The sand dune system is one of the largest on the east coast of Scotland and forms a peninsula on the northern edge of the Tay at the mouth of the estuary. It is a complex site which provides a valuable example of an active dune system and a full range of dune habitats which support a wide range of plants, mosses, liverworts and invertebrates (Barry Links SSSI Citation Document).

Identified SACs include the Moray Firth SAC, designated for its population of bottlenose dolphin and the Isle of May SAC and the Berwickshire and North Northumberland Coast SAC, both designated for their populations of grey seal. The River Tay SAC, River Dee SAC, and the River South Esk SAC which lists Atlantic salmon, *Salmo salar*, as a primary feature and the River Teith SAC, a tributary of the River Forth and which lists Atlantic salmon as a qualifying feature are also considered as salmon may migrate past the coast on the way to and from feeding grounds. In addition to salmon, river lamprey *Lampetra fluviatilis*, brook lamprey *Lampetra planeri* and sea lamprey *Petromyzon marinus* are a primary feature of the River Teith SAC and a qualifying feature of the River Tay SAC. River lamprey and sea lamprey also migrate to sea during their life cycle. Freshwater pearl mussel *Margaritifera margaritifera* is a primary feature of the River Dee SAC and River South Esk SAC and has the potential to be affected by any effects on Atlantic salmon populations (salmonids are the main host of the parasitic larvae of freshwater pearl mussel). Otter *Lutra lutra* is also present as a primary feature of the River Dee SAC and River Teith SAC, and as a qualifying feature of the River Tay SAC and may be present in the vicinity of the works.

Consideration of Likely Significant Effect (LSE) on those European sites with the potential to interact with the licensable marine activities is provided in Section 7.

Table 3.1: Summary of the designated sites and specific features that have been screened in as having the potential to interact with the licensable marine activities.

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
Barry Links SSSI and GCR	0 km (overlaps with southern section of the application boundary)	• Geomorphology: Coastal geomorphology of Scotland • Coastlands: Sand dunes • Non-vascular plants: Bryophyte assemblage (including Warne's thread moss *Bryum warneum*) • Invertebrates: Invertebrate assemblage (including shore spider *Dictyna major,* stiletto fly *Dialineura anilis,* small blue butterfly *Cupido minimus*)	To maintain the condition of the sand dune habitats (including bryophyte and invertebrate species) and sand dune geomorphology, whilst allowing coastal processes to operate as far as possible.

Barry Links SAC	0 km (overlaps with southern section of the application boundary)	• Embryonic shifting dunes
		• Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")
		• Fixed coastal dunes with herbaceous vegetation ("grey dunes")
		• Atlantic decalcified fixed dunes (Calluno-Ulicetea)
		• Humid dune slacks
			• To avoid deterioration of the qualifying habitats thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and
			• To ensure for the qualifying habitats that the following are maintained in the long term:
			  ○ Extent of the habitat on site
			  ○ Distribution of the habitat within site
			  ○ Structure and function of the habitat
			  ○ Processes supporting the habitat
			  ○ Distribution of typical species of the habitat
			  ○ Viability of typical species as components of the habitat
			  ○ No significant disturbance of typical species of the habitat
			• Overlaps with the Firth of Tay and Eden Estuary SPA and Ramsar.

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
Outer Firth of Forth and St Andrews Bay Complex pSPA	0 km (overlaps with subtidal part of the works)	Regularly supporting non-breeding populations of the following Annex I species: • Red-throated diver *Gavia stellate* • Slavonian grebe *Podiceps auratus* • Little gull *Larus minutus* • Common tern *Sterna hirundo* • Arctic tern *Sterna paridisaea* Regularly supporting populations of European importance of the following migratory species: • Common eider *Somateria mollissima* • European shag *Phalacrocorax aristotelis* • Northern gannet *Morus bassanus* Regularly supporting nationally important waterfowl assemblages, including: • Long tailed duck *Clangula hyemalis* • Common scoter *Melanitta nigra* • Velvet scoter *Melanitta fusca* • Common goldeneye *Bucephala clangula* • Red-breasted merganser *Mergus serrator* Regularly supporting nationally important seabird assemblages during the breeding season, including: • Atlantic puffin *Fratercula arctica* • Black-legged kittiwake *Rissa tridactyla* • Manx shearwater *Puffinus puffinus* • Common guillemot *Uria aalge* • Herring gull *Larrus argentatus*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, subject to natural change, thus ensuring that the integrity of the site is maintained in the long-term and it continues to make an appropriate contribution to achieving the aims of the Birds Directive for each of the qualifying species • This contribution will be achieved through delivering the following objectives for each of the site's qualifying features: ○ Avoid significant mortality, injury and disturbance of the qualifying features, so that the distribution of the species and ability to use the site are maintained in the long-term; ○ To maintain the habitats and food resources of the qualifying features in favourable condition.

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
		Regularly supporting nationally important seabird assemblages during the non-breeding season, including: • Black-headed gull *Chroicocephalus ridibundus* • Common gull *Larus canus* • Razorbill *Alca torda* • Herring gull • Common guillemot • European shag • Black-legged kittiwake	
Firth of Tay and Eden Estuary SPA and Ramsar	0 km (overlaps with southern section of the application boundary)	Regularly supporting breeding populations of the following Annex I species: • Marsh harrier *Circus aeruginosus* • Little tern *Sterna albifrons* Regularly supporting populations of the following Annex I species over winter: • Bar-tailed godwit *Limosa lapponica* Regularly supporting populations of European importance of the following migratory species: • Redshank *Tringa tetanus* • Greylag goose *Anser anser* • Pink-footed goose *Anser brachyrhynchus* Wetland of international importance regularly supporting waterfowl assemblages, including: • Velvet scoter *Melanitta fusca* • Pink-footed goose • Greylag goose • Redshank	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and • To ensure for the qualifying species that the following are maintained in the long term: ○ Population of the species as a viable component of the site ○ Distribution of the species within site ○ Distribution and extent of habitats supporting the species ○ Structure, function and supporting processes of habitats supporting the species ○ No significant disturbance of the species

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
		• Cormorant *Phalacrocorax carbo* • Shelduck *Tadorna* • Bar-tailed godwit • Common scoter *Melanitta nigra* • Black-tailed godwit *Limosa islandica* • Goldeneye *Bucephala clangula* • Red-breasted merganser *Mergus serrator* • Goosander *Mergus merganser* • Oystercatcher *Haematopus ostralegus* • Grey plover *Pluvialis squatarola* • Sanderling *Calidris alba* • Dunlin *Calidris alpina* • Long-tailed duck *Clangula hyemalis*	
Firth of Tay and Eden Estuary SAC	0 km (overlaps with southern section of the application boundary)	• Harbour seal *Phoca vitulina*	• To avoid deterioration of the habitats of the qualifying interest or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for the qualifying interests. • To ensure for the qualifying interests that the following are maintained in the long term: ○ Population of the species as a viable component of the site; ○ Distribution of the species within site; ○ Distribution and extent of habitats supporting the species; ○ Structure, function and supporting processes of habitats supporting the species; and

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
			○ No significant disturbance of the species.
Moray Firth SAC	140 km	• Bottlenose dolphin *Tursiops truncatus*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are established then maintained in the long term: ○ Population of the species as a viable component of the site; ○ Distribution of the species within site; ○ Distribution and extent of habitats supporting the species; ○ Structure, function and supporting processes of habitats supporting the species; and ○ No significant disturbance of the species.
Isle of May SAC	33 km	• Grey seal *Halichoerus grypus*	• To avoid deterioration of the habitats of the qualifying interest or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for the qualifying interests. • To ensure for the qualifying interests that the following are maintained in the long term: ○ Population of the species as a viable component of the site;

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
			○ Distribution of the species within site; ○ Distribution and extent of habitats supporting the species; ○ Structure, function and supporting processes of habitats supporting the species; and ○ No significant disturbance of the species.
Berwickshire and North Northumberland Coast SAC	66 km	• Grey seal *Halichoerus grypus*	• Subject to natural change, ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its qualifying interests. This will be achieved by maintaining or restoring: ○ The extent and distribution of qualifying natural habitats and habitats of qualifying species; ○ The structure and function (including typical species) of qualifying natural habitats; ○ The structure and function of the habitats of qualifying species; ○ The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely; ○ The populations of qualifying interests; and ○ The distribution of qualifying interests within the site.
River Tay SAC	39 km	• Atlantic Salmon *Salmo salar* • Sea lamprey *Petromyzon marinus* • River lamprey *Lampetra fluviatilis*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
			integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: ○ Population of the species, including range of genetic types for salmon, as a viable component of the site ○ Distribution of the species within site ○ Distribution and extent of habitats supporting the species ○ Structure, function and supporting processes of habitats supporting the species ○ No significant disturbance of the species
River Dee SAC	63 km	• Freshwater pearl mussel *Margaritifera margaritifera* • Atlantic salmon *Salmo salar*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: ○ Population of the species, including range of genetic types for salmon, as a viable component of the site ○ Distribution of the species within site ○ Distribution and extent of habitats supporting the species

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
			○ Structure, function and supporting processes of habitats supporting the species ○ No significant disturbance of the species ○ Distribution and viability of freshwater pearl mussel host species ○ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species
River South Esk SAC	24 km	• Freshwater pearl mussel *Margaritifera margaritifera* • Atlantic salmon *Salmo salar*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: ○ Population of the species, including range of genetic types for salmon, as a viable component of the site ○ Distribution of the species within site ○ Distribution and extent of habitats supporting the species ○ Structure, function and supporting processes of habitats supporting the species ○ No significant disturbance of the species ○ Distribution and viability of freshwater pearl mussel host species

Designated site	Distance from Application Boundary	Qualifying features	Conservation objectives
			○ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species
River Teith SAC	85 km	• Sea lamprey *Petromyzon marinus* • River lamprey *Lampetra fluviatilis* • Atlantic salmon *Salmo salar*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: ○ Population of the species, including range of genetic types for salmon, as a viable component of the site ○ Distribution of the species within site ○ Distribution and extent of habitats supporting the species ○ Structure, function and supporting processes of habitats supporting the species ○ No significant disturbance of the species.

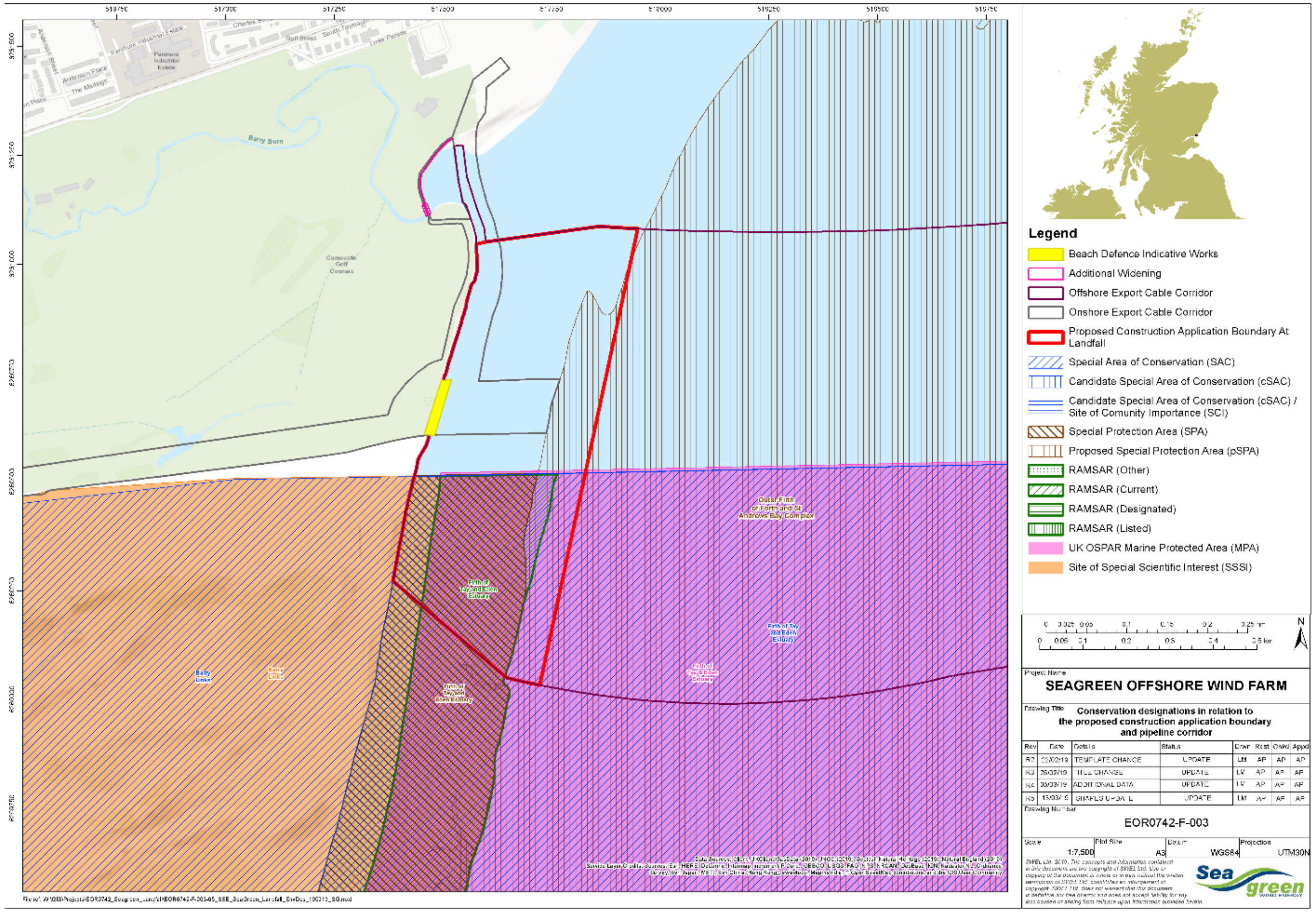


Figure 3.1: Designated sites in close proximity to the proposed alternative cable installation works application boundary.

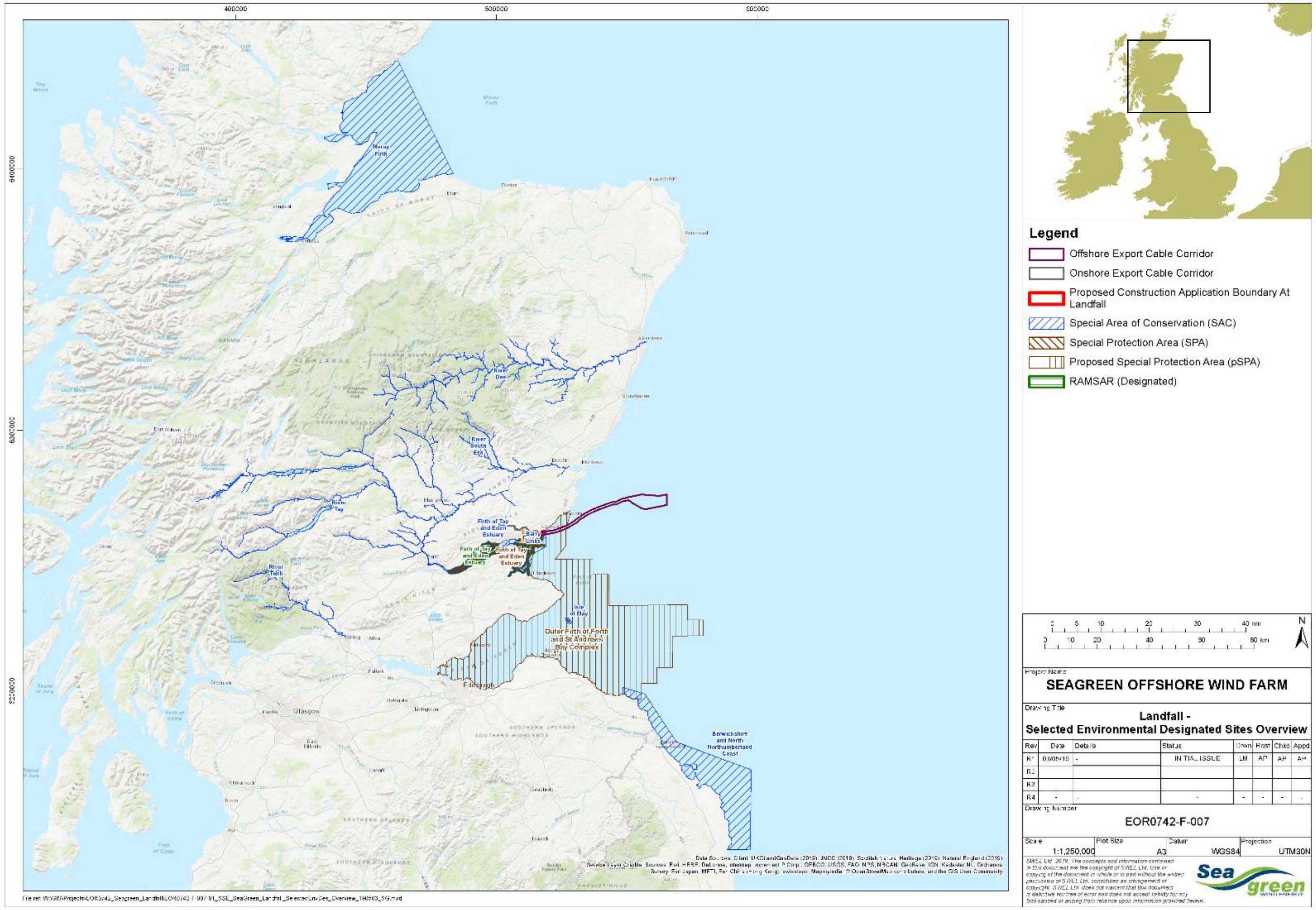


Figure 3.2: Designated sites in relation to the proposed alternative cable installation works application boundary.

3.3 Other Designations

There is a designated bathing water in Carnoustie Bay which is classified as being of good quality (SEPA, 2016). The Carnoustie bathing water is situated to the south of, and accessible from, the town of Carnoustie. It is in a relatively small and shallow bay approximately 0.7 km in length that slopes gently towards the water and is located approximately 122 m from the proposed alternative cable installation works application boundary and approximately 148 m from the consented offshore export cable route corridor (Figure 3.3). During high and low tides the approximate distance to the water's edge can vary from 0 to 300 m. At high tide the water reaches the sea wall on some parts of the beach leaving no sand visible (SEPA, 2015).

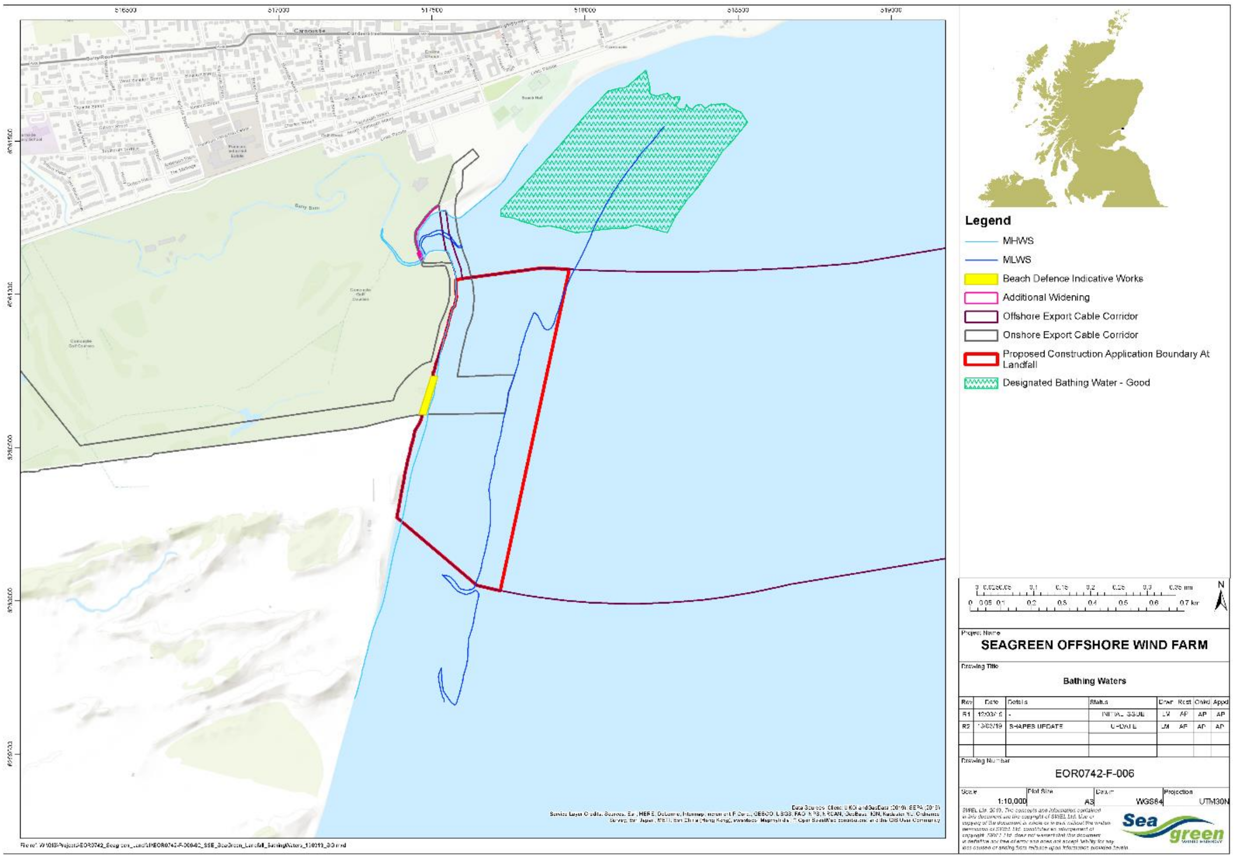


Figure 3.3: Carnoustie designated bathing water.

3.4 Physical Environment and Water Environment

At the cable landfall, the upper beach above MHWS consists entirely of the rock revetment which has replaced the crest of the backing dune and its landward slope (Seagreen, 2012, Chapter 7: Physical Environment). This coast has a recent history of severe erosion and the dune face is recorded to have retreated up to 10m in one year (Wright, 1981). In response, 0.5km of protective gabions and boulder rip-rap were constructed in 1978, extending from Carnoustie to the northern limit of the MoD range, just beyond the exit of the Barry Burn. On account of a perceived erosional threat to the MoD firing ranges, sited in the dunes behind the eastern beach, the boulder rip-rap was further extended in 1992/ 3 from Barry Burn south along a 3km stretch of the east side of Buddon Ness and up to the full frontal dune height of 7-10m (SNH, 2011). As a result, the eastern sands now exist only as intertidal sand, with the upper beach above MHWS being entirely boulder rip-rap which now replaces the crest of the backing dune and its landward slope. This was confirmed by two site visits undertaken at low tide in February 2019 and at high tide in April 2019 (see Section 2.2).

In order to understand the physical and water environment in the vicinity of the proposed works it is necessary to understand the processes that govern the coastline adjacent to Carnoustie. Therefore, the following considers a study area which encompasses an area from the south at Buddon Ness, north to Arbroath.

The coastline in the vicinity of Carnoustie consists largely of coastal dune heathland overlain by a variety of sand dunes, fronted by sand dominated beaches with areas of exposed rocky foreshore to the north towards Arbroath. To the south of the landfall location, the coastline is characterised by a wide rock revetment coastal defence structure; landward of this is the Barry Links SAC dune system. South of the proposed works area at Buddon Ness there is a small sandy spit which is highly dynamic, moving with tidal and wave conditions. There is also a series of intertidal and subtidal sand bars at Gaa Sands, 500 m to the east of Buddon Ness (Seagreen, 2012, Chapter 7: Physical Environment).

Barry Links can be subdivided in to three units: the east sands from Carnoustie beach to Buddon Ness, the area of the Ness itself, and the western sands from the Ness to Monifieth. The east sands are composed of medium grade, non-calcareous sand with occasional patches of gravel. At the eastern extremity of the Barry Links site, the foreshore at Carnoustie is a low-gradient sandy beach backed by erosion protection structures. To the west of this, the northern 4 km of the eastern sands of Barry Links is a low-gradient, east-facing beach, approximately 300 m wide. At low tide this beach is characterised by several shore-parallel intertidal sand bars, with intervening pools and runnels which are deflected southwards and extend the entire length of the foreshore to Buddon Ness (SNH, 2011; Seagreen, 2012, Chapter 7: Physical Environment).

The Barry Links SAC is designated for coastal dune heathland, shifting dunes, dune grassland, humid dune slacks and shifting dunes with marram. This site is also designated as a SSSI for notable bryophytes, geomorphology, other invertebrates and supralittoral sediment (Seagreen, 2016b, Chapter 9: Ecology and Ornithology). Geomorphology at Barry Links is strongly influenced by sediment transport and tidal conditions in the Tay. The flood tide flows south along the shore to the east of Buddon Links and the ebb flows east out of the Tay and then northwards over the Gaa Sands, with an anticlockwise eddy forming which sweeps back to the east shore of Buddon Ness from the north. On both the ebb and flood tides, sediment is swept southwards along the east shore of the Barry Links towards Buddon Ness. As the ebb tide is stronger than the flood tide on the western shore of Buddon Ness, sediments are swept eastwards towards Buddon Ness. The recent erosion and coastal retreat at Barry Links can be attributed to this anticlockwise eddy.

The sediments of the sandy beach at Carnoustie and at the landfall location are mobile and exposed (Seagreen, 2012, Chapter 7: Physical Environment). Drift of beach sediment within Carnoustie Bay occurs in a north to south direction, however, coastal retreat has been found to be slowing particularly to the north of Carnoustie with coastal erosion limited to episodic storm events (Seagreen, 2012, Chapter 7: Physical Environment).

The landfall lies within the Deil's Heid to Carnoustie River Basin Management Plan (RBMP) area. The coastal water body portion of the RBMP covers an area of 72.9km^2 including the Arbroath (West Links) and Carnoustie designated Bathing Waters. Carnoustie Bay is designated as a bathing water of good quality (see Figure 3.3) and are approximately 122 m from the alternative cable installation works application boundary and approximately 148 m from the landfall.

SEPA has classified the Deil's Heid to Carnoustie RBMP coastal water body as having an overall status of Good with High confidence in 2008 (SEPA, 2015, 2016) an overall ecological status of Good and an overall chemical status of Pass. SEPA has 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 (Seagreen, 2012, Chapter 8: Water and Sediment Quality).

The current status of the water body meets the requirements of the Water Framework Directive (2000/60/EC ("WFD"). As such, SEPA are obliged to ensure that there is no deterioration from that "Good" status, unless it is as a result of a new activity providing significant specified benefits to society or the wider environment.

3.5 Benthic Ecology and Intertidal Ecology (including Annex I habitats)

The intertidal area in the vicinity of the proposed cable installation works and application boundary at the Seagreen landfall (see Figure 1.1) is described within the Seagreen Offshore ES as not being species rich or habitat diverse (Seagreen, 2012, Chapter 11: Benthic Ecology and Intertidal Ecology). However, the artificial substrata of the rock revetment as well as areas of exposed bedrock or washed up timber support high diversity of species and habitats. The rock revetment is colonised by yellow/orange and grey lichens (e.g. *Xanthoria parietina* and *Caloplaca marina*), black lichens (e.g. *Verrucaria maura*), with winkles (*Littorina saxatilis* and *Melarhaphe neritoides*), limpet (*Patella vulgata*), barnacle (*Semibalanus balanoides*) and mussel (*Mytilus edulis*). The mobile and exposed sediments of the sandy beach are very species poor, lacking benthic fauna and macrofauna. The lower eulittoral sediments are dominated by polychaetes. Tidal pools are also species poor, only supporting fish and mobile species caught by the falling tide, however, the sand mason worm (*Lanice conchilega*) is occasionally found (Seagreen, 2012, Chapter 11: Benthic Ecology and Intertidal Ecology). The application boundary overlaps with the Firth of Tay and Eden Estuary SAC, as described in Section 3.2.

3.6 Natural Fish and Shellfish Resource

Due to their mobile nature and wide ranging habits, the study area considered for fish and shellfish species is much larger than that for other species, in order to understand which species have the potential to be present either as adults, or more likely, as juveniles in nursery areas. Therefore, in order to give the baseline context, data from the nearest ICES Rectangles was utilised to understand which species of commercial importance may move through the area or be present in the vicinity of the landfall during construction. ICES Rectangles 41E7 and 42E7 are in the vicinity of the proposed cable installation works, however, it is unlikely that many of the species found within these rectangles will be found in any great numbers close to shore. However, this area provides spawning and nursery areas for herring, whiting, *Nephrops*, cod, sandeel, plaice and lemon sole, as well as nursery areas for spurdog, tope shark, common skate, blue whiting, ling, hake, anglerfish, mackerel, sprat and saithe (Coull *et al*, 1998; Ellis *et al*, 2012). Elasmobranch species have slow growth rates and low reproductive output and are therefore of conservation concern when present. King scallop (*Pecten maximus*) and queen scallop (*Aequipecten opercularis*) are also present in the area (Seagreen, 2018a, Chapter 9: Natural Fish and Shellfish Resource). Species more likely to be found in shallower inshore waters include whelk (*Buccinum undatum*); lobster (*Homarus gammarus*); velvet swimming crab (*Necora puber*); juvenile saithe, spotted ray and edible crab (*Cancer pagurus*); and mature female spurdog and tope shark which migrate inshore to give birth to young. However, it is unlikely that these species will be found in any great numbers in up to 2.5 m water depth (Seagreen, 2012, Chapter 12: Natural Fish and Shellfish Resource).

Migratory, or diadromous, fish are also present. Atlantic salmon (*Salmo salar*) are Annex II species present as a primary feature of the River Tay SAC, River Dee SAC and River South Esk SAC, and present as a qualifying feature of the River Teith SAC. Most fish leave rivers around mid-April to end of May. Freshwater pearl mussel (*Margaritifera margaritifera*) is an Annex II species present as a primary feature of the River Dee SAC and River South Esk SAC, which relies upon migratory salmonid species for part of its life cycle (Seagreen, 2018a, Chapter 9: Natural Fish and Shellfish Resource). Migratory sea lamprey and river lamprey are known to be present in rivers near the proposed work area, including the River Teith and River Tay. These return to rivers to spawn in May-June and April-May, respectively. Sea lamprey undertake migration to the open sea, whereas river lamprey migrate to estuaries (Seagreen, 2013, Chapter 4: Fish and Shellfish (Addendum)). Brown/Sea trout (UK BAP priority species) is also known to be present in nearby rivers, spawning in late autumn. They do not undertake the same migration as salmon, instead remaining in coastal waters (Seagreen, 2012, Chapter 12: Natural Fish and Shellfish Resource).

3.7 Marine Mammals

Marine mammals have the potential to migrate across large distances and therefore the study area for the purposes of this environmental report is subsequently quite large, encompassing areas within the known foraging ranges of species likely to be present close to the Seagreen landfall. These species include harbour seal, grey seal, harbour porpoise, bottlenose dolphin and minke whale.

Harbour seals are found in the Firth of Tay and Eden Estuary SAC. The 2016 harbour seal count for this SAC was 51 (SCOS, 2017). The most recent count of harbour seal during the August moult (2011-2016) for the whole of the East Scotland Management Unit (MU) was 368 (SCOS, 2017), with most counted in the Firth of Forth and a small number counted in the Firth of Tay and the Angus and Aberdeenshire coast. Grey seals (*Halichoerus grypus*) are also found in the vicinity of the proposed work area. The most recent East Coast Scotland MU grey seal complete count was 3,812 (SCOS, 2017), with 936 grey seals counted across the Firth of Tay and Eden Estuary SAC.

The closest harbour seal haul out to Carnoustie Bay is at Buddon Ness which lies approximately 3 km to the south of the cable installation works. Harbour seal moult survey counts for Buddon Ness were 3 in 2012, 2 in 2014 and none in the most recent surveys in 2017. In the 5 x 5 km grid cell containing the landfall site, predicted harbour seal density according to SMRU seal usage maps (Russell *et al*. 2017) is very low at <0.003 seals per km^2.

The main concentration of grey seal population is to the south, with large haul-outs at Abertay Sands at Tentsmuir, approximately 7 km to the southwest of the proposed cable installation works. During surveys in August 2017, a total of 596 grey seals were counted at Abertay Sands. In the 5 x 5 km grid cell containing the landfall site, predicted grey seal density according to SMRU seal usage maps (Russell *et al*. 2017) is 0.8 seals per km^2.

There are also likely to be bottlenose dolphins, harbour porpoise and possibly minke whale present within the vicinity of the proposed works, with occasional sightings of white-beaked dolphin. Bottlenose dolphins are known to regularly move between the Moray Firth and the Tay and Forth Estuary (Cheney *et al*. 2013) and are regularly sighted off the Angus coastline during summer surveys (Quick *et al*. 2014, Arso Civil *et al*. 2019).

Quick *et al*. (2014) demonstrated that individual bottlenose dolphins from the Moray Firth are known to range up and down the east coast, but there is much spatial and temporal variability in individual movements. In the Tayside area dolphins were encountered more often in and around the Tay estuary in waters less than 20 m deep and within 2 km of the coast. The Tay estuary has consistently high encounter rates of bottlenose dolphins over the years. Between 71 (95% CI 63-81) and 91 (95% CI 82-100) bottlenose dolphins from the east coast population were estimated to be using the Tay area at some point during 2009 to 2013, representing approximately 35 to 46% of the total Scottish east coast population (Quick *et al*. 2014). Arso Civil *et al*. (2019) reported that this number had increased to 114 (95% CI 95-137) in 2015. Spatial mixing of individuals during the summer between St Andrews Bay and the Tay estuary and the Moray Firth SAC was estimated to be a minimum of ~6% per year and ~30% in total between 2009 and 2015. The entrance to the Firth of Tay and waters around Montrose were identified as areas of consistent high use.

The East Coast Marine Mammal Acoustic Study (ECOMMAS) monitoring stations closest to Carnoustie (at Arbroath to the north east, and at Fife Ness to the south, both stations approximately 5 km from the coast) detected dolphins on average 2% of monitored days between 2013 and 2016, of which 60% of these were estimated to be bottlenose dolphins with the remainder likely being white-beaked dolphins (Palmer *et al*. 2017).

Other marine mammal species observed during surveys of the Seagreen Alpha and Seagreen Bravo project areas and OTA include minke whale *Balaenoptera acutorostrata*, harbour porpoise *Phocoena phocoena* and white-beaked dolphin *Lagenorhynchus albirostris*, although these species are much less likely to be found in the very shallow, near shore environment of the works location and are therefore unlikely to be subject to any impacts from the proposed works.

3.8 Ornithology

The cable laying process has the potential to disturb and displace birds using shoreline, nearshore and marine habitats. However, the spatial extent of disturbance risk from cable laying is limited, only extending to up to approximately 300m from construction (depending on the species and exact activity). Risk of disturbance and displacement is therefore highly localised so the baseline environment relevant to this assessment covers only a small coastal and beach corridor.

Consideration has therefore been given to this baseline data and whether there were any large concentrations of birds recorded on or in proximity to the cable route corridor.

The construction activity would take place in relative proximity to the Outer Firth of Forth and St Andrews Bay Complex pSPA, which is proposed to be designated for a variety of bird populations of European importance including Arctic tern, Atlantic puffin, common tern, Manx shearwater, northern gannet, black-headed gull, common eider, common goldeneye, common gull, common scoter, little gull, long-tailed duck, razorbill, red-breasted merganser, red-throated diver, Slavonian grebe, velvet scoter, guillemot, European shag, herring gull and kittiwake (SNH, 2016). The Firth of Tay and Eden Estuary SPA and Ramsar site supports breeding marsh harrier and little tern, and overwintering populations of bar-tailed godwit, greylag goose, pink footed goose and redshank. It also supports an internationally important assemblage of overwintering waterfowl including cormorant, pink-footed goose, greylag goose, shelduck, eider, long-tailed duck, common scoter, velvet scoter, goldeneye, red-breasted merganser, oystercatcher, grey plover, sanderling, dunlin, black-tailed godwit, bar-tailed godwit and redshank.

Winter intertidal vantage point (VP) surveys undertaken between October 2011 and March 2012 (Seagreen, 2012, Chapter 10: Ornithology) recorded bar-tailed godwit, great northern diver, red-throated diver, common scoter, long-tailed duck, Eurasian curlew, herring gull, black-headed gull, a further 16 Birds of Conservation Concern (BoCC) Amber listed species and four species of lower conservation value. This included two species that are qualifying features of the Firth of Tay and Eden Estuary SPA (bar-tailed godwit and redshank) and seven species listed in the SPA assemblage (long-tailed duck, cormorant, eider, common scoter, red-breasted merganser, oystercatcher and sanderling). The most frequently recorded species was eider, followed by common scoter and herring gull. Seabirds were also recorded during the surveys with razorbill, guillemot, European shag and gannet present throughout. Red-throated diver was seen in moderate numbers, and great northern diver was recorded on a single occasion. Low numbers of waders were observed using the foreshore area, with the most common species being oystercatcher. Wildfowl were relatively numerous and were dominated by seaduck, including eider, long-tailed duck, common scoter and red-breasted merganser.

During an intertidal survey carried out between 2015 and 2016 (Seagreen, 2016b) a total of 41 different bird species were recorded, 16 of which were species associated with the Firth of Tay and Eden Estuary SPA and Ramsar site and 14 of which were species associated with the Outer Firth of Forth and St Andrews Bay Complex pSPA. The most common species were observed to be a mixed assemblage of seagulls, waders, ducks and divers occurring across the intertidal area of the landfall. For all species recorded, the distribution across the survey area was generally even with no distinct clusters of activity, other than for a rocky area towards the north where many species (e.g. oystercatcher) were observed to be roosting. However, across the intertidal area these species were recorded as being evenly distributed. Birds are also regularly disturbed by other activities such as shooting at the Barry Sands firing range and by dog walkers (Seagreen, 2016b).

3.9 Archaeology and Cultural Heritage

The nearest recorded wreck location to the proposed cable installation works is approximately 2 km to the north east and outside of the export cable route corridor (see Figure 3.4). There are no Designated Wrecks or other cultural heritage assets with legal designations within the export cable route corridor. Seven ‘Live’ wrecks[3] and five ‘Dead’ wrecks[4] were identified within the export cable route corridor (Seagreen 2012: Chapter 17: Archaeology and Cultural Heritage).

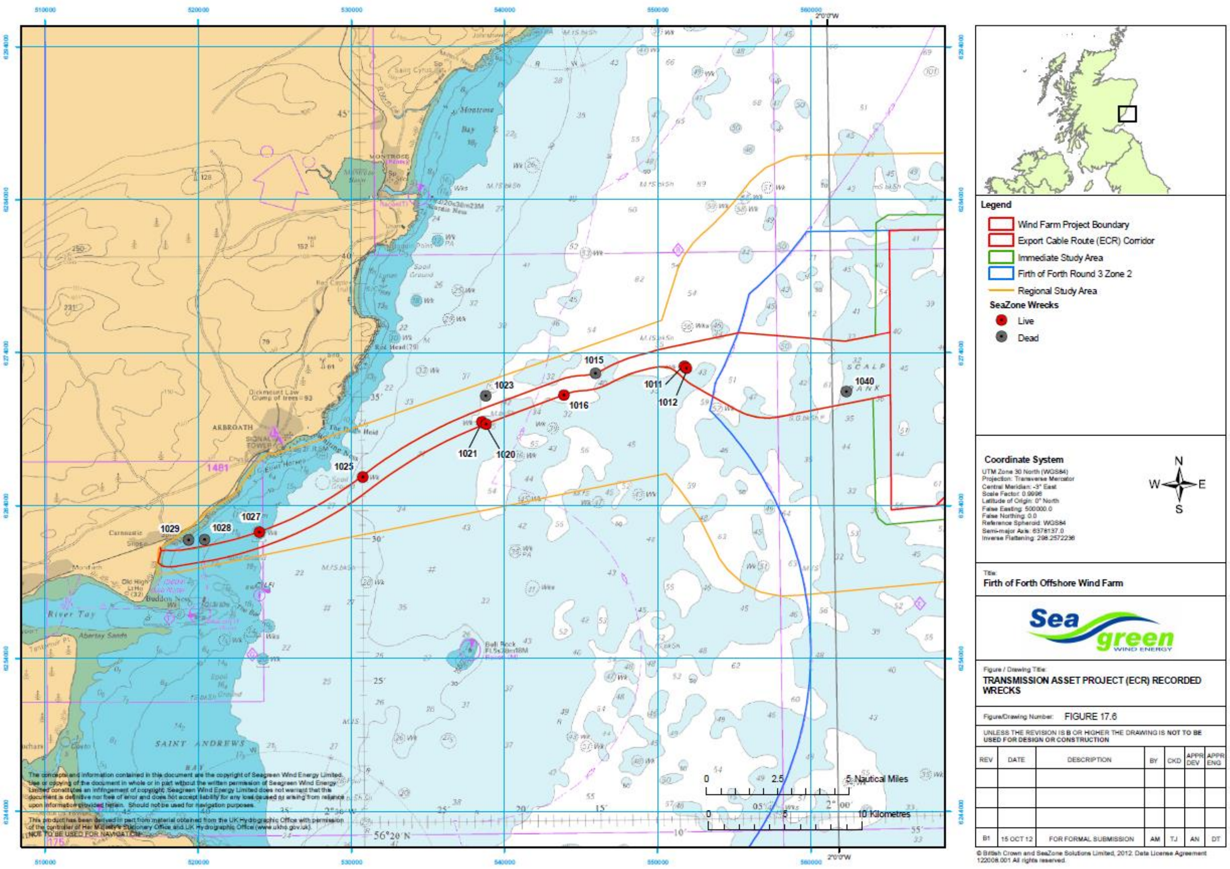


Figure 3.4: Recorded wrecks in the vicinity of the export cable route corridor (Figure 17.6 taken from Seagreen 2012: Chapter 17: Archaeology and Cultural Heritage).

There are a number of recorded maritime and aircraft losses within the OTA study area considered in the ES, a number of which have known positions, and which have been confirmed in the archaeological assessment of geophysical data (Seagreen, 2012: Chapter 17: Archaeology and Cultural Heritage). A significant number of maritime loss events, both vessels and aircraft have been identified in the wider outer Forth and North Sea basin in proximity to the Seagreen Alpha and Seagreen Bravo project areas. Further, there are a large number of maritime losses listed with arbitrary or tentative locations recorded within the region. The potential for the discovery of

3 Where the wreck is known or thought to exist at the assigned coordinates

4 Where the wreck is known to have been lost in this general area, but the wreck has not been identified in its recorded location, despite repeated surveys

unrecorded cultural heritage assets within the export cable route corridor was regarded as moderate (Seagreen, 2012: Chapter 17: Archaeology and Cultural Heritage).

The geoarchaeological and geotechnical assessment of the geotechnical survey borehole logs suggested that the potential for the discovery of relict land surface deposits and features of archaeological interest is low and there is limited potential for the discovery of residual artefacts.

3.10 Aviation, Military and Communications

Part of the application area overlaps with the Ministry of Defence (MoD) Barry Buddon firing range complex (Figure 3.5). The southern area of the Barry Sands has restricted access due to the MoD Barry Buddon firing range, which overlaps with a section of the OTA cable corridor. As shown in Figure 3.5 while there is an overlap with the military danger areas, the proposed cable installation works and breach of the rock revetment will not occur within the boundary of the danger areas or the MoD property.

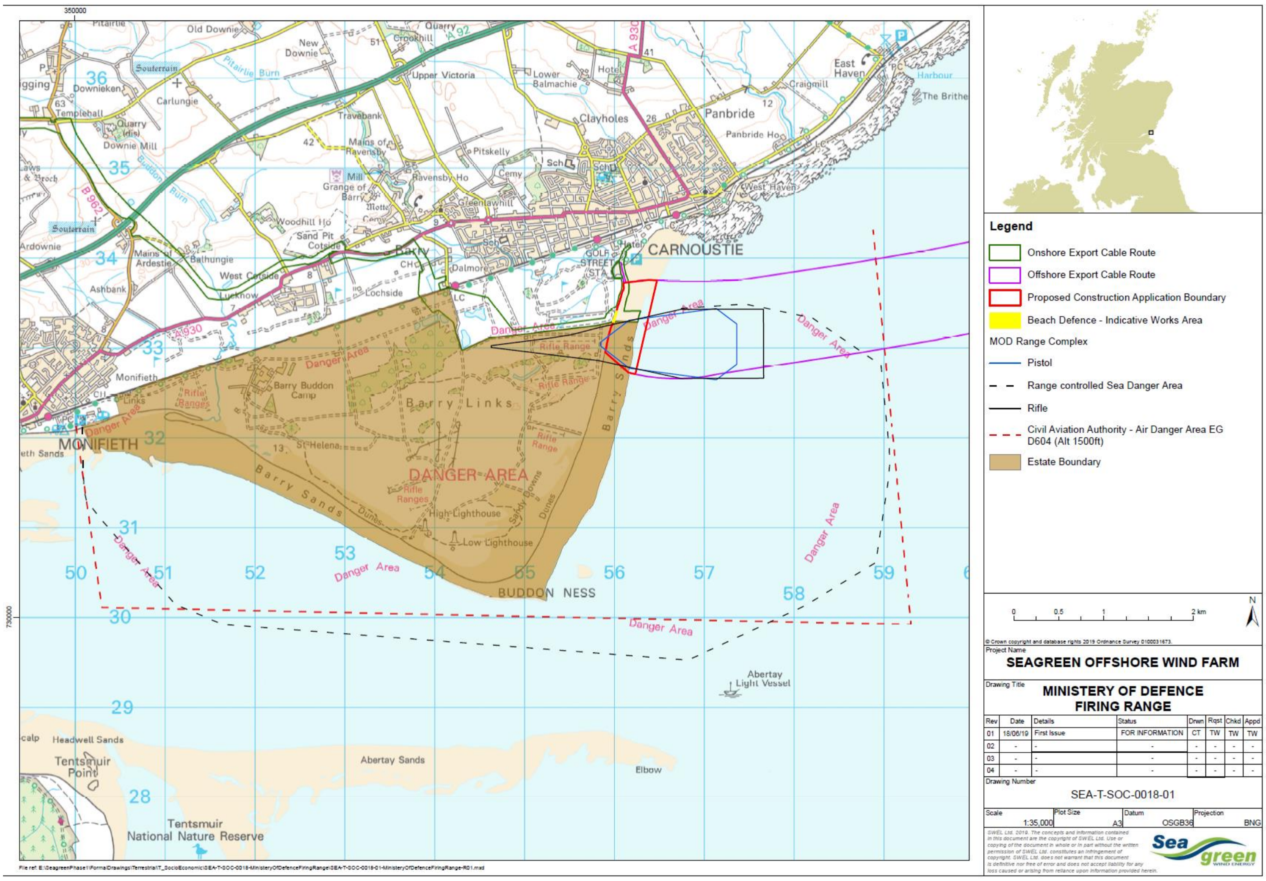


Figure 3.5: Ministry of Defence (MoD) Firing Range.

3.11 Other Marine Users and Activities

An aggregate (sand and gravel) resource area overlaps with the proposed Seagreen alternative cable installation methodology application boundary, however, there are no aggregate extraction licence areas in the vicinity of the proposed works. The closest open marine disposal site is 10.5 km from the proposed works (NMPI, 2019). There are no active or disused subsea communications or power cables within the vicinity (Seagreen 2018; Seagreen 2012; KIS-ORCA, 2019). There are no oil and gas activities in the vicinity of the proposed works and the nearest marine gas pipeline (FM13, owned and operated by National Grid) is approximately 7.5 km east of the export cable route in the mouth of the River Tay (Seagreen 2012, Chapter 20: Other Marine Users and Activities).

The Barry Sands, Carnoustie Bay, Monifeith, Lunan Bay, Montrose Bay, Arbroath Beach and Tentsmuir beaches are used for recreational activities. Carnoustie Bay is identified as an area suitable for swimming, sailing, windsurfing, fishing, sea kayaking and surfing (Seagreen 2012, Chapter 19: Socio Economics, Tourism and Recreation) and is also designated as a bathing water of good quality (see Figure 3.3 and Section 3.3). The designated bathing waters are approximately 122 m from the alternative cable installation works application boundary and approximately 148 m from the landfall. Lunan Bay has one of the largest expanses of sand in the Angus region and is popular with visitors for day trips and activities such as surfing. Tentsmuir and Monifieth are also popular for day visitors, valued for their large populations of birds and seals (Seagreen 2012, Chapter 19: Socio Economics, Tourism and Recreation).

4. Management Measures

There are a number of management measures which have been designed-in to the cable installation methodology, to reduce potential effects on the environment. In addition, Seagreen will require the implementation of a number of industry standard measures during the installation activities, which reduces the potential for certain impacts. These measures are listed in Table 4.1 below and are referred to in the individual assessments where relevant.

Table 4.1: Management Measures.

Measure	Description
Designed-in measures	
Selection of appropriate construction plant	Selection of appropriate plant would reduce the potential for over-excavation and reduce delays during construction.
Minimising working and stockpile areas	Working and stockpiling areas would be kept to a minimum size during the construction phase.
Excavation and reinstatement on a 'layer by layer' basis	Excavation of material along each trench would be undertaken in separate sediment layers and material of different grades would be stored separately within temporary stockpile areas where practicable. In intertidal areas, berms will be created to store the material which will be flattened to ensure that the berms do not become too high where practicable.
	Reinstatement in the intertidal zone will be undertaken on a 'layer by layer' basis in reverse order to the excavation sequence. This reduces potential for adverse effects on the sediment structure and profile within the affected area.
Reinstatement of the rock revetment	The rock revetment will be reinstated following completion of the works. Initial inspection has determined that some additional rock may be needed. Rock materials removed from the rock revetment will, where practicable, be reused during reinstatement if this is possible. Rock that is used to replace any material on the rock revetment will be either imported from Norway or from a UK quarry. The quarried material will be taken from onshore and will be transported dry to reduce the potential risk of Invasive Non-Native Species.
Flood Risk	A localised coastal flood warning system will be implemented during construction in consultation with SEPA.

Measure	Description
	Where possible, works will not be carried out during a coastal flood or storm event.
Cable burial	A topographic survey will be carried out to identify and map the contours of the seabed, beach and rock revetment prior to construction. Following reinstatement, a repeat topographical survey will be carried out to confirm that the original profiles and bathymetry have been restored.
	The beach and adjoining sea bed bathymetry along the line of the proposed cable landfall trench will be regularly surveyed during the lifetime of the project to ensure that there is adequate cover of the HDPE Pipes.
	If the HDPE Pipes become exposed, they will be reburied to a suitable depth to maintain adequate cover.
	Weighted collars will be secured on the HDPE pipes to prevent the risk of the HDPE pipes floating up to the surface of the beach due to storm wave induced liquefication of the beach sediments.
Communications and awareness	
Advisory Safety Distances	During cable installation works, working areas in the intertidal zone will be marked off to prevent public access, and advisory safety distances (of up to 500 m radius) will be recommended around the cable installation works in the subtidal zone. Advisory safety distances will be notified via issue of a Notice to Mariners.
Notices to Mariners	Seagreen will issue Notices to Mariners in advance of installation activities to alert vessels and other interests of the timing and location of the works.
Fisheries Liaison	A Fisheries Liaison Officer (FLO) will be appointed for the construction phase. The FLO will maintain dialogue with fishermen prior to all Seagreen construction activities to ensure that fishermen are informed of the activity and are aware of any restricted areas. The fishing community can raise issues regarding the activity with the FLO. Information regarding the works will be provided to the fishing industry through appropriate bulletins, publications and Notices to Mariners.
Environment	

Measure	Description
Environmental Management and Pollution Prevention	An Environmental Management Plan (EMP) and Marine Pollution Contingency Plan (MPCP) will likely form a consent requirement of any awarded Marine Licence for the alternative cable landfall methodology. These plans will contain proposed measures for the mitigation of construction noise, vibration and dust, and will outline the relevant pollution prevention measures for the works (e.g. bunding and drip catchment for hydraulic oils and fuels).
Waste Management	Wastes will be managed as part of the proposed EMP, which will include waste management measures to minimise, reuse, recycle and dispose of waste streams in compliance with relevant waste legislation.
Archaeological mitigation	An Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will likely form a consent requirement of any awarded Marine Licence for the alternative cable landfall methodology and will be adhered to throughout the works.

5. Assessment of Effects

5.1 Approach

The following sections provide an assessment of the potential environmental impacts of the alternative landfall cable installation activities in relation to the following environmental topics:

- Physical Environment and Water Environment;
- Benthic Ecology and Intertidal Ecology;
- Natural Fish and Shellfish Resources;
- Marine Mammals;
- Ornithology;
- Archaeology and Cultural Heritage;
- Aviation, Military and Other Users; and
- Other Marine Users and Activities.

The following environmental topics have been screened out of the assessment, as presented to MS-LOT during the meeting held on the 20th March 2019 (see Section 1.3) and set out in the Consenting Approach Document (Seagreen, 2019a), submitted to MS-LOT as part of the EIA Screening request:

- Commercial Fisheries;
- Shipping and Navigation;
- Seascape, Landscape and Visual Amenity;
- Air Quality;
- Human Health; and
- Climate Change.

5.1.1 Identification of Impacts and Effects

The proposed Seagreen Alternative Cable Landfall works have the potential to create a range of 'impacts' and 'effects' with regard to the physical, biological and human environment. The definitions of impact and effect used in this assessment are drawn from the Design Manual for Roads and Bridges (DMRB) (Highways Agency *et al*., 2008).

The term 'impact' is used to define a change that is caused by an action. For example, installation of sheet piles (action) results in increased levels of subsea noise (impact). The term 'effect' is used to express the consequence of an impact. For example, in the offshore environment the installation of sheet piles (activity) results in increased levels of subsea noise (impact), with the potential to disturb marine mammals (effect). Each assessment concludes whether the alternative landfall cable installation activities are likely to result in a negligible, minor, moderate or major effect on the receptor. The level of effect is based upon professional judgement and the available evidence to support the conclusions made.

Consideration of the potential for Likely Significant Effect (LSE) on European sites is presented in Section 8.

5.2 Physical Environment and Water Environment

Cable installation activities may disturb geomorphological features of the Barry Links SAC, SSSI and GCR

Cable installation activities have the potential to disturb the designated features of the Barry Links SAC, SSSI and GCR, which include embryonic shifting dunes and fixed coastal dunes. Although the final export cable route across the intertidal area has not been confirmed, the proposed location for the trench through the revetment is located to the north of the boundary of the Barry Links SAC, SSSI and GCR site (see Figure 1.1) and therefore cable installation activities are unlikely to directly disturb these sites. The upper beach consists of the rock revetment (MHWS extends half way up the rock revetment) which has replaced the crest of the backing dune and its landward slope (Seagreen, 2012, Chapter 7: Physical Environment) therefore direct disturbance effects on dune features are not anticipated. SNH have also advised that there is very little geomorphic connection between beach sediment processes and adjacent dune forms and habitats. As a result the works are unlikely to affect the natural heritage interests of Barry Links SSSI or GCR and are unlikely to have significant effects on the Barry Links SAC qualifying habitats (SNH, 2019a).

For these reasons, and due to the designed-in management measures set out in Section 4, it is considered that any effects on the geomorphological features of the Barry Links SAC, SSSI and GCR will be **negligible**.

Cable installation activities may affect sediment transport processes

The temporary presence of the trench(es), trench boxes and sheet piling have the potential to affect sediment transport processes by interrupting longshore sediment transport. Cable installation activities will involve the excavation of either one (Option 1) or three (Option 2) open trenches across the intertidal (170 m length) and subtidal (190 m length) zones with the potential for sheet piling in subtidal areas (and the rock revetment) and trench boxes in areas of dry ground.

The net longshore drift of beach sediment within Carnoustie Bay is north to south and relatively modest (Seagreen, 2012, Chapter 7: Physical Environment). Effects will be temporary and relatively short term (up to four months), occurring over one installation event (Option 1) or over one installation event per cable (Option 2). Any effects on sediment transport processes are likely to be minor during this period and reversible, as it is expected that the behaviour characteristics of the directly affected areas will be reinstated naturally within a few tidal cycles following completion of the works.

For these reasons it is considered that any effects on sediment transport processes will be **negligible**.

Cable installation activities in the intertidal and subtidal zones may increase Suspended Sediment Concentrations (SSC) within the water column and deposit material on the seabed

Cable installation activities may increase SSC in the water column and lead to subsequent deposition of material on the seabed. Increases in SSC are likely to be localised, with deposition occurring within a short distance either side of the trench. Increases in SSC will be temporary and occur over a relatively short duration of trenching and backfilling activity, occurring over one installation event (Option 1) or over one installation event per cable (Option 2). Effects will also be reversible, with SSC likely to return to baseline levels relatively quickly following completion of works (Seagreen, 2012, Chapter 7: Physical Environment). Furthermore, the location of the trenching in the intertidal and subtidal zones is an area of breaking wave activity where sediment transport is most likely to occur (although this natural process is limited in magnitude) and hence there would be relatively high SSC levels in these zones under baseline conditions.

The Carnoustie designated bathing waters, classified as 'good' status, is approximately 148 m from the proposed works. SEPA raised concern that large scale sediment and sand / silt disturbance has the potential to affect the status of the bathing waters through increased faecal coliform concentrations in the water column when sediment is disturbed during excavation in intertidal and subtidal areas (see Table 1.1).

Faecal pollutants can arise from human sewage, farming activities and livestock (e.g. cattle, sheep), industrial processes, surface water urban drainage, domestic animals (e.g. dogs) and wildlife (e.g. birds) and can enter bathing waters via:

1. direct discharges into the marine environment at, or in the vicinity of, the beach; and/or
2. the freshwater network draining into a bathing water, which can be prone to elevated bacterial levels, as a result of diffuse pollution and/or point source inputs upstream.

On review of available information, there are two potential sources of faecal coliforms in the vicinity of Carnoustie. These include watercourses such as the Barry Burn and Lochty Burn, and discharge from sewage treatment plants or overflows. The closest sewage outfalls are at East Haven (4 km to the north), Hatton (5.5 km to the north) and Tayport (13 km to the south)[5]. Map 1 in the SEPA bathing water profile for Carnoustie (SEPA, 2015) also shows a combined sewer overflow discharging into Carnoustie Bay adjacent to the designated bathing water. Discharge from the overflow is only expected to last one or two days following rainfall and only a temporary elevation of bacteria levels compared to dry conditions is expected.

SEPA (2015) suggest that the Barry Burn and Lochty Burn to the north of the Carnoustie bathing waters may be a source of agricultural and / or animal faecal coliforms, in addition to the human sources from sewerage. The Barry Burn due to the presence of a piggery and a large poultry facility within its catchment is likely to be a significant source of animal faecal coliforms (SEPA< 2015).

While the works are close to the bathing waters, it is considered unlikely that sediment disturbed during the works would affect the bathing waters. The sediment in the area is relatively coarse sand and is likely to settle within a few metres of disturbance (Seagreen, 2012). Potential sources of faecal coliforms are significantly to the north of the proposed works. While each of these sources to the north has the potential to affect the bathing waters and the sediments within the

[5] https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=750

boundary of the proposed works, the prevailing currents and sediment transport process are from the north to the south (HR Wallingford, 1997; Seagreen, 2012). Therefore, any disturbance of sediment that may have been contaminated is expected to be transported away from the designated bathing waters. As such it is considered highly unlikely that the works could result in any elevation of faecal coliforms that could affect the status of the designated bathing water.

Due to the short-term, localised and temporary nature of the potential impact and the fact that the works are unlikely to result in increases in faecal coliform concentrations at the designated bathing waters, the effect of cable installation activities on increased SSC within the water column and associated deposition is considered to be **negligible**.

Cable installation activities through the rock revetment have the potential to affect flood risk

Computational modelling of a potential breach of the revetment and dune system adjacent to Carnoustie Golf Course indicated that there was no risk to properties during a 200 year extreme water level event (See Appendix A). Some minor inundation of Carnoustie golf course was predicted via the simulated breach. However this area is likely to flood during a 200 year event through inundation from the Barry Burn even without a breach of the rock revetment. Therefore, the flood risk due to breach of the rock revetment is not deemed a significant contribution under this scenario.

Potential flood risk posed by the removal of the rock revetment is assessed as insignificant and highly unlikely to occur during the period of installation and the lifetime of the project (25 years). A small area of Carnoustie golf course, otherwise considered to be low vulnerability, may be inundated during the 200 year modelled event. However, this is not considered to provide a significant contribution to flooding when considering potential inundation from the Barry Burn.

Risk of erosion to the dune system and danger to construction operatives should a storm event occur during construction will be mitigated. This will be undertaken via a localised coastal flood and storm event warning system implemented in consultation with SEPA. Construction will not take place during a storm event in order to ensure a flood event does not occur. With these measures in place the likelihood of a flood event occurring via a breach of the rock revetment will be greatly reduced and any potential impacts unlikely to occur. In the highly unlikely event that a flooding were to occur, any impacts are likely to be short term and localised with flooded areas recovering once the waters have receded. As such specific flood risk mitigation measures are not considered necessary and the potential effect is considered to be **negligible**.

Potential exposure of buried cables due to beach lowering

In their response to the EIA Screening Request (Seagreen, 2019c) SNH recommend that Seagreen investigate the potential for lowering of the beach during the lifetime of the project and the potential for this to result in re-exposure of the HDPE pipes in the intertidal and subtidal zones. To assess this risk, RPS (2019) undertook a desk based beach lowering assessment which examines historical changes in beach level and uses these historical data points to examine whether the HDPE pipes would become exposed.

RPS (2019) used historical data provided by OS Maps for the years 1858, 1900 and 1938[6] and from a study undertaken along the rock revetment by HR Wallingford (1991) (see Appendix B). HR Wallingford undertook beach surveys and level change assessments at Barry Sands in 1990 for the MoD site that lies immediately to the south of the proposed landfall site. The assessment used survey profiles over the period 1979 – 1990 to develop a rate of beach level decline which included the effect of the presence of the rock revetment.

Based on the available data and the site visits undertaken in 2019 (see Section 2.2) the decline in the beach level over the period 1989 to 2019 is assessed as between 2.4 to 1.4 m. This gives a maximum beach lowering rate of 0.08 m/year which corresponds well with the HR Wallingford upper bound estimate of 0.11 m/year (see Appendix B).

Seagreen propose to dig a trench to a depth of 3m below current beach levels across the intertidal area out to the -2.5 m LAT depth contour. The diameter of the HDPE pipes in which the cables will be installed is approximately 0.8 m, providing a cover depth at 2019 beach levels of 2.2 metres. If the beach levels continue to drop at the average maximum rate experienced over the last 30 years (0.08 m/year) then the HDPE pipes will not become exposed over the lifetime of the installation (25 years). However, it is possible that, due to the effects of climate change on the frequency and magnitude of storms, the rate of beach decline may increase to a rate similar to or greater than the upper bound values derived by HR Wallingford. In this case the HDPE pipes could become exposed before the end of the lifetime of the project.

It should also be noted that the beach is exposed to a fairly aggressive wave climate even during typical annual storm events (RPS, 2019). Thus, there is a possibility that the top layer of the sand may liquefy for part of the time during the passing of each individual the storm wave. This could result in the HDPE pipes being gradually floated up to the surface of the beach once the cover depth has reduced and result in a premature exposure of the HDPE pipes.

While there is potential that the HDPE pipes may become exposed during the lifetime of the project, the implementation of the designed in management measures identified in Table 4.1 (including annual visual monitoring of the buried HDPE pipes and the use of concrete collars to weigh down the pipes) means that the likelihood of such exposure is considered to be low. If the cables were to become exposed any impacts are considered to be short term and localised and will be removed once the HDPE pipes are reburied. As such additional mitigation measures are not considered necessary and the potential effect is considered **minor**.

5.3 Benthic Ecology and Intertidal Ecology

Cable installation activities may result in temporary intertidal and subtidal habitat loss/disturbance

Cable installation activities may result in temporary benthic habitat loss or disturbance. The worst case scenario is represented by Option 2, with a total area of temporary habitat loss/disturbance resulting from trenching activities and associated working areas within the intertidal and subtidal

[6] https://maps.nls.uk/geo/find/#zoom=12&lat=56.4877&lon=-2.8478&layers=102&b=1&point=56.4772,-2.7350

zones of up to 21,940 m^2 (0.022 km^2). This worst case scenario figure is considered to be relatively small in the context of the presence of similar habitats in the wider area (i.e. Carnoustie Bay).

Benthic communities at the cable landfall were not identified as being particularly diverse or species rich and there was a lack of any species or habitats that were of particular conservation concern (Seagreen, 2012, Chapter 11: Benthic Ecology and Intertidal Ecology). Re-colonisation is likely to occur via recruitment from adjacent populations, and therefore recovery potential is considered to be high (Tilling and Budd, 2016).

Habitat loss/disturbance will be temporary and will take place over a relatively short duration (up to four months), occurring over one installation event (Option 1), or over one installation event per cable (Option 2). Effects will also be reversible, with trenches in the intertidal zone being backfilled on completion of the works and trenches in the subtidal zone allowed to backfill naturally.

The impact will be of relatively small spatial extent, short term duration, temporary and reversible, and considering the nature of the benthic environment at this location and the potential for recoverability, the effect of temporary habitat loss/disturbance is considered to be **negligible**.

In Section 2.2 it is noted that the intertidal zone has the potential to be shorter than that suggested by the charted data (see Figure 1.1). However, as the distance from the toe of the rock revetment to a depth of 2.5 m LAT is considered in this assessment to be 360 m long as a worst case, the potential area affected remains 21,940 m^2 and the assessment above does not change.

Removal and replacement of the rock revetment may result in temporary habitat loss/disturbance

Removal and replacement of a section of the rock revetment may result in temporary habitat loss and disturbance to colonising communities. The total area of disturbance resulting from the removal of a section of the rock revetment is up to 2,100 m^2, resulting in the temporary removal of habitat and potential disturbance of habitat either side of the removed section. This represents a total of 0.02% of the overall habitat provided by the 3.5 km long and 30 m wide rock revetment along the Angus coast. Only a portion of the rock revetment is covered at high tide therefore the area affected is likely to be smaller. Removed rock material will be reused for reinstatement or taken to a licensed onshore disposal site if not suitable for reuse. An additional 6,000 m^3 of rock may be required to complete the revetment reinstatement, providing some additional surfaces for colonisation.

Habitat loss/disturbance will be temporary and will take place over a relatively short duration (up to four months), occurring over one installation event. In addition, a fourth HDPE pipe will be installed in the rock revetment as a spare to avoid future disturbance.

The rock revetment is largely colonised by lichens, winkles *Litorina saxatilis* and *Melarhaphe neritoides*, the limpet *Patella vulgata*, the barnacle *Semibalanus balanoides* and mussel *Mytilus edulis* (Seagreen, 2012, Chapter 11: Benthic Ecology and Intertidal Ecology). These communities are anticipated to recover following cessation of the works and reinstatement of the rock revetment through colonisation from populations present in adjacent areas. Recovery potential is considered to be high (Tilling and Budd, 2016).

The impact will be of relatively small spatial extent, short term duration, temporary and reversible, and considering the potential for recoverability, the effect of temporary habitat loss/disturbance is considered to be **negligible**.

Cable installation activities in the subtidal zone may result in temporary increases in SSC and associated sediment deposition

Cable installation activities may result in temporary increases in SSC and associated sediment deposition, leading to smothering of subtidal benthic communities. The worst case scenario is represented by Option 1, with up to 17,100 m^3 of sediment removed from the 190 m long subtidal zone during trench excavation activities. However, as the excavation will occur over a number of days the amount released into the subtidal zone will be substantially less than this volume each day and is unlikely to result in significant additional SSC in the water column.

Benthic communities at the cable landfall were not identified as being particularly diverse or species rich and there was a lack of any species or habitats that were of particular conservation concern (Seagreen, 2012, Chapter 11: Benthic Ecology and Intertidal Ecology). The communities in the subtidal zone occur in a dynamic and scoured environment and are therefore tolerant of high sediment concentrations in the water column. In addition, it is likely that any sediment released will be re-mobilised and transported within one tidal cycle.

Increases in SSC will be temporary and intermittent and will take place over a relatively short duration of trenching and backfilling activity, occurring over one installation event (Option 1) or over one installation event per cable (Option 2). Effects will also be reversible, on the basis that levels of SSC are likely to rapidly return to background concentrations following cessation of the activity.

The impact will be of relatively small spatial extent, short term duration, temporary and reversible, and considering the nature of the benthic environment at this location, the effect of increased suspended sediment and associated sediment deposition is considered to be **negligible**.

In Section 2.2 it was noted that the subtidal zone has the potential to be longer than suggested by the charted data (see Figure 1.1). Therefore, the distance from MLWS to a depth of 2.5 m LAT has the potential to be greater than 190 m and could be up to 340 m long as a worst case (assuming the intertidal zone is only 20 m in length). This would mean that the worst case scenario (represented by Option 1) is for up to 30,600 m^3 of sediment removed from a 340 m long subtidal zone. This scenario would not change the conclusions presented above on the basis that the volume of sediment released into the water column on a daily basis will be substantially less than the total volume and considering that any increases in SSC will be temporary and localised, taking place over a relatively short duration and effects will also be reversible with levels of SSC rapidly returning to background concentrations.

5.4 Natural Fish and Shellfish Resources

Cable installation activities may result in temporary subtidal habitat loss/disturbance

Cable installation activities may result in temporary subtidal habitat loss/disturbance to fish and shellfish communities. The worst case scenario is represented by Option 1, with a total area of temporary habitat loss/disturbance resulting from trenching activities within the subtidal zone of up to 5,700 m^2. Any habitat loss/disturbance will be temporary and will take place over a relatively short duration (up to four months) occurring over one installation event (Option 1) or over one installation event per cable (Option 2).

In general, the nursery and spawning grounds that extend into the nearshore area are extensive and cover large areas within the Outer Firth of Forth and Firth of Tay and the wider North Sea (Ellis *et al*., 2012; Seagreen, 2012, Chapter 12: Natural Fish and Shellfish Resource). Therefore, only a small proportion of any spawning grounds which coincide with the cable works are likely to be affected.

The key rivers for migratory salmon are all some distance away from the landfall, the closest being the River Tay, some 15 km to the south. While some adults may pass close to the landfall location, recent evidence suggests smolts head directly out to sea on leaving their natal river (Newton *et al*., 2017) and are unlikely to be in the vicinity of the works in any great numbers, or for any great length of time.

Mobile species will be able to avoid the impacted area and there is unlikely to be any discernible effect due to the availability of similar habitat in the wider area. Sessile shellfish species may be more vulnerable and habitat loss/disturbance could lead to direct loss of individuals in the impacted area. However, the area affected in comparison to the distribution of these species in the wider area is very small. Once installation activities have ceased, habitats will begin to recover and within one or two tidal cycles will have returned to baseline conditions.

The impact will be of relatively small spatial extent, short term duration, temporary and reversible, therefore the effect of temporary subtidal habitat loss/disturbance on fish and shellfish communities is considered to be **negligible**.

In Section 2.2 it was noted that the subtidal zone has the potential to be longer than suggested by the charted data (see Figure 1.1). Therefore, the distance from MLWS to a depth of 2.5 m LAT has the potential to be greater than 190 m and could be up to 340 m long as a worst case (assuming the intertidal zone is 20 m in length as per Section 2.2). This would mean that the worst case scenario (represented by Option 1) is for up to 10,200 m^2 of temporary habitat loss/disturbance. This scenario would not change the conclusions presented above on the basis that habitat loss/disturbance would be temporary and take place over a relatively short duration (up to four months). Effects will also be reversible, on the basis that the trenches will be allowed to backfill naturally, following the installation of the cable.

Cable installation activities in the subtidal zone may result in temporary increases in SSC and associated sediment deposition

Cable installation activities may result in temporary increases in SSC and associated sediment deposition, affecting fish and shellfish communities. The worst case scenario is represented by Option 1, with up to 17,100 m^3 of sediment removed from the subtidal zone (190 m in length) during trench excavation activities, although the amount of sediment released in any one day will be significantly less than this. Potential increases in SSC will be temporary and will take place over relatively short duration (up to four months). Effects will also be reversible, on the basis that levels of SSC are likely to rapidly return to background concentrations following cessation of activities.

Migration of Atlantic salmon takes place throughout the year with smolt downstream migration from rivers (Tay, Forth, Dee, Eden and North and South Esk) occurring between April and May (Seagreen, 2012, Chapter 12: Natural Fish and Shellfish Resource) and adults returning throughout the year with peaks in migration in late summer and early autumn. Mobile fish species will be able to avoid localised areas disturbed by increased SSC.

Deposition of sediment on the seabed may result in smothering of animals, and fish eggs and larvae and shellfish species may be particularly vulnerable due to their lower mobility. In general, the nursery and spawning grounds that extend into the nearshore area are extensive and cover large areas within the Outer Firth of Forth and Firth of Tay and the wider North Sea (Ellis *et al*., 2012; Seagreen, 2012, Chapter 12: Natural Fish and Shellfish Resource). Therefore, only a small proportion of any spawning grounds which coincide with the landfall are likely to be affected by increased SSC in the water column and subsequent deposition on the seabed (Seagreen, 2012, Chapter 12: Natural Fish and Shellfish Resource).

The impact will be of relatively small spatial extent, short term duration, temporary and reversible, therefore the effect of increased suspended sediment and associated sediment deposition on fish and shellfish communities is considered to be **negligible**.

In Section 2.2 it was noted that the subtidal zone has the potential to be longer than suggested by the charted data (see Figure 1.1). Therefore, the distance from MLWS to a depth of 2.5 m LAT has the potential to be greater than 190 m and could be up to 340 m long as a worst case (assuming the intertidal zone is only 20 m in length). This would mean that the worst case scenario (represented by Option 1) is for up to 30,600 m^3 of sediment removed from a 340 m long subtidal zone. This scenario would not change the conclusions presented above on the same basis as described for benthic ecology and intertidal ecology, in that any effects will be reversible, temporary and occur over a relatively short duration.

Cable installation activities may result in underwater noise

Cable installation activities (including cable laying and associated vessel activity) and sheet piling activities have the potential to result in underwater noise, leading to effects on fish and shellfish receptors. In relation to cable installation activities, noise modelling undertaken for the Seagreen ES (Subacoustech, 2012) demonstrated that the effect ranges for selected fish species associated with noise generated by cable laying activities, and vessels, will be very small and limited to the immediate vicinity of the area where works are being carried out at a given time. In relation to sheet piling, vibro-piling methods will be used to install sheet piles in the rock revetment and shallow subtidal areas. Modelling of vibro-piling noise undertaken by Subacoustech (2015) for the Beatrice offshore wind farm suggests that noise levels are substantially below injury thresholds for marine mammals (and therefore also fish) and that any lethal effects will only occur within 1 m of the piling activity.

The proposed activities are not in the vicinity of any spawning or nursery grounds of species that are sensitive to noise (e.g. herring, the nearest herring spawning ground is much further to the north, see Figure 5.1). Adult salmon may be in the vicinity during sheet piling activity, but the magnitude of sound generated is expected to be relatively small scale and significantly smaller than that predicted for foundation piling at the offshore wind farm. Popper *et al*., (2014) suggest that there is a low risk of behavioural effects from noise from hammer piling beyond hundreds of metres for salmon, which is considered to be of medium sensitivity to sound. The nearest salmon river is the River Tay, some 15 km to the south. While some adults may pass close to the cable installation works, recent evidence suggests smolts head directly out to sea on leaving their natal river (Newton *et al*., 2017) and are unlikely to be in the vicinity of the proposed works in any great numbers, or for any great length of time.

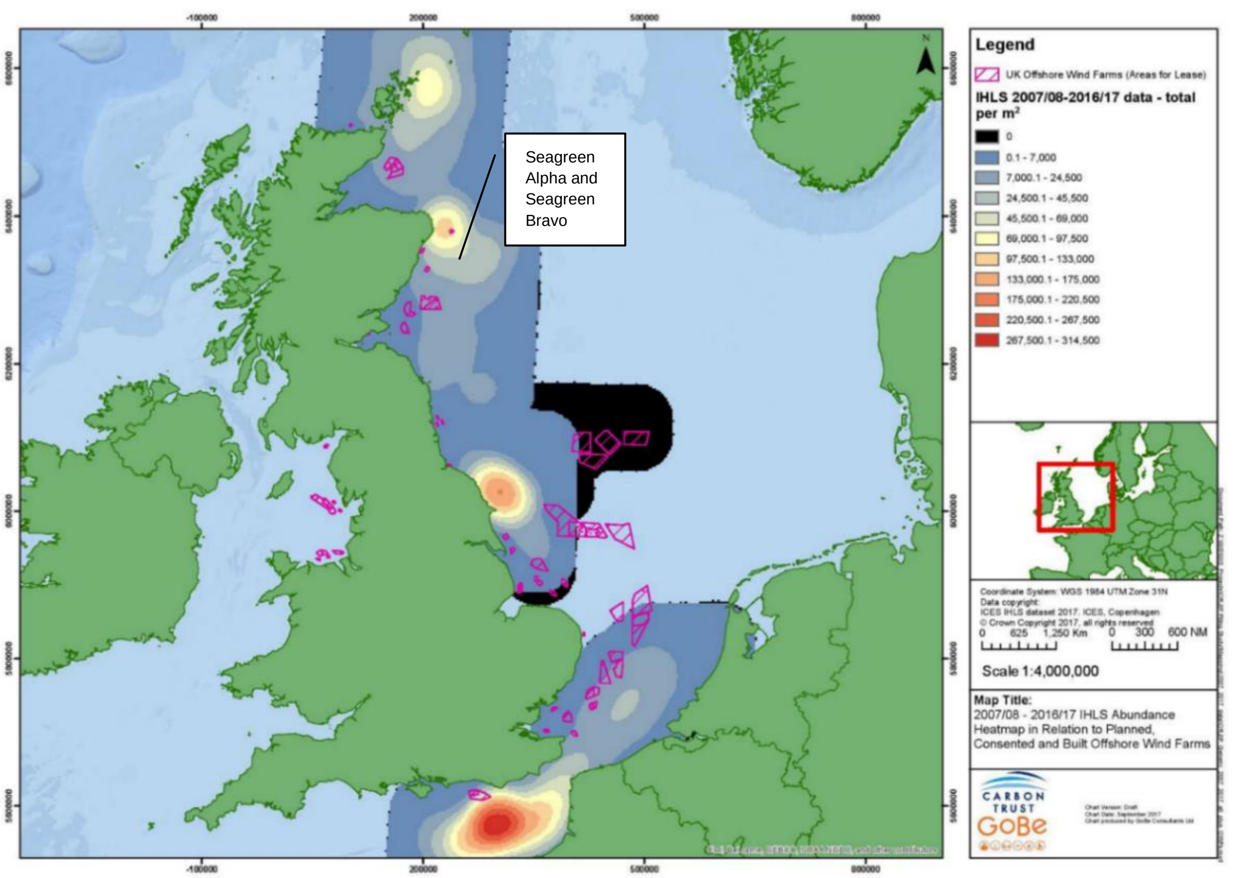


Figure 5.1: International Herring Larvae Survey (IHLS) 10 year data in relation to planned, consented and built offshore wind farms. Source Boyle and New, 2018.

Due to the low level, localised, short term and reversible (as fish will start to return to the area once activity has ceased) nature of the impact, and considering the distance of key spawning habitat, the sensitivity of the receptors (including Atlantic salmon, river and sea lamprey as features of SACs) and the distance from the nearest river designated for key migratory species (15 km to the River Tay SAC) the effect of underwater noise on fish and shellfish receptors is considered to be **negligible**.

5.5 Marine Mammals

Cable installation activities may result in noise disturbance

Cable installation activities may result in noise disturbance to marine mammal receptors. The magnitude and spatial extent of the impact from excavation activities is considered to be small, on the basis that the works will be restricted to shallow, nearshore waters (i.e. 2.5 m LAT (360 m from

MHWS and 190 m from MLWS)) where marine mammals are less likely to be relative to deeper waters. In addition, noise modelling (Seagreen, 2012) has demonstrated that the modelled ranges for disturbance associated with cable installation activities (e.g. vessel activity and trenching for cable laying) are highly localised and limited to the immediate vicinity of the area where works are being carried out (up to a maximum of 16 m for vessel noise and 40 m for cable laying (Seagreen, 2012)).

The magnitude and characteristics of vessel noise varies depending on ship type, ship size, mode of propulsion, operational factors and speed. Vessels of varying size produce different frequencies, generally becoming lower frequency with increasing size. Although it has yet to be determined whether plant will include barge mounted or jack up mounted backhoe excavators and whether any rock will be transported to the site at high tide by barges, vessels will largely be stationary during much of the installation activities. Underwater noise from backhoe trenching will be caused by noise from engines or hydraulic power units radiating through the hull of the barge into the water. As such, noise levels would be expected to be similar to a small vessel and below the noise levels produced by larger vessels underway which frequently transit past the area out of the Tay. Therefore, noise from backhoe trenching activities is not considered to be a significant contributor to overall underwater noise levels.

The magnitude and spatial extent of the impact from vibro-piling to install sheet piles in the rock revetment and shallow subtidal areas may be greater than that from vessels and trenching/cable laying activities detailed above. However, modelling of vibro-piling noise undertaken by Subacoustech (2015) for the Beatrice offshore wind farm suggests that noise levels generated by vibro-piling are substantially below injury thresholds for marine mammals. Further, modelling by Subacoustech (2015) suggests that behavioural effects may only potentially occur out to a few hundred metres for marine mammals, with behavioural avoidance potentially occurring up to 410 m for minke whales, 100 m for harbour porpoises, 43 m for bottlenose dolphins and 46 m for harbour and grey seals. In addition, a field study by Graham *et al*. (2017) demonstrated that harbour porpoise and bottlenose dolphin in the Moray Firth were not completely displaced by vibration piling in a coastal habitat. Only bottlenose dolphins showed a measurable (but weak) behavioural response to both impact and vibration piling, with a small reduction in the amount of time that they spent around the construction works during piling.

Seals and cetaceans may avoid the immediate vicinity of the proposed works area due to the presence of plant (including barges and jack up vessels), and noise generated from cable laying and vibro-piling activity. However, due to the highly mobile nature of all marine mammal species and the small scale of the affected area, this disturbance is not expected to have a significant effect on any individual marine mammals.

Elevations in underwater noise will be localised, temporary and intermittent and will take place over a short duration (up to four months for vessel and plant activity and up to 21 days for vibro-piling to install sheet piles). Effects will also be reversible, with normal activity likely to rapidly resume following cessation of the works and in the gaps between noisy activities during the four month period of total activity. Based on the low density of both harbour and grey seals and bottlenose dolphin in the area, their high mobility, and the short duration of vibro-piling activity, it is considered that effects on marine mammals as a result of underwater noise generated during the works will be **minor**.

5.6 Ornithology

Cable installation activities may result in temporary disturbance or displacement of birds

The combination of visual and noise disturbance from construction activity has the potential to cause displacement and disturbance to birds. This result is that the impacted birds behave differently from the behaviour they would be reasonably expected to exhibit without the presence of that activity (Gill, 2007). Disturbance can manifest in a number of forms of varying severity depending on the nature, duration and intensity of the disturbance source:

- Birds looking up or heads raised, temporarily stopping feeding or roosting;
- Birds moving away from the cause of the disturbance by swimming before resuming previous activity;
- Birds taking flight and landing somewhere in the same feeding area; and
- Birds taking flight and leaving the survey area completely (i.e. displacement).

The resulting impacts of disturbance episodes for seabirds birds are variable (Cutts *et al*., 2013). In general, each subsequent level of severity will result in a greater reduction in feeding time, and greater energy expenditure. Flushing (moving away in response to disturbance) is an energetic implication that, in severe and prolonged cases, can result in decreases in the overall fitness of a population, which in turn can lead to reduced breeding success and increased mortality. Birds that are more tolerant than other individuals and remain in an area affected by disturbance may not forage efficiently, and if there are additional pressures on the birds (for example cold weather), then this may impact upon the survival of individual birds or their ability to breed later in the year.

For birds on the sea, behavioural responses to the presence of vessels also involve flushing, either into flight or by diving in the case of species such as divers and auks. This reduces feeding time and increases energy expenditure, with knock on impacts to breeding success and mortality possible.

Birds in a coastal setting, including qualifying and assemblage species of the SPA and pSPA, have large foraging ranges, however, and are adapted to move to find food, notably in response to the tidal cycles and moving distribution of prey. Considering this ability, the widespread availability of alternative roosting and foraging habitat, a degree of existing habituation to disturbance (given recreational and other beach and coastal activities), the temporary and reversible nature of this effect, the effect of this disturbance/displacement is considered to be **negligible**.

5.7 Archaeology and Cultural Heritage

Cable installation activities may affect marine archaeology

Cable installation activities have the potential to affect marine archaeology through direct and indirect impact to the seabed. It is also possible that finds of archaeologist interest may be identified as a result of trenching activities.

The nearest recorded wreck location to the landfall is approximately 2 km to the north east of the cable installation works and outside of the export cable route corridor. While there is still potential for new finds and material to be discovered, mitigation will be secured through a Written Scheme of Investigation (WSI) and Protocol for Archaeological Discoveries (PAD), which will include the establishment and avoidance of Archaeological Exclusion Zones (AEZs) and the means of reporting any potential discoveries to the project archaeologist during the works.

The spatial extent of the impact will be limited to a short section of the intertidal and subtidal cable route. Any impact on marine archaeology would be permanent and irreversible, however, as noted above mitigation will ensure direct impact is avoided. The period over which there is potential for impact to occur is of short-term duration (up to four months).

Seabed disturbance may cause secondary physical effects to marine archaeology assets through settlement of SSC out of the water column, however the increases in SSC from the cable installation activities are anticipated to be short term and localised, with associated sediment deposition also predicted to be localised.

Due to the implementation of a WSI and PAD, and due to the short term and localised nature of increased SSC and associated sediment deposition, the effects of cable installation activities on marine archaeology are considered to be **negligible**.

5.8 Aviation, Military and Communications

Cable installation activities may affect military activities

Part of the application area overlaps with the Ministry of Defence (MoD) Barry Buddon firing range complex (Figure 3.5). However, while there is an overlap of the application area with the military danger areas, the proposed cable installation works, and breach of the rock revetment will not occur within the boundary of the danger areas, or the MOD property and therefore these activities are unlikely to be affected. In addition, any potential interaction between activities will be of short duration (up to four months), temporary and managed via the communications protocol to be developed by Seagreen and the MoD, as required by the existing OTA Marine Licence.

Due to the lack of overlap with cable installation works and breach of the rock revetment with the firing range complex, combined with the implementation of a communications protocol between the MoD and Seagreen, the effects of the cable installation activities are considered to be **negligible**.

5.9 Other Marine Users and Activities

Cable installation activities may affect the activities of other marine users receptors in the vicinity

Cable installation activities in the intertidal and subtidal zones have the potential to affect the activities of other marine users in the vicinity of the works, including recreational receptors utilising the beach.

The extent of the impact will be limited to a short section of the intertidal and subtidal cable route, with any potential exclusion of recreational activities limited to a small area associated with the presence of any marked off working areas (intertidal) and advisory clearance distances (subtidal) around the cable installation works. Any effects will be temporary, short-term (up to four months), occurring over one installation event (Option 1) or over one installation event per cable (Option 2) and are reversible.

Carnoustie Bay is identified as an area suitable for swimming, sailing, windsurfing, fishing, sea kayaking and surfing and is also designated as a bathing water of good quality. There is considered to be limited potential for effects on water quality from release of sediment due to the distance between the proposed works and the bathing water (148 m) and considering that increases in SSC are anticipated to be localised to the works. Management measures will be implemented to reduce effects on recreational receptors during the works, including local site notices.

Due to the potential for temporary displacement of recreational activities, over a relatively short-term duration, and considering the proposed management measures, the effect is considered to be **minor**.

6. Cumulative Effects

This section considers the potential for cumulative effects arising from the alternative landfall cable installation activities identified in Section 2 alongside other known activities. These other activities are described in Table 6.1, and are based on those identified in the Consenting Approach document (Seagreen, 2019) and presented to MS-LOT on 20th March 2019. A review of activities was undertaken for this Environmental Report. Only two projects were identified as having the potential for cumulative impacts, Port of Dundee Expansion and Marine Aggregate Extraction project (Royal Haskoning, 2013) and the Eastern HVDC link (NGET and SHETL, 2012). However, the Port of Dundee development is more than 15 km from the landfall location at Carnoustie and the Eastern HVDC link has been postponed to beyond 2021[7] and is considered dormant[8]. Therefore, both projects have been scoped out of the cumulative assessment. The cumulative assessment therefore only considers potential cumulative effects with the remaining portion of the Seagreen OTA beyond the 2.5m LAT contour.

Table 6.1: Other activities considered in cumulative assessment.

Activity/Project	Description
Installation works associated with other phases of the Seagreen OTA construction, including the remaining OTA installation works.	The alternative cable landfall installation methodology forms part of the wider Seagreen OTA installation works. Activities associated with the wider Seagreen OTA installation works include activities above MHWS and the remaining OTA installation works to the OWF site. Given that the works above MHWS occur within the terrestrial environment it is unlikely that there will be any cumulative effects as there is no impact pathway between these works and the majority of receptors present below MHWS. However, birds that are present in intertidal areas may potentially be found in terrestrial habitats and therefore the cumulative effect with the onshore works is assessed for birds. Due to the distance between the OTA landfall works and the offshore wind farm site (approximately 70 km), cumulative effects arising from this phase of the works have been scoped out (as described in the Consenting Approach document, Seagreen, 2019).

An assessment of the potential cumulative effects is presented in Table 6.2. The assessment of cumulative effects with the remaining Seagreen OTA installation works has been based on the assessments undertaken in the Seagreen ES (Seagreen, 2012) and the ES for the optimised project (Seagreen, 2018a).

---

[7] https://www.ssen.co.uk/EasternHVDClink/

[8] https://www.4coffshore.com/transmission/interconnector-eastern-hvdc-link-(e4dc-peterhead---hawthorn-pit)-icid9.html

Table 6.2: Assessment of Cumulative Effects

Receptor	Other Seagreen Construction Activities
Physical Environment and Water Environment	The remaining OTA installation works (i.e. the installation of the export cable from the point at which the alternative cable landfall works are completed (2.5 m LAT) to the OWF) will take place in the subtidal zone. As a result, these works are only likely to interact with the subtidal aspects of the alternative cable landfall works. Increases in SSC and deposition will be limited in spatial extent to the length of the trench, and for deposition, a short distance either side. Any potential effects will be of short duration. Cumulative effects on SSC and associated sediment deposition are not anticipated as cable installation will be temporally and spatially sequential along the export cable route. Effects from the subtidal elements of the remaining Seagreen OTA installation works are expected to be negligible (Seagreen, 2012) and will occur further offshore than those from the alternative cable landfall (i.e. beyond 2.5 m LAT). As a result, any cumulative effects are expected to be **negligible**. There is considered to be no potential for cumulative effects to the Barry Links SAC, SSSI and GCR as other Seagreen project activities to install the export cables in subtidal areas (e.g. jetting and ploughing activity) will not disturb these features. There will be no cumulative effect on sediment transport processes as the remaining OTA installation works will not require sheet piling. It was considered in the Seagreen ES (Seagreen, 2012) that effects on other marine users and activities from the OTA would be negligible. The OTA and the alternative cable landfall do not directly overlap with the designated bathing water adjacent to the town of Carnoustie. The bathing waters are 122 m from the proposed alternative cable installation works application boundary and approximately 148 m from the consented offshore export cable route corridor (see Figure 3.3)). Therefore, it is considered that any effects to the bathing waters will remain **negligible**. There is considered to be no potential for cumulative effects in relation to flood risk as other Seagreen project activities to install the export cables in subtidal areas (e.g. jetting and ploughing activity) will not disturb these features. There is considered to be no potential for cumulative effects in relation to beach drawdown and cable exposure as other Seagreen project activities to install the export cables in subtidal areas (e.g. jetting and ploughing activity) are unlikely to affect the processes that determine the beach profile.

Receptor	Other Seagreen Construction Activities
Benthic Ecology and Intertidal Ecology	There is no potential for cumulative effects in the intertidal zone or at the rock revetment as the remaining OTA installation works will only take place in the subtidal zone. Habitat loss/disturbance in the subtidal zone with potential for loss of infauna and epifauna during OTA installation works was assessed as negligible (Seagreen, 2012). The impact of the alternative landfall cable installation is assessed as being negligible. Effects are likely to occur in different areas and are spatially separated along the export cable route corridor. Therefore, the effects of habitat loss/disturbance on subtidal benthic communities are not expected to significantly overlap with the proposed cable installation works and cumulative effects are considered to be **negligible**. Cumulative effects on SSC and associated sediment deposition are not anticipated as cable installation will be temporally and spatially sequential along the export cable route. Therefore, the cumulative effect of increased SSC and sediment deposition on subtidal benthic communities is considered to be **negligible.**
Natural Fish and Shellfish Resources	The potential impacts of the alternative landfall cable installation activities are assessed as being negligible for temporary subtidal habitat loss and disturbance on fish and shellfish communities. The remaining OTA installation works to the OWF site are likely to result in localised, temporary and reversible effects on fish and shellfish from habitat loss/disturbance. The total area affected by both the alternative cable landfall works and the remaining OTA works will represent a small proportion of the total available spawning and nursery habitat for key species and herring nursery grounds are much further to the north. Migratory species are not likely to be present in any great numbers and will avoid areas where habitat disturbance has occurred. Therefore, cumulative effects are assessed as being **negligible**. Cable trenching activities along the OTA resulting in an increase in SSC and sediment deposition were assessed as negligible (Seagreen, 2012). The impact of the alternative landfall cable installation activities is also assessed as negligible. Effects from the remaining aspects of the OTAQ will occur further offshore than those from the alternative cable landfall (i.e. beyond 2.5 m LAT) and are unlikely to add to SSC levels in the same area, due to this spatial separation. Cumulative effects on SSC and associated sediment deposition are not anticipated as cable installation will be temporally and spatially sequential along the export cable route. Fish that occur in subtidal areas close to shore are also tolerant of high levels of SSC. Therefore, the cumulative effect of increased SSC and sediment deposition on fish and shellfish communities is considered to be **negligible.**

Receptor	Other Seagreen Construction Activities
	Underwater noise from other Seagreen OTA construction activities will result in short term, localised disturbance to fish and shellfish and the effects were considered to be negligible (Seagreen, 2012). The impact of underwater noise from the alternative landfall cable installation activities is also assessed as negligible. Any impacts experienced will be short term, localised and reversible with fish returning to the area once activities have ceased. Therefore, the cumulative effect of noise disturbance from all Seagreen OTA construction activities and the alternative cable landfall is considered to be **negligible.**
Marine Mammals	Seagreen OTA construction activities will result in short term, localised disturbance to marine mammals from underwater noise. Effects were considered to be minor (Seagreen, 2012). The impact of underwater noise from the alternative landfall cable installation activities is also assessed as minor. Given the spatial separation between the two activities, the low densities of marine mammals, the short term nature of the impacts and low magnitude of the impact the cumulative effect of noise disturbance is considered to be **minor**.
Ornithology	There is potential for cumulative disturbance/displacement of coastal birds during any temporal overlap between the alternative cable landfall installation works and installation of the remaining OTA cable. It should be noted that birds in a coastal setting, including qualifying and assemblage species of the SPA and pSPA, have large foraging ranges, however, and are adapted to move to find food, notably in response to the tidal cycles and moving distribution of prey. Given the widespread availability of alternative roosting and foraging habitat, a degree of existing habituation to disturbance (given recreational and other beach and coastal activities) and the temporary and short term nature of any potential effects it is considered that the cumulative effect of temporary disturbance or displacement is **negligible**. There is the potential that that the remaining OTA works will act cumulatively with the alternative landfall cable installation works on birds present in both intertidal and terrestrial environments. Birds in the intertidal area are likely to be disturbed by noise generated by plant and machinery. However, it is unlikely that noise generated by the machinery and plant operating onshore will add to this disturbance, due to the distance between the activities. Therefore, it is considered that cumulative effects of temporary disturbance or displacement are unlikely to occur and if they did they would be **negligible**.
Archaeology and Cultural Heritage	Other Seagreen OTA construction activities have the potential to affect archaeological assets, particularly the trenching works for the remainder of the OTA cable route to the Seagreen Alpha and Seagreen Bravo OWFs. Eighteen targets of medium archaeological significance were identified within the OTA corridor (Seagreen,

Receptor	Other Seagreen Construction Activities
	2012). Given that the alternative landfall cable installation works and the remaining OTA installation works will be subject to an agreed WSI and PAD, it is considered that any cumulative effects will be effectively managed and therefore **negligible**.
Aviation, Military and Communications	Due to the lack of overlap between the military firing range danger areas and the cable installation works, no cumulative effects are anticipated. Any potential cumulative effects between the alternative cable landfall and the remaining OTA activities would be managed via the communications protocol with the MoD that will be in place for the remaining Seagreen OTA works and for this marine licence.
Other Marine Users and Activities	The extent of the impact on recreational receptors will be limited to a short section of the intertidal and subtidal cable route, with any potential exclusion of activities limited to a small area associated with the presence of any marked off working areas (intertidal) and any advisory safety distances (subtidal) around the cable installation works. Management measures will be implemented to reduce effects on recreational receptors during the works, including local site notices and Notices to Mariners. Therefore, the cumulative effect is assessed as being **negligible**.

7. Inter-related Effects

This section examines the potential for inter-related effects to occur during the alternative cable landfall installation project. These are considered to be:

- **Project lifetime effects:** Assessment of the potential for effects that occur throughout more than one phase of the project (e.g. installation, operation and maintenance, decommissioning), to interact to potentially create a more significant effect on a receptor than when assessed in isolation; and
- **Receptor led effects:** Assessment of the potential for effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, effects on Benthic Ecology and Intertidal Ecology receptors may interact to produce a different or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

7.1 Project Lifetime Effects

The greatest potential for project lifetime effects to occur with respect to the alternative cable landfall are associated only with installation activities. There are unlikely to be any impacts during operation and maintenance (due to the cable being buried under the rock revetment and intertidal and subtidal areas). Further, any effects that may occur as a result of decommissioning are likely to be of a similar or lesser scale to those experienced during construction. In addition, the effects will be separated in time (25 years) and will be localised, temporary and of short term duration. Therefore, across the project lifetime, effects are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.

7.2 Receptor-led Effects

It is considered that the greatest potential for receptor led effects across the lifetime of the alternative cable installation project is in relation to potential effects on the Physical Environment and Water Environment, Benthic Ecology and Intertidal Ecology and, Natural Fish and Shellfish Resources. These effects were assessed as negligible in isolation, and although potential combined effects may arise (i.e. spatial and temporal overlap of effects), it is predicted that this will not be any more significant than the individual effects in isolation. This is due to the effects being localised, temporary and short lived over a short timescale. In addition, designed-in measures will also serve to ensure effects remain negligible. For the remaining receptors only one effect pathway was considered in each case (Marine Mammals, Ornithology, Archaeology and Cultural Heritage, Aviation, Military and Communications, Other Marine Users and Infrastructure) with other effects having been scoped out in the Consenting Approach document (Seagreen, 2019a, see Section 5.1). Therefore, any potential receptor led effect interactions are predicted to be no greater than the individual effects assessed in isolation.

8. Consideration of Likely Significant Effects on Protected Areas

The location of the alternative landfall cable installation works in relation to the European sites identified in Section 3.2 is shown in Figure 3.1 and Figure 3.2. Consideration of the potential for Likely Significant Effects (LSE) on these sites is discussed below. This assessment has been conducted in response to the comments provided by SNH in their response to the EIA Screening request (SNH, 2019).

8.1 Outer Firth of Forth and St Andrews Bay Complex pSPA

As concluded by SNH (SNH, 2019a) (see Table 1.1), it is unlikely that marine works will have a significant effect on any of the features of this pSPA. Apart from the limited spatial and temporal scale of the works, this is because the species involved are seabirds and therefore primarily marine in their distribution, rather than nearshore, intertidal or coastal. In addition, the intertidal and shoreline areas are outside the pSPA (Figure 3.1). Therefore, there is no potential for impacts arising from the cable installation activities at the landfall which may lead to negative effects on the qualifying species of the pSPA. Therefore, there is no LSE either alone or in-combination with any other projects or aspects of the Seagreen OTA arising from any of the impacts identified in this assessment.

8.2 Firth of Tay and Eden Estuary SPA

As noted above, as concluded by SNH (SNH, 2019a) (see Table 1.1), it is unlikely that marine works will have a significant effect on any of the features of this pSPA due to the short-term nature of the marine works. In addition, the works are outside the SPA and the nearshore, intertidal and coastal areas are not used to any significant degree by names or assemblage SPA qualifying species (Figure 3.1). Therefore, there is no potential for impacts arising from the cable installation activities at the breach of the rock revetment or within the intertidal zone which may lead to negative effects on the qualifying species of the SPA. Therefore, there is no LSE either alone or in-combination with any other projects or aspects of the Seagreen OTA arising from any of the impacts identified in this assessment.

8.3 Barry Links SAC

The coastal dune heathland, shifting dunes, dune grassland, humid dune slacks and shifting dunes with marram features of the Barry Links SAC cover a total area of 7.7 km^2 behind the rock revetment and to the south of the proposed works.

While there is some overlap with the proposed application boundary, the cable installation works will not directly interact with the SAC (see Figure 3.1). SNH (SNH, 2019) also concluded that given the highly mobile nature of the sand habitat and the localised nature of any effect, it is highly unlikely that the works will have significant effects on the qualifying habitats of the SAC. Therefore, there is no potential for impacts arising from the cable installation activities at the breach of the rock revetment or within the intertidal zone which may lead to negative effects on the qualifying habitats of the SAC. Therefore, there is no LSE either alone or in-combination with any other projects or aspects of the Seagreen OTA arising from any of the impacts identified in this assessment.

8.4 Firth of Tay and Eden Estuary SAC

Despite historically supporting large numbers of harbour seals, the Firth of Tay and Eden Estuary SAC has undergone dramatic declines in harbour seal numbers. As a qualifying feature of the site, the harbour seal is in ‘Unfavourable’ conservation status and is declining (Scottish Natural Heritage, 2018a). Population modelling has concluded that the population is likely to become extinct (Hanson *et al*. 2015).

Harbour seal from the SAC may occur in the vicinity of the cable installation works and therefore may be affected by subsea noise and vessel activity. However, the number of harbour seals potentially affected is extremely low and the effects are assessed as being localised, short term and reversible (i.e. once the activity has ceased normal behaviour will resume and animals will return to the area where disturbance occurred). Therefore, the potential for the activities to result in negative effects on harbour seal as features of the Firth of Tay and Eden Estuary SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA. SNH (SNH, 2019) also concluded that the localised nature and short duration of any effect would mean that it is unlikely that the proposed works would have significant effect on qualifying features of the SAC.

8.5 Moray Firth SAC

The most recent status assessment of the bottlenose dolphin population of the Moray Firth SAC is “stable or increasing” (Cheney *et al*. 2018). Bottlenose dolphin from the SAC may be present in the vicinity of the works as they transit between the Moray Firth and the more southerly parts of their range, particularly the Tay estuary. Therefore, they may be affected by subsea noise and vessel activity in the vicinity of the cable installation works. However, the effects are assessed as being localised, short term and reversible (i.e. once the activity has ceased, normal behaviour will resume and animals will return to the area where disturbance occurred) and the potential for the activities to result in negative effects on the bottlenose dolphin population as a feature of the Moray Firth SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment, either alone or in-combination with any other projects or aspects of the Seagreen OTA.

8.6 Isle of May SAC

The SAC supports the largest grey seal breeding colony on the east coast of Scotland and the fourth largest in the UK. The pup production estimate at the Isle of May increased from 936 in 1989 to 2,133 in 2000, after which it has remained relatively stable with annual pup production estimates between ~1,900 and ~2,300. Pup production was estimated at 2,272 in 2014 (SCOS 2016). As a qualifying feature of the site grey seal has maintained ‘Favourable’ conservation status (Scottish Natural Heritage, 2018b).

The Isle of May is designated as a breeding site and the project activities will not affect animals present at the SAC during the breeding season. Grey seals which breed on the Isle of May are likely to spend the rest of the year foraging in other regions of the UK (Russell *et al*. 2013), however, seals that breed in the SAC may be present in the vicinity of the works out with the breeding season if they remain to forage on the east coast of Scotland, or as they transit between other haul outs and the Isle of May prior to, or after, the breeding season. Therefore, they may be affected by subsea noise and vessel activity in the vicinity of the cable installation works. However, the effects are assessed as being localised, short term and reversible (i.e. once the activity has ceased normal behaviour will resume and animals will return to the area where disturbance occurred) and the potential for the activities to result in negative effects on grey seals as a feature of the Isle of May SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA.

8.7 Berwickshire and North Northumberland Coast SAC

Pup production estimates from monitored grey seal colonies were at approximately 4,600 in 2014 (SCOS, 2017). It is the most south-easterly site selected for the species and supports around 2.5% of annual UK pup production. Pup production at the breeding colonies within the SAC was estimated at 1,600 at the Farne Islands, and 3,000 at Fast Castle in 2014 (SCOS, 2017). Between 2010 and 2014 there was little change in the pup production estimates at the Farne Islands, however, between 2014 and 2016 the pup production estimate increased by 28% (SCOS, 2017). The pup production estimates at Fast Castle have shown significant increases since 2000 and in 2014 the breeding colony at Fast Castle became the biggest grey seal breeding colony in the North Sea (SCOS, 2017). As a qualifying feature of the site, grey seal has maintained ‘Favourable’ conservation status (Scottish Natural Heritage, 2018c).

The Berwickshire and North Northumberland Coast SAC is designated as a collection of important breeding colonies and the project activities will not affect animals present at the SAC during the breeding season. Grey seals which breed here are likely to spend the rest of the year foraging in other regions of the UK (Russell *et al*. 2013). Seals that breed in the SAC may be present in the vicinity of the works out with the breeding season if they travel to forage on the east coast of Scotland, or as they transit between other haul outs and the SAC prior to, or after, the breeding season. Therefore, they may be affected by subsea noise and vessel activity in the vicinity of the cable installation works. However, the effects are assessed as being localised, short term and reversible (i.e. once the activity has ceased normal behaviour will resume and animals will return to the area where disturbance occurred) and the potential for the activities to result in negative effects on grey seals as a feature of the Berwickshire and North Northumberland Coast SAC is considered to be negligible. Therefore, there is no LSE, nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA.

8.8 River Tay SAC

The Atlantic salmon, river lamprey and sea lamprey features of the River Tay SAC are all assessed as “Favourable, maintained” (SNH, 2019b).

The River Tay lies approximately 39 km south west of the alternative landfall cable installation site. Whilst there may be some potential for the migratory fish citation species (Atlantic salmon, river and sea lamprey) to be in the area and to potentially be affected by habitat loss/disturbance, elevated SSC or underwater noise within the vicinity of the cable installation works, the effects are all considered to be localised and reversible (i.e. once the activity has ceased, normal behaviour will resume and fish will return to the area where disturbance occurred) and negligible. In addition, the distance from the cable installation location combined with evidence to suggest that migrating Atlantic salmon smolts move rapidly out to sea rather than staying close to the coastline (Newton *et al*., 2017), suggests salmon migrating past the works are unlikely to be in the area for long, or in great numbers. Adult river lamprey mainly stay within estuarine areas (Maitland, 2003) and although they may move the short distance up the coast towards Carnoustie they are unlikely to do so in any great numbers and are therefore unlikely to be affected by the works. Less is known of the marine distribution of adult sea lamprey other than they can be found in both coastal areas and further offshore (Maitland, 2003). However, there are not any records of large numbers of sea lamprey in the area and it is unlikely that significant effects to sea lamprey populations from the works will occur as adults move out to sea or return to the Tay in order to spawn.

The potential for the activities to result in negative effects on the features of the River Tay SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA.

8.9 River Dee SAC

The Atlantic salmon feature of the River Dee SAC is assessed as “Favourable, maintained” and freshwater pearl mussel is assessed as “Unfavourable no change” (SNH, 2019c).

The River Dee SAC lies 83 km north, northeast of the alternative landfall cable installation site. Whilst there may be some potential for Atlantic salmon to be in the area and potentially be affected by habitat loss/disturbance, elevated SSC or underwater noise within the vicinity of the cable landfall site, the effects are all considered to be localised and reversible (i.e. once the activity has ceased normal behaviour will resume and fish will return to the area where disturbance occurred) and negligible. In addition, the distance from the cable installation location combined with evidence to suggest that migrating Atlantic salmon smolts move rapidly out to sea rather than staying close to the coastline (Newton *et al*., 2017) also suggests salmon migrating past the works are unlikely to be in the area for long or in great numbers. Therefore, the potential for the activities to result in negative effects on Atlantic Salmon as features of the River Dee SAC is considered to be negligible.

Freshwater pearl mussels are sessile organisms found in the upper reaches of the River Dee. They are unlikely to be directly affected by the alternative landfall cable installation but may be indirectly affected by impacts on migratory Atlantic salmon (and sea trout) populations (hosts for the parasitic larval stage of the freshwater pearl mussel). However, given effects on these species are considered to be negligible it is likely that any effects on freshwater pearl mussels will also be negligible.

Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA.

8.10 River South Esk SAC

The Atlantic salmon feature of the River South Esk SAC is assessed as “Unfavourable, recovering” and freshwater pearl mussel is assessed as “Unfavourable no change” (SNH, 2019d).

The River South Esk lies 27 km north, northeast of the alternative landfall cable installation site. Whilst there may be some potential for Atlantic salmon to be in the area and potentially to be affected by habitat loss/disturbance, elevated SSC or underwater noise within the vicinity of the cable landfall site, the effects are all considered to be localised and reversible (i.e. once the activity has ceased normal behaviour will resume and fish will return to the area where disturbance occurred) and negligible. In addition, the distance from the location of the cable installation works combined with evidence to suggest that migrating Atlantic salmon smolts move rapidly out to sea rather than staying close to the coastline (Newton *et al*., 2017), also suggests salmon migrating past the works are unlikely to be in the area for long or in great numbers. Therefore, the potential for the activities to result in negative effects on Atlantic Salmon as features of the River South Esk SAC is considered to be negligible.

Freshwater pearl mussels are sessile organisms found in the upper reaches of the River South Esk. They are unlikely to be directly affected by the alternative landfall cable installation but may be indirectly affected by impacts on migratory Atlantic salmon (and sea trout) populations (hosts for the parasitic larval stage of the freshwater pearl mussel). However, given effects on these species are considered to be negligible it is likely that any effects on freshwater pearl mussels will also be negligible.

Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA.

8.11 River Teith SAC

The Atlantic salmon feature of the River Teith SAC is assessed as “Unfavourable, recovering”, river lamprey as “Favourable, maintained” and sea lamprey is assessed as “Unfavourable, declining” (SNH, 2019e).

The River Teith SAC lies 85 km to the south of the alternative landfall cable installation site. Whilst there may be some potential for the migratory fish citation species (Atlantic salmon, river and sea lamprey) to be in the area and potentially affected by habitat loss/disturbance, elevated SSC or underwater noise within the vicinity of the cable landfall site, the effects are all considered to be localised and reversible (i.e. once the activity has ceased normal behaviour will resume and fish will return to the area where disturbance occurred) and negligible. In addition, the distance from the location of the cable installation works, combined with evidence to suggest that migrating Atlantic salmon smolts move rapidly out to sea rather than staying close to the coastline (Newton *et al*., 2017) also suggests salmon migrating past the works are unlikely to be in the area for long or in great numbers. Adult river lamprey mainly stay within estuarine areas (Maitland, 2003) and are therefore unlikely to migrate up the coast towards Carnoustie and are unlikely to be affected by the works during their sea going phase. Less is known of the marine distribution of adult sea lamprey other than they can be found in both coastal areas and further offshore (Maitland, 2003). However, the river Teith is some distance from the proposed works and there are not any records of large numbers of sea lamprey in the area. It is unlikely that significant effects to sea lamprey populations from the works will occur.

Therefore, the potential for the activities to result in negative effects on the features of the River Dee SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment either alone or in-combination with any other projects or aspects of the Seagreen OTA.

9. Summary

This Environmental Report has been prepared in support of a Marine Licence application by Seagreen for an alternative landfall cable installation methodology at Carnoustie. The alternative method is for open cut trenching between the original proposed landward entrance points of the HDD (approximately 100 m above MHWS), through the rock revetment, down to a depth of 2.5 m (LAT) (approximately 190 m below charted MLWS). The Marine Licence application boundary for the alternative methodology includes the rock revetment and the intertidal and subtidal zones. The works landward of the rock revetment are subject to separate onshore planning approval from Angus Council and do not form part of this Marine Licence application.

This Environmental Report has provided an assessment of the potential environmental impacts of the licensable marine activities, based on the scope presented in the Consenting Approach document. A summary of the environmental impacts identified, and assessment of the potential effect is presented in Table 9.1 below.

Table 9.1: Summary of Environmental Effects.

Receptor	Potential Impact	Assessment of Potential Effect
Physical Environment and Water Environment	Cable installation activities may disturb geomorphological features of the Barry Links SAC, SSSI and GCR	Negligible
	Cable installation activities may affect sediment transport processes	Negligible
	Cable installation activities in the intertidal and subtidal zones may increase SSC within the water column and deposit material on the seabed	Negligible
	Flood Risk	Negligible
	Potential exposure of buried cables due to beach lowering	Minor
Benthic Ecology and Intertidal Ecology	Cable installation activities may result in temporary intertidal and subtidal habitat loss/disturbance	Negligible
	Removal and replacement of the rock revetment may result in temporary habitat loss/disturbance	Negligible

Receptor	Potential Impact	Assessment of Potential Effect
	Cable installation activities in the subtidal zone may result in temporary increases in SSC and associated sediment deposition	Negligible
Natural Fish and Shellfish Resources	Cable installation activities may result in temporary subtidal habitat loss/disturbance	Negligible
	Cable installation activities in the subtidal zone may result in temporary increases in SSC and associated sediment deposition	Negligible
	Cable installation activities may result in underwater noise	Negligible
Marine Mammals	Cable installation activities may result in noise disturbance	Minor
Ornithology	Cable installation activities may result in temporary disturbance or displacement of birds	Negligible
Archaeology and Cultural Heritage	Cable installation activities may affect marine archaeological receptors	Negligible
Military, Aviation and Communications	Cable installation activities may affect military activities	Negligible
Other Marine Users and Activities	Cable installation activities may affect the activities of other marine users receptors in the vicinity	Minor
Cumulative Effects	Cumulative effects arising from the alternative landfall cable installation activities identified in Section 2 alongside the remaining OTA activities.	Negligible - Minor

10. References

Arso Civil, M., N. Quick, B. Cheney, E. Pirotta, P. Thompson, and P. S. Hammond. (2019) Changing distribution of the east coast of Scotland bottlenose dolphin population and the challenges of area-based management. Aquatic Conservation Marine and Freshwater Ecosystems.

Boyle, G and New, P. (2018) Impacts on Fish from Piling at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options. Final Report to Offshore Renewables Joint Industry Programme (ORJIP).

Coull., K.A., Johnstone, R. and Rogers, S.I., (1998) Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd.

Cheney, B., I. M. Graham, T. Barton, P. S. Hammond, and P. M. Thompson. (2018) Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area of Conservation: 2014-2016. Scottish National Heritage Research Report No 1021.

Cheney, B., P. M. Thompson, S. N. Ingram, P. S. Hammond, P. T. Stevick, J. W. Durban, R. M. Culloch, S. H. Elwen, L. Mandleberg, V. M. Janik, N. J. Quick, V. Islas-Villanueva, K. P. Robinson, M. Costa, S. M. Eisfeld, A. Walters, C. Phillips, C. R. Weir, P. G. Evans, P. Anderwald, R. J. Reid, J. B. Reid, and B. Wilson. (2013) Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins Tursiops truncatus in Scottish waters. Mammal Review **43**:71-88.

Cutts N., Hemingway K. and Spencer J. (2013) Waterbird Disturbance Mitigation Toolkit: Informing Estuarine Planning & Construction Projects. Produced by the Institute of Estuarine & Coastal Studies (IECS) University of Hull.

Duck, C.D. & Morris, C.D. (2016) Surveys of harbour and grey seals on the south-east (border to Aberlady Bay) and south-west (Sound of Jura to Solway Firth) coasts of Scotland, in Shetland, in the Moray Firth and in the Firth of Tay in August 2015. Scottish Natural Heritage Commissioned Report No. 929.

Ellis, J.R., Milligan, S., Readdy, L., South, A., Taylor, N. and Brown, M., (2010) Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones).

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012) *Spawning and nursery grounds of selected fish species in UK waters*. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

Envision Mapping (2012) Firth of Forth OSWF: Phase 1 & ECR Habitat Mapping Analysis Firth of Forth OSWF Habitat Mapping. Report to Seagreen Wind Energy Ltd.

Gill, J. (2007) Approaches to measuring the effects of human disturbance on birds. Ibis. Volume149, Issues1 March 2007.

Hanson, N., D. Thompson, C. Duck, J. Baxter, and M. Lonergan. (2015) Harbour seal (Phoca vitulina) abundance within the Firth of Tay and Eden estuary, Scotland: recent trends and extrapolation to extinction. Aquatic Conservation: Marine and Freshwater Ecosystems.

Highways Agency, Scottish Government, Welsh Assembly Government and the Department for Regional Development Northern Ireland (2008). Design Manual for Roads and Bridges (DMRB) Volume 11: Environmental Assessment, Section 2, Part 5 HA 205/08. Available online: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/index.htm [Accessed 7 May 2019]

IECS (2012) Firth of Forth (Round 3) Offshore Wind Farm Development: Survey Report Benthic Services – Export Cable Route. Report to Seagreen Wind Energy Ltd. 12th July 2012.JNCC (2019) Firth of Tay and Eden Estuary SAC, Available at: http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUcode=UK0030311.

KIS-ORCA (2019) Kingfisher Information Service – Offshore Renewable and Cable Awareness interactive map, Available at: http://kis-orca.eu/map#.XHa6VYj7Tcs.

Malcolm, I.A., Godfrey, J. and Youngson, A.F. (2010) Review of migratory routes and behaviour of Atlantic salmon, Sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables. Scottish Marine and Freshwater Science Volume 1 No 14

Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Marine Scotland (2018) NMPI, Available at: https://marinescotland.atkinsgeospatial.com/nmpi/.

National Grid Electricity Transmission and Scottish Hydro Electric Transmission (2012) Eastern HVDC Link Offshore Works Scoping Report. February 2012.

Newton, M., Main, R. and Adams, C. (2017) *Atlantic Salmon Salmo salar smolt movements in the Cromarty and Moray Firths, Scotland*. LF000005-REP-1854, March 2017.

NIRAS (2012) Seagreen Firth of Forth Offshore Wind Farm Development: Offshore Transmission Assets Project – Ornithological Technical Report. July 2012.

NOAA (2016) Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. National Marine Fisheries Service (NOAA).

Palmer, K., K. Brookes, and L. Rendell. (2017) Categorizing click trains to increase taxonomic precision in echolocation click loggers. The Journal of the Acoustical Society of America **142**.

Quick, N. J., M. Arso Civil, B. Cheney, V. Islas, V. Janik, P. M. Thompson, and P. S. Hammond. (2014) The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC. This document was produced as part of the UK Department of Energy and Climate Change's offshore energy Strategic Environmental Assessment programme.

Royal Haskoning DHV (2013) Port of Dundee Expansion and Marine Aggregate Extraction. EIA Scoping Report and HRA Screening Report. Scottish Enterprise. 10 June 2013. Final Report. 9X5853

RPS (2019) Seagreen Alpha and Seagreen Bravo Offshore Wind Farms, Alternative Landfall Cable Installation Marine LIcence Application – Beach Lowering Assessment. IBE1596, 19 June 2019.

Russell, D., E. Jones, and C. Morris. (2017) Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals. Scottish Marine and Freshwater Science **Vol 8, No 25**.

Russell, D. J. F., B. McConnell, D. Thompson, C. Duck, C. Morris, J. Harwood, and J. Matthiopoulos. (2013) Uncovering the links between foraging and breeding regions in a highly mobile mammal. Journal of Applied Ecology **50**:499-509.

SCOS (2016) Scientific Advice on Matters Related to the Management of Seal Populations: 2016.

SCOS (2017) Scientific Advice on Matters Related to the Management of Seal Populations: 2017, Available at: http://www.smru.st-andrews.ac.uk/research-policy/scos/.

Scottish Natural Heritage (2011) A methodology to assess the causes and rates of change to Scotland's beaches and sand dunes – Phase 1. SNH Commissioned Report No. 364.

Scottish Natural Heritage (2016) Outer Firth of Forth and St Andrews Bay Complex Proposed Special Protection Area (pSPA) NO. UK9020316 SPA Site Selection Document: Summary of the scientific case for site selection, Available at: https://www.nature.scot/sites/default/files/2017-11/Marine%20Protected%20Area%20%28Proposed%29%20-%20Site%20selection%20document%20-%20Outer%20Firth%20of%20Forth%20and%20St%20Andrews%20Bay%20Complex.pdf

Scottish Natural Heritage (2018a). Site Details for Firth of Tay and Eden Estuary SAC, Available at: https://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8257

Scottish Natural Heritage (2018b) Site Details for Isle of May SAC, Available at: http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=820

Scottish Natural Heritage (2018c) Site Details for Berwickshire and North Northumberland Coast SAC, Available at: https://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8207

Scottish Natural Heritage (2019a) SNH Advice on Screening Opinion Request for an Alternative Landfall Cable Installation Method for the Seagreen Alpha and Seagreen Bravo Offshore Wind Farms, Firth of Forth. Letter dated 23rd April 2019.

Scottish Natural Heritage (2019b) Site Details for River Tay SAC, Available at: https://sitelink.nature.scot/site/8366

Scottish Natural Heritage (2019c) Site Details for River Dee SAC, Available at: https://sitelink.nature.scot/site/8357

Scottish Natural Heritage (2019d) Site Details for River South Esk SAC, Available at: https://sitelink.nature.scot/site/8364

Scottish Natural Heritage (2019e) Site Details for River Teith SAC, Available at: https://sitelink.nature.scot/site/8367

Seagreen (2012) Seagreen Alpha and Seagreen Bravo Offshore Wind Farms, Environmental Statement. A4MRSEAG-Z-DOC100-SPR-060.

Seagreen (2013a) Environmental Statement Addendum.

Seagreen (2013b) Seagreen Phase 1 Offshore Project Habitats Regulations Appraisal, Information to Inform Appropriate Assessment.

Seagreen (2016a) Seagreen Phase 1 Onshore Transmission Works Habitats Regulations Appraisal Screening Report (Chapter 3: Special Areas of Conservation).

Seagreen (2016b) Environmental Statement Volume I, June 2016, Chapter 9: Ecology and Ornithology and supporting technical Appendix 9.4: Intertidal Bird Survey and Appendix 9.8: Overwintering Bird Survey 2015-2016;

Seagreen (2016c) Seagreen Phase 1 Onshore Transmission Works Habitats Regulations Appraisal Screening Report (Chapter 4: Special Protected Areas);

Seagreen (2018a) Optimised Seagreen Phase 1 Project, Environmental Impact Assessment (EIA) Report, September 2018, LF000009-ENV-MA-RPT-0001.

Seagreen (2018b) Optimised Seagreen Phase 1 Project, Habitats Regulations Appraisal (HRA) Report, September 2018.

Seagreen (2019a) Seagreen Alpha and Bravo Offshore Wind Farms Alternative Landfall Cable Installation Marine Licence Application – Consenting Approach. LF000009-CST-OF-REP-0020.

Seagreen (2019b) Seagreen Offshore Wind Farm Export Cable Installation Project Description. LF000009-CST-OF-RPT-0015.

Seagreen (2019c) Seagreen Offshore Wind Farm Alternative Cable Landfall Installation Method Design Envelope. LF000009-CST-OF-RPT-0014.

SEPA (2015) Bathing water profile: Carnoustie, Available at: https://www.sepa.org.uk/media/39294/carnoustie-bathing-water-profile.pdf

SEPA (2016) Scottish bathing waters 2016, Available at: https://www.sepa.org.uk/media/219168/1282_sepa_bathing_waters_2016_web.pdf

Subacoustech (2012) Modelling of Noise during Impact Piling Operations at the Firth of Forth Phase 1 Offshore Wind Farm, Subacoustech Environmental Report No., E297R0209 (Appendix H6 to Seagreen Alpha and Seagreen Bravo Offshore Wind Farms, Environmental Statement).

Subacoustech (2015) Subsea noise modelling of vibropiling at the Beatrice Offshore Wind Farm, Moray Firth. E492R0202, 17th June 2015. LF000005-REP-538. Appendix B to LF000005-PLN-142

Wright, R. (1981) Beaches of Tayside. Department of Geography, University of Aberdeen, for the Countryside Commission for Scotland. Reprinted 2001 by Scottish Natural Heritage as a Commissioned Report.

Appendix A - Alternative Landfall Cable Installation Marine Licence Application – Flood Risk Assessment (FRA)

SEAGREEN ALPHA AND BRAVO OFFSHORE WIND FARMS

Alternative Landfall Cable Installation Marine Licence Application – Flood Risk Assessment (FRA)

IBE1596
Alternative Landfall Cable Installation Marine Licence Application – Flood Risk Assessment (FRA)
Rev04
19 June 2019

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
00	Review	Andrew Sloan	Pippa Van Kuijk / Adam Payne	Andrew Jackson	16/05/19
01	Issue to client	Andrew Sloan	Adam Payne	Adam Payne	17/05/19
02	Addressing Comments	Andrew Sloan	Adam Payne	Adam Payne	06/06/2019
03	Re-issue to client	Andrew Sloan	Adam Payne	Adam Payne	13/06/2019
04	Addressing Legal Comments	Andrew Sloan	Adam Payne	Adam Payne	19/6/2019

Approval for issue

Adam Payne		19 June 2019

Prepared by:

RPS

Andrew Sloan
Senior Engineer - Water Environment and Flood Risk Management

Elmwood House
74 Boucher Road, Belfast
Co. Antrim BT12 6RZ

T +44 2890 667 914
E andrew.sloan@rpsgroup.com

Prepared for:

Seagreen Wind Energy Limited

Tamsin Watt
Consents Manager

One Waterloo Street
Glasgow
G2 6AY

T +44 7812 588 032
E tamsin.watt3@sse.com

Contents

Tables

Figures

1 INTRODUCTION

Seagreen Wind Energy Ltd ("Seagreen") is progressing the Seagreen Alpha and Seagreen Bravo offshore wind farms (OWFs) off the east coast of Scotland in the outer Firth of Forth and Firth of Tay area (the "projects"). The projects received consent under S36 of the Electricity Act 1989 (as subsequently varied) together with Marine Licences from the Scottish Ministers in 2014, one for Seagreen Alpha, one for Seagreen Bravo, and one for the Offshore Transmission Asset (OTA). Together the projects comprise up to 150 wind turbines with associated infrastructure and array cables. The consented export cable corridor makes landfall at Carnoustie.

Seagreen is applying for a marine licence for an alternative cable landfall installation methodology to be implemented at Carnoustie, as a potential alternative to Horizontal Directional Drilling (HDD) installation methodology, which has already gained consent as part of the existing marine licence (reference 04678/14/0, as varied in 2019 (04678/19/0)) (the "Existing Marine Licence"). This alternative method is for ploughing or mechanical trenching (also termed 'open cut' trenching) between the original proposed entrance points of the HDD, through the rock revetment. Trenching will continue across the intertidal area as set out within the Existing Marine Licence, down to the 2.5 m depth contour (Lowest Astronomical Tide (LAT)) (approximately 190 m seaward of charted MLWS), to meet the offshore cable installation works.

The alternative landfall methodology proposes the removal of a portion of coastal protection rock revetment in the vicinity of Carnoustie (see Figure 1.1), to enable trenching and subsequent burial of the export cables. The alternative cable landfall Marine Licence application is supported by an Environmental Report, to which this Flood Risk Assessment is appended. In preparing that Environmental Report and the Marine Licence application, Seagreen consulted with a range of stakeholders including the Scottish Environmental Protection Agency (SEPA), to discuss their views on the potential for flood risk, as a result of a possible breach of the rock revetment. A meeting to discuss SEPA's views took place on the 2nd April 2019 between representatives of SEPA, Angus Council, Seagreen and RPS. At this meeting, SEPA indicated that a Flood Risk Assessment (FRA) should be carried out based on water levels derived for the Coastal Flood Boundary (CFB) dataset and Light Detection and Ranging (LiDAR) ground model data. These datasets should be used to develop a computational hydraulic model to determine potential risks from a potential flood event from a breach in the rock revetment coastal defence during installation of the alternative cable landfall. Marine Scotland Licensing Operations Team (MS-LOT) was also notified that Seagreen intended to undertake a FRA for the proposed works.

Seagreen also sought an EIA screening opinion from MS-LOT in respect of the alternative cable landfall Marine Licence application and, as part of preparing their screening opinion MS-LOT consulted with a range of stakeholders including SEPA. SEPA's screening response received on the 3rd May 2019, indicated that SEPA have no objection to the proposed development on flood risk grounds and would expect Angus Council to undertake their responsibilities as the relevant Flood Prevention Authority. SEPA's response also stated that the dune system immediately behind the rock revetment rose to an elevation of over 5m Above Ordnance Datum (AOD) which is over 1.2m higher than the predicted 1 in 200 year still water level. However, it was noted that this level does not take account of wave action, funnelling or local bathymetry which could increase flood levels.

This FRA has been prepared in response to consultation with SEPA and MS-LOT, to assess the potential flood risk to Carnoustie should an extreme coastal water level event occur while the trench in the rock revetment is open. Based on the available guidance (SEPA, 2015) two modelling scenarios have been assessed;

- A present day 200 year extreme water level scenario occurring while the rock revetment has been removed and the dunes are exposed. This scenario assumes a catastrophic failure of the dune system and represents a worst case scenario. While the guidance (SEPA, 2015) requires this scenario to be undertaken it is highly unlikely that an event of this nature would occur during the eight week period that the rock revetment trench is open. However, in order to adhere to the guidance this scenario to provide the required assessment.

- A climate change 200 year extreme water level scenario. This scenario assesses the potential future flood risk to Carnoustie should a breach of the rock revetment and dune system occur in the year 2100. The scenario again assumes a catastrophic failure of the rock revetment and dune defence system. This assessment should be considered as a sensitivity investigation to future changes in sea level as the 2100's are beyond the 25 year design life of the proposed cable and this scenario is highly unlikely to occur during the eight week period in 2020 that the rock revetment trench is open. As such this scenario provides an extreme worst case future scenario.

Figure 1.1 indicates the location of the proposed onshore and offshore working corridors and the area of rock revetment proposed to be removed and replaced.

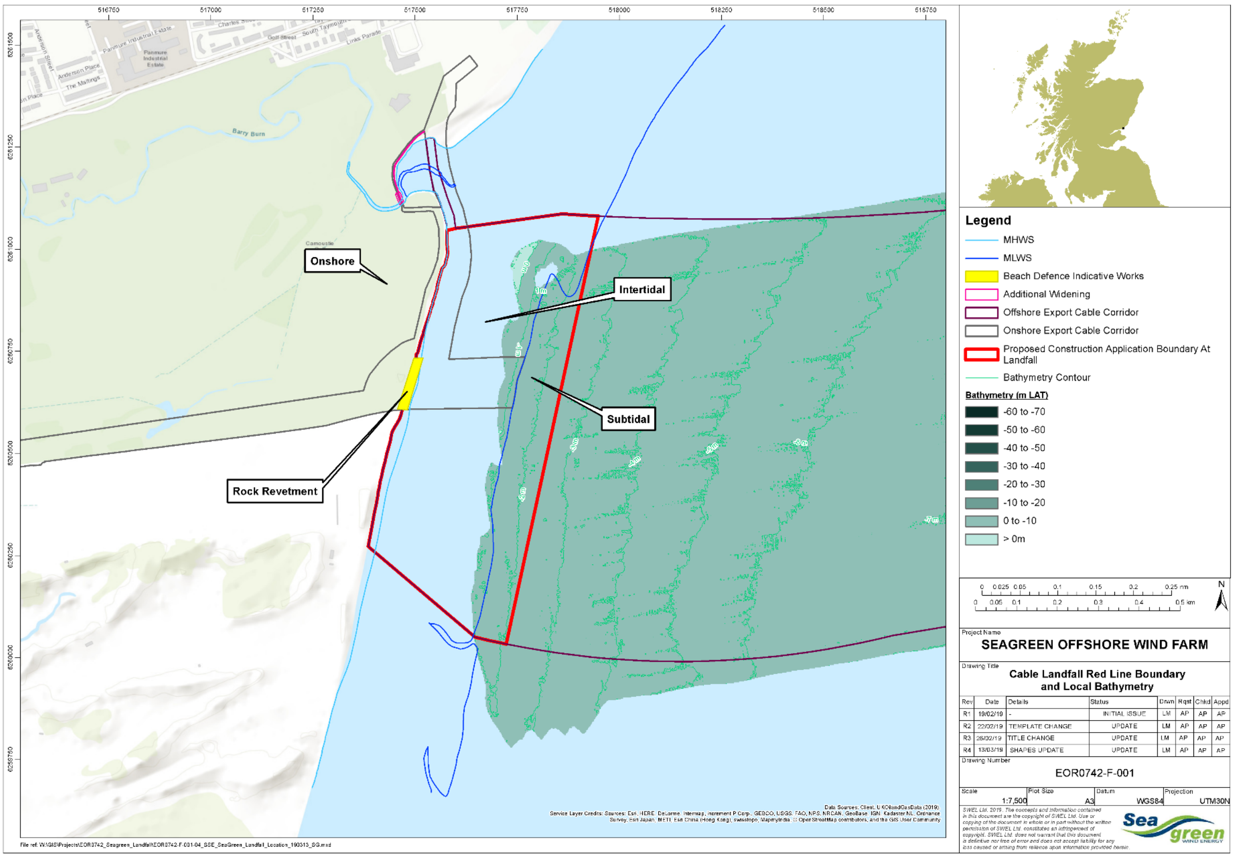


Figure 1.1: Landfall location and working corridor locations

2 METHODOLOGY

The methodology carried out during this FRA is based on good practice guidance and uses industry standard software. The following points outline the approach taken, datasets used and the guidance followed;

1. The extreme water level assessment is based on the Environment Agency (EA) guidance document Coastal Flood Boundary Conditions for UK Mainland and Islands; Practical Guidance Design Sea Levels, Environment Agency (2011). This guidance details the procedure for combining typical tidal profiles with surge profiles to generate relevant extreme water level profiles. Three datasets are required in order to inform the assessment;
   - Extreme Sea Level – these are extracted from the Environment Agency CFB[1] dataset
   - Base astronomical tide curve – The base astronomical tide curve is a time series of the tidal cycle at the location which is generated using tidal data provided with the Admiralty Tide Tables for the nearest appropriate port (in this instance the Port of Leith). The tidal data is used with a computerised version of the Simple Harmonic Method (a mathematical model for generating certain motions, such as tidal cycles) to generate sinusoidal tidal curves around the mean sea level. In order to generate the required profile, the MIKE by DHI, MIKE21 Tidal Prediction of Heights computer software tool was used. A portion of the generated tidal profile is then extracted which contains levels between mean high water springs (MHWS) and the highest astronomical tide (HAT).
   - Surge Component – extracted from the Environment Agency CFB dataset.
2. Technical Flood Risk Guidance for Stakeholders (SEPA, 2015) states that a FRA is required when the site or parts of the site may be at 'medium to high risk' of flooding. That means that there is a 0.5% annual probability of flooding in any given year, this probability relates to the 200 year return period flood. The guidance identifies the scenarios that need to be undertaken in order to complete a compliant FRA for a planning application, or any other FRA study undertaken for regulatory purposes. As recommended by the guidance (SEPA, 2015) the 200 year and 200 year plus climate change events have been modelled in this study.
3. The SEPA (2019) document 'Climate Changes Allowances for Flood Risk Assessment in Land Use Planning' sets out recommended allowances for climate change that can be applied to FRAs submitted in support of planning applications. The allowances relating to sea level rise detailed in this document are based on the outputs from UK Climate Projections 2018 (UKCP18) and give the cumulative sea level rise from 2017 to 2100. Cumulative sea level rise takes into account the effects of isostatic rebound (the uplift and readjustment of the land masses when glaciers recede which has been occurring across the UK since the last ice age). The 200 year plus climate change scenario provides an indication of possible future flood risk in the vicinity of Carnoustie during the 2100's. However, as the design life of the proposed works is 25 years and the works are proposed across an eight week period in 2020, the 200 year plus climate change scenario provides a conservative estimate of potential flood risk and a sensitivity assessment to future changes in sea level. The climate change allowance has been applied to the entire coastal boundary profile.
4. The SEPA (2015) 'Flood Modelling Guidance for Responsible Authorities' provides technical guidance for the modelling aspect of flood studies in Scotland. This document details that 2D hydrodynamic modelling is required to investigate flooding events. The software package Infoworks ICM from Innovyze has therefore been selected as the modelling software, as it provides the appropriate 2D hydrodynamic functions. Infoworks ICM uses a flexible irregular mesh to represent the topography of the land area to be included within the model, with the mesh being generated using Digital Terrain

[1] https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels

Model (DTM) data such as LiDAR. The use of flexible mesh enables complex topographical features to be represented accurately using high resolution mesh while flatter more uniform areas can be represented using lower resolution mesh, to reduce the time required to undertake the computational aspects of the modelling.

5. The data outputs which represent the coast within the modelling exercise were established through undertaking the processes in points 1, 3 and 4 and are applied to the 2D mesh in order to simulate the inflow of water across the topography of the flooded area and routes the flow based on the topographical features and land forms defined in the mesh using the LiDAR data.
6. The dimensions and duration of the breach in the rock revetment (i.e. the area of the rock revetment through which water will flow and the time period over which this occurs) have been defined in the model based on Environment Agency guidance (2010). The guidance defines a number of types of sea defence types (e.g. earth bank, dune, hard). For this study a defence type of dune was considered the most appropriate, on a precautionary basis, as the rock revetment on the seaward side of the dune is in place for predominantly coastal erosion purposes rather than to mitigate against flood risk. This defence type has been chosen based on a description of the dune rock revetment system from Scottish Natural Heritage (SNH, 2011), '*This coast has a recent history of severe erosion and the dune face is recorded to have retreated up to 10m in one year (Wright, 1981). In response, 0.5km of protective gabions and boulder rip-rap were constructed in 1978, extending from Carnoustie to the northern limit of the MoD range, just beyond the exit of the Barry Burn. On account of a perceived erosional threat to the MoD firing ranges, sited in the dunes behind the eastern beach, the boulder rip-rap was further extended in 1992/ 3 from Barry Burn south along a 3km stretch of the east side of Buddon Ness and up to the full frontal dune height of 7-10m*'.

3 DATA COLLECTION

The following datasets were collected in order to undertake hydrodynamic modelling of a breach of the rock revetment and the dune system:

- AIRBUS 1m LiDAR Data;
- Coastal Flood Boundary (CFB) (EA, 2019) provides extreme water levels for a range of Annual Exceedance Probabilities for the coast of the United Kingdom;
- Normalised Surge profile (EA, 2019) for the closest analysed site, for this project the profile for Leith was utilised as the closest available dataset; and
- Tidal Harmonic constituents (UKHO, 2019) for Arbroath Harbour, to generate representative tidal cycle profiles. This is the nearest available dataset to Carnoustie.

In addition to the above datasets RPS undertook a site walkover in order to gain an appreciation of the site layout and condition, along with an understanding of possible breach location, mechanisms and potential consequences.

4 PROPOSED WORKS

The proposed cable installation works through the rock revetment for the purposes of the alternative cable landfall Marine Licence application include the excavation of a single open trench, in which up to four High Density Polyethylene (HDPE) pipes will be installed, through which the three export cables will be pulled. It should be noted that the fourth pipe will be installed to provide a spare should a further cable need to be pulled through at a later date (e.g. in the event of a cable failure). This will avoid further removal of, or disturbance to, the rock revetment. Three HDPE pipes will be installed across the remaining areas including onshore, intertidal and subtidal. These works are scheduled to be carried out over an eight week period.

Open cut trenching will require temporary removal of a section of the rock revetment, to enable the HDPE pipes to be installed underneath. The trench will be up to 70 m in width at the top, 32 m in length (30 m at base; a trapezoid trench to provide stability) and 10 m deep with a 1 in 3 gradient and is likely to be excavated using a rock grapple. A width of 70 m is required based on installation of the four HDPE pipes at suitable separation distance to avoid electrical interference while also reducing environmental impact where possible; and a length of 32 m is based on the length of the rock revetment from onshore to the toe of the rock revetment in the intertidal zone. Temporary sheet piling may be required to maintain safe working conditions until the trench work is completed. A further 2 m below the base of the rock revetment will be excavated into which the pipes will be placed within the trench at 5 to 10 m spacing. The pipes will have 1 m cover below the rock revetment base. Following placement of the pipes, concrete will be poured over the pipes for stabilisation underneath the rock revetment.

The rock revetment will then be reinstated using the material originally removed from the rock revetment. Initial inspection has determined that some of the rock may need to be replaced due to deterioration of the rock material since the rock revetment was installed. Therefore, up to a maximum of 6,000 m^3 of additional rock may be required in order to reinstate the rock revetment. Rock material would be moved onto the rock revetment using a crane mounted on a barge. Rock materials removed from the rock revetment will, where practicable, be reused during reinstatement.

Material excavated from the rock revetment that is suitable for re-use will be stockpiled onshore until the rock revetment is reinstalled. Alternatively, the material may be crushed for re-use on site. Where the material is not suitable for re-use it will be transported to a licenced onshore disposal site. Storage, crushing activity and any transport to a licenced disposal site will be covered by the onshore planning approval process being progressed with Angus Council. Removal and reinstatement of the rock revetment will be covered by both the Marine Licence application and the onshore planning approval process.

The temporary removal and reinstatement of a section of the rock revetment is anticipated to be undertaken in the following order:

- Remove rock armour;
- Remove Geofabric rock under layer;
- Excavate cable pipe trench;
- Install sheet piling;
- Install HDPE pipes;
- Install concrete cap over HDPE pipes at rock revetment toe;
- Remove sheet piles;
- Replace Geofabric rock under layer; and
- Replace and reinstate rock armour.

From the toe of the rock revetment, up to three HDPE pipes will be installed across the intertidal and subtidal zones down to a depth of 2.5 m (LAT) (total length of section 360 m) in either a single trench (Option 1) or up to three trenches (Option 2).

5 COMPUTATIONAL MODELLING

5.1 Coastal Water Level Boundary

5.1.1 Tide Profile

A representative tidal profile was generated for the Carnoustie coastline using the harmonic constants (parameters describing the gravitational interaction between the Earth, Moon and Sun which causes movement of the surface of the sea or ocean) for Arbroath Harbour as defined in the Admiralty Tide Tables (UKHO, 2019). The harmonic constants allow the astronomically influenced tidal cycle to be generated for any period of time. The tidal profile was generated for a one year period, a one week portion containing the highest tide for the simulated year was then extracted.

5.1.2 Extreme Water Levels

The Environment Agency's Coastal flood boundary (CFB) conditions for UK mainland and islands (SC060064) project generated a range of return period (RP) water levels at approximately 2 km intervals around the coast of the UK. In addition to the extreme water levels, the project developed a series of representative normalised storm surge profiles, to enable total extreme water level profiles to be generated. Table 5.1 details the range of extreme water levels calculated for the stretch of coastline adjacent to Carnoustie. As recommended by the Flood Modelling Guidance for Responsible Authorities (SEPA, 2015), the 200 year and 200 year plus climate change events have been modelled in this study.

Table 5.1: Extreme Coastal Water Levels for Carnoustie (m AOD) (EA, 2019)

Return Period	Water Level (m AOD)
1	3.22
2	3.3
5	3.39
10	3.46
20	3.53
25	3.56
50	3.63
75	3.68
100	3.7
150	3.76
200	3.79
250	3.81
300	3.84
500	3.91
1000	3.99

5.1.3 Storm Surge Profile

The storm surge profile for Leith has been determined to be the most representative for the stretch of coast at Carnoustie. Figure 5.1 illustrates the normalised surge profile for Leith generated during the CFB project which was applied to this study in order for a surge profile to be generated for Carnoustie.

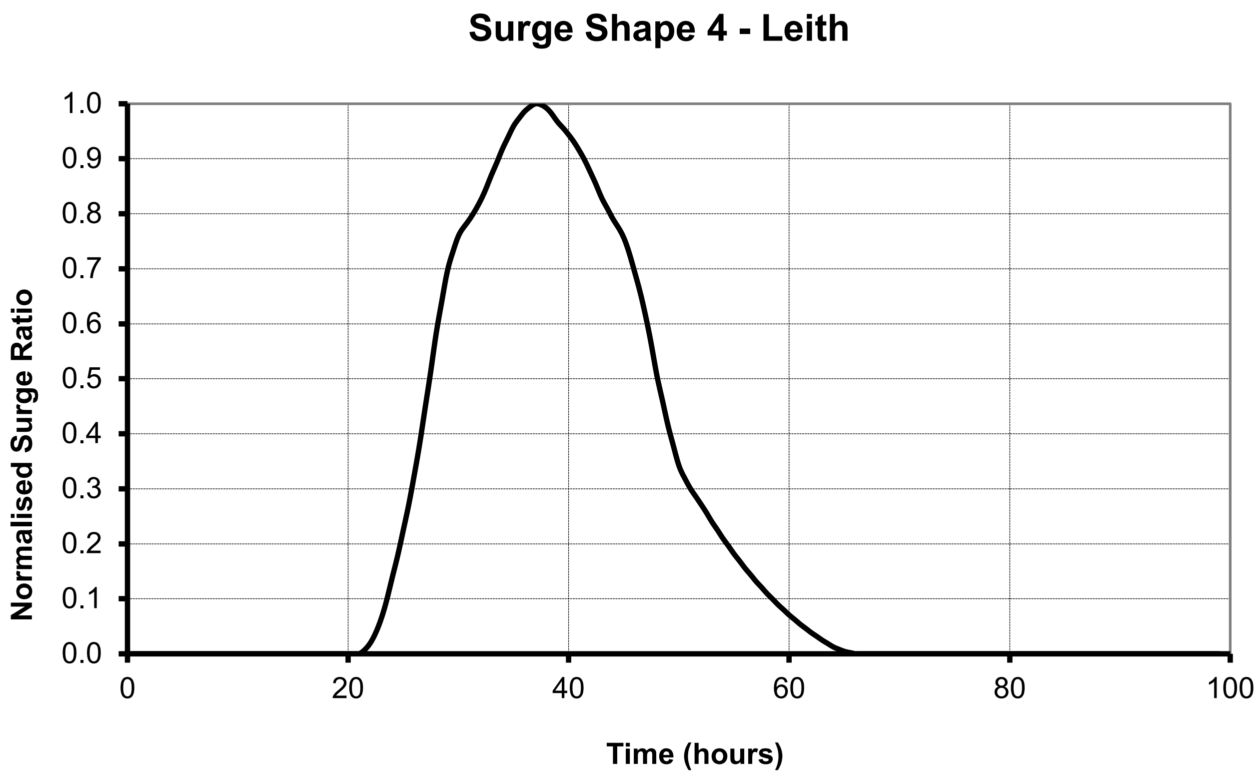


Figure 5.1: Normalised Storm Surge Profile (EA, 2019)

5.1.4 Extreme Water Level Profiles

The normalised storm surge profile was scaled, based on the difference between the peak water level extracted from the astronomical tide profile and the target extreme water level from Table 5.1. The scaled surge profile was then appended to the astronomical tidal profile, with coincident peaks, to achieve a representative combined tidal and storm surge profile for the required time frame. The sequence of calculations below provides an overview of the process of generating the extreme water level profiles.

1. CFB Extreme Water Level - Peak Astronomical Tide Level = Peak Surge Value
2. Peak Surge Value x CFB Normalised Representative Surge Profile = Scaled Surge Profile
3. Astronomical Tide Profile + Scaled Surge Profile = Extreme Coastal Water Level Profile

Figure 5.2 illustrates the tidal profile, storm surge profile and resultant combined water level profile for the 1 in 200 year boundary for Carnoustie.

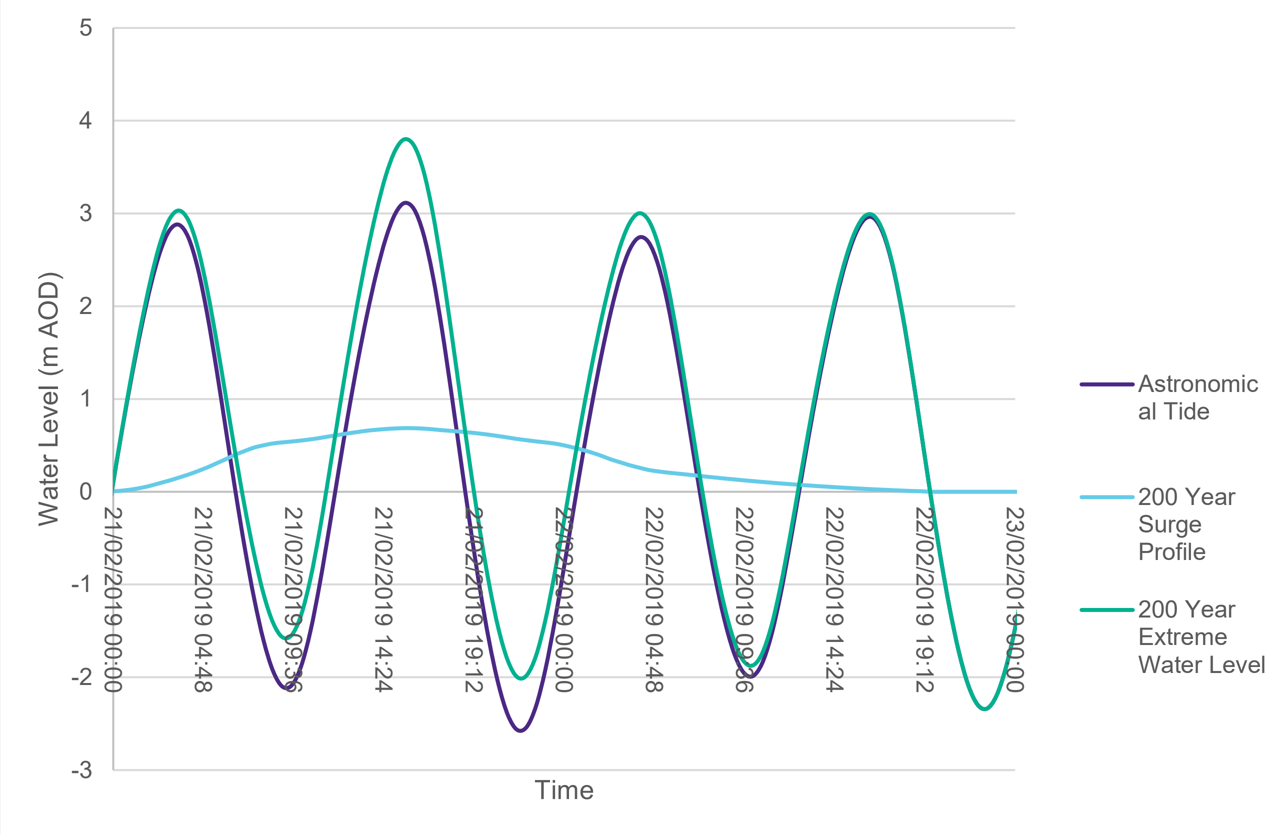


Figure 5.2: Carnoustie Extreme Water Level Profile

5.1.5 Climate Change

Sea level rise is caused by the thermal expansion of the oceans as well as global ice melt, due to the increase in temperature as a result of climate change. These effects can be compounded or counteracted by isostatic rebound. It should be noted that in Scotland, isostatic rebound is partially offsetting sea level rise to varying degrees around the coastline.

As presented in the SEPA guidance document, Climate Change Allowances for Flood Risk Assessment in Land Use Planning (SEPA, 2019), the outputs from the UK Climate Predictions 2018 (UKCP18) indicate that the cumulative rise in sea levels along the coast of the Tay River Basin District, in which Carnoustie is situated, will be 0.85m between 2017 and 2100. This value relates to the High End Future Scenario 95th percentile confidence limit, defined by UKCP18 and can therefore be considered a conservative estimation of climate change. The uplift in water levels has been applied uniformly to the entire water profile, rather than only increasing the scaled surge profile, to achieve a representative climate change water level boundary.

5.2 Hydraulic Model

5.2.1 Model Construction

RPS used Infoworks ICM to undertake the breach modelling of the rock revetment and dune system in the vicinity of the proposed works. A fully 2 dimensional model was deemed the appropriate approach to simulate the consequential inundation of the rock revetment and dune breach, as set out above in Section 2. LiDAR data was purchased which covered a sufficient area to ensure the full extent of inundation could be assessed. The LiDAR data was used to define the elevations for the triangulated mesh of the shore and floodplain area. To ensure the accurate determination of flow paths in the 2D mesh, the processed or "bare earth" LiDAR data was used. As per industry standard, this version of the digital terrain model (DTM) has been processed to remove buildings, trees, hedge rows etc. which would act as a solid barrier to modelled flow. The maximum mesh size used in the model was 50m^2 which was considered to provide sufficient detail for this type of model.

A roughness value of 0.035 was applied uniformly to the 2D domain as any inundation will generally be flowing over sand and well maintained grass. The roughness value within a 2D hydraulic model enables the macro-topography as well as features such as hedgerows and street furniture to be implicitly represented in the model.

5.2.2 Breach Parameters

The proposed extent of the works has been defined in Section 3, however guideline parameters based on those applied by the Environment Agency (2010) have been used to define the breach parameters. As a conservative estimate the breach height has been taken as the difference between the highest point of the dune system in the vicinity of the works and floodplain level on the landward side of the dunes. Table 5.2 defines the recommended breach width and time of closure for various defence types.

Table 5.2: Selection of Breach Dimension and Time to Closure

Location	Defence Type	Breach Width	Time to Closure (hrs)
Open Coast	Earth Embankment	200m or the total asset length where < 200mm	72
	Dunes	100 or the total asset length where < 100m	72
	Hard (walls)	50 or the total asset length where < 50m	72
Estuary and Tidal Rivers	Earth Embankment	50 or the total asset length where < 50m	72
	Hard (walls)	20 or the total asset length where < 20m	72
Fluvial Rivers	Earth Embankment	40 or the total asset length where < 40m	36
	Hard (walls)	20 or the total asset length where < 20m	36

The parameters recommended for a defence type “dune” have been used, with a breach width of 100m and a duration of 72hrs. Based on the LiDAR data the floodplain level on the landward side of the dune system is 3.4m AOD, this level was therefore taken as the base level of the breach. Figure 5.3 is an image of the rock revetment currently in place at the study site: some erosion is evident at the crest with noticeable depressions at a number of locations along the face of the rock revetment. The dune system continues to rise behind the rock revetment for approximately 50m and then begins to slope down to floodplain level, at approximately 200m behind the rock revetment face. Figure 5.4 is a view looking away from the rock revetment towards the lower flood plain area. Figure 5.5 provides an overview of the rock revetment, dune system and floodplain area.

As per the EA (2010) guidance, the breach of the dune system occurs one hour before peak extreme water level is reached and an instantaneous catastrophic failure occurs. The approach utilised to represent the breach is based on the EA (2010) guidance, good practice, industry standard methods and industry standard software. As per the EA (2010) guidance the methodology provides a conservative worst case scenario and resultant flood extent.

Figure 5.3: Rock revetment face with crest erosion

Figure 5.4: View from rock revetment crest towards the potential floodplain area

Figure 5.5: Overview of rock revetment and dune system

6 MODEL RESULTS AND MAPPING

Figure 6.1 illustrates the modelled flood extents for the 200 year and 200 year plus climate change breach flood extents. The results indicate that due to the relatively high elevation of the ground behind the dune system, the potential inundation if a breach were to occur during a 200 year coastal event would be limited to a small portion of the golf course. The extremely conservative nature of the peak level applied for the 200 year plus climate change event results in a more extensive flood extent which could potentially reach the golf course club house buildings. It should be noted that this represents an estimated 95th percentile high end emissions scenario for the year 2100. The construction period of the cable installation is scheduled to take place over an eight week period in 2020 and the design life of the proposed works is 25 years, this event is therefore extremely unlikely to occur during that period. However as per the SEPA (2015) guidance these scenarios have been modelled to represent an extreme worst case

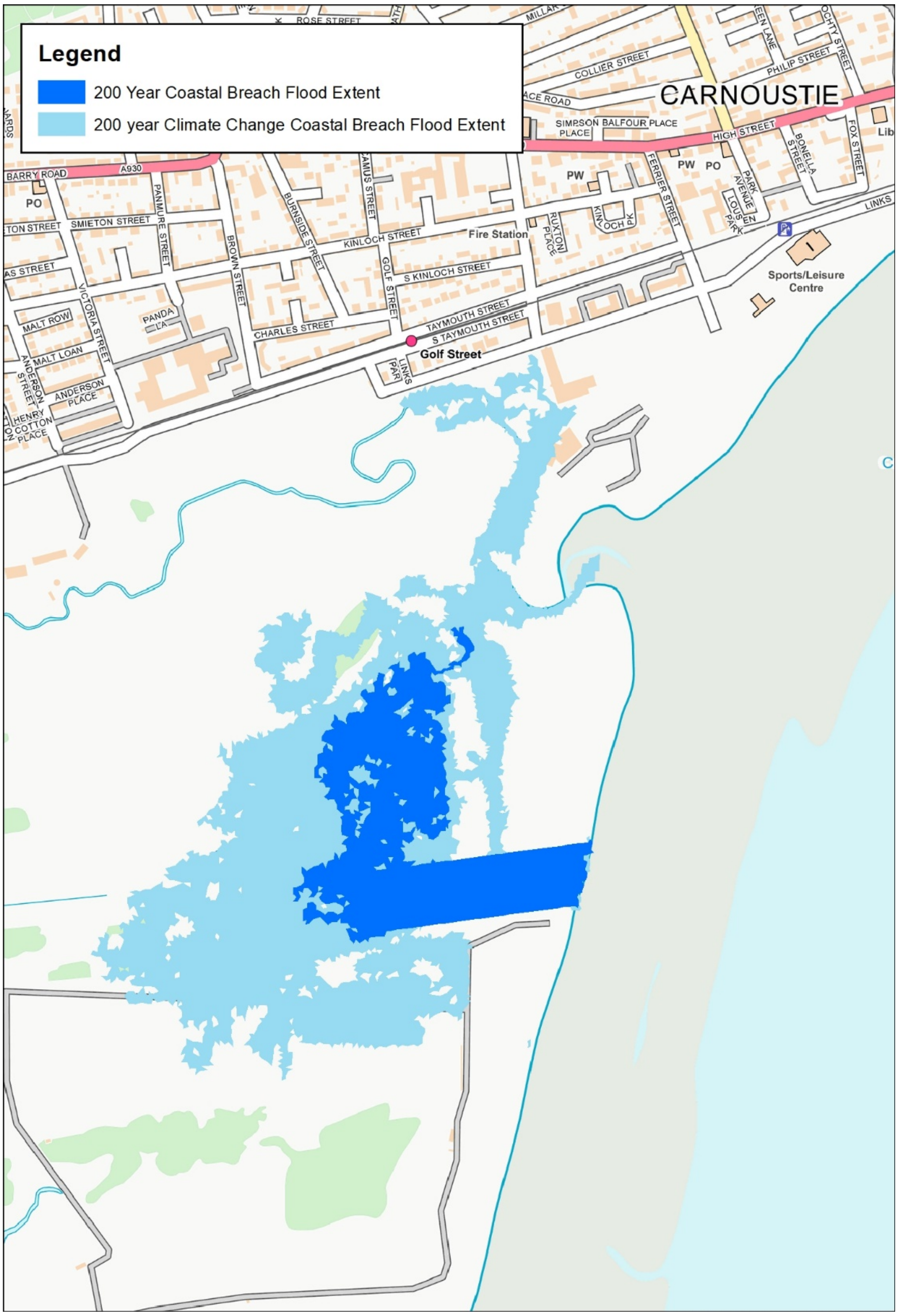


Figure 6.1: 200 year and 200 year plus climate change flood extents

Figure 6.2 presents the predicted floodplain depths during a 1 in 200 year breach event. The majority of predicted depths are between 0.2 and 0.5 m with some localised areas of greater depths of up to 2m. However, in general the extent of flooding is relatively minimal.

The extent of flooding simulated for a 200 year plus climate change event is presented in Appendix A. This provides an indication of possible future flood risk in the vicinity of Carnoustie during the 2100's and should be considered as a sensitivity investigation to future changes in sea level. Appendix A demonstrates that flooding under this scenario would be more extensive, However, as described in Section 1, the design life of the proposed works is 25 years and the works are proposed across an eight week period in 2020, therefore, this event is extremely unlikely to occur during the construction or operational phase of the proposed works.

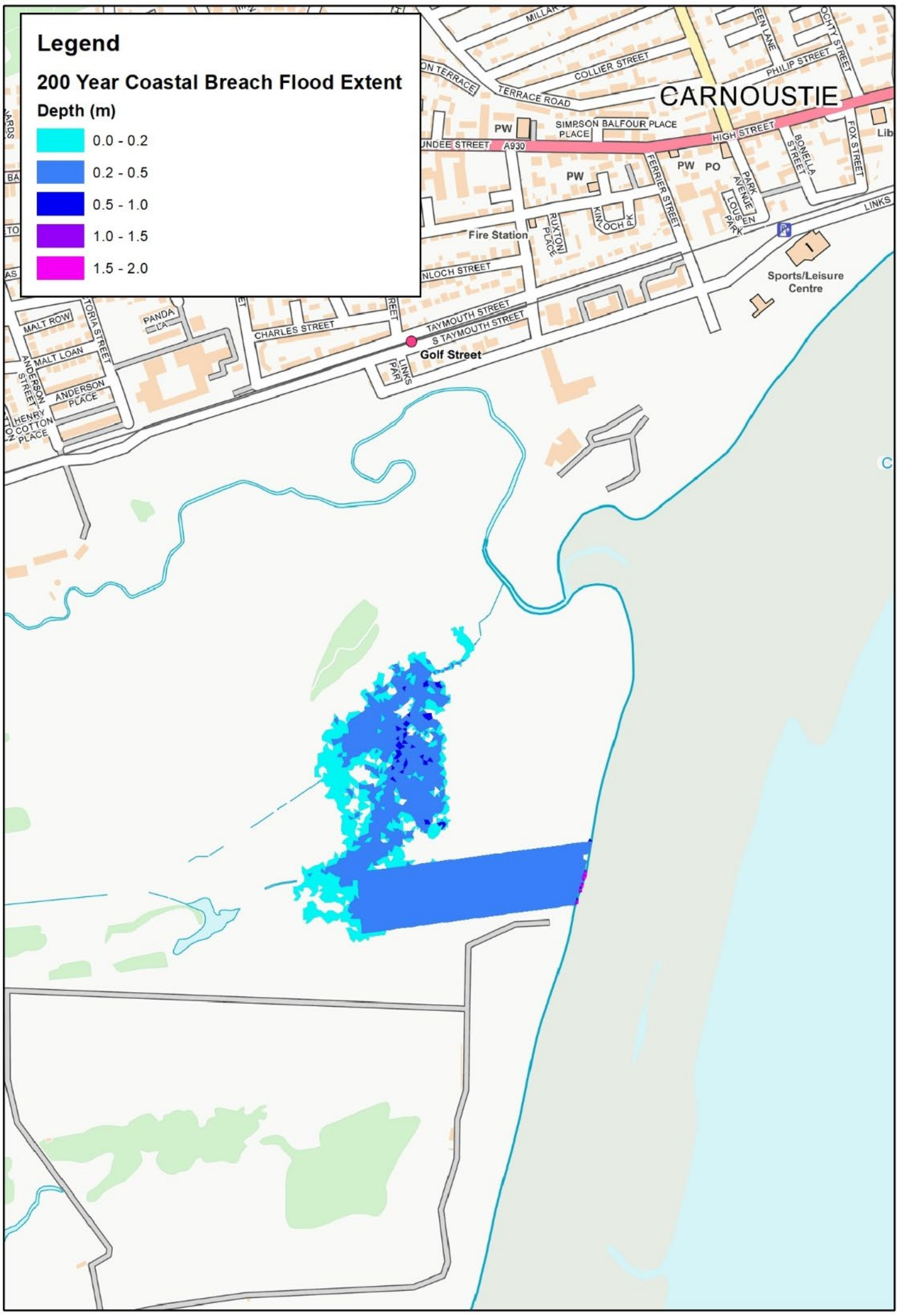


Figure 6.2: 200 year coastal event flood depth map

It should be noted that during the modelling exercise the water level profiles derived in Chapter 4 have only been applied to the section of coastline adjacent to the alternative cable landfall site as this is the area of concern and where a breach is likely to occur. Should the profiles be applied along the coastline to the mouth of the Barry Burn, which would be the case during a storm event, the inundation area due to flooding of the Barry Burn would be more extensive than flooding due to a breach in the rock revetment. This is because, separately from the proposed works forming the alternative cable landfall Marine Licence application, the Barry Burn has a high likelihood of flooding under this scenario. Based on a comparison of the 200 year water level data available from the SEPA Flood Map website[2].and the digital terrain model (DTM) levels in the vicinity of Barry Burn it is highly likely that the water levels predicted will result in significant inundation of the land adjacent to the burn, the extent of which would be much greater than that from the breach in the rock revetment. In the event that the Barry Burn were to flood, this would potentially impact properties on the seaward side of the railway, as well as the golf course during a 200 year event. Based on a review of those datasets and expert judgement it is considered highly likely that the Barry Burn would flood a greater area of the golf course and would be significantly greater in magnitude than any flooding from a breach in the rock revetment.

[2] http://map.sepa.org.uk/floodmap/map.htm

7 SUMMARY OF FINDINGS

Computational modelling of a potential breach of the rock revetment and dune system adjacent to Carnoustie Golf Course indicated that there was no risk to properties during a 200 year extreme water level event. Some minor inundation of an area of golf course (considered by SEPA as being of low vulnerability) was predicted via the simulated breach. However, through consideration of the water levels of a 200 year flooding event and from the known topography of the land behind the rock revetment and in the vicinity of the burn, any flooding from the Barry Burn is estimated to be of a much greater extent that any flooding from the breach in the rock revetment. As the Barry Burn and adjacent areas are likely to flood during a 200 year event through inundation from the Barry Burn, the flood risk resulting from a breach in the rock revetment is considered insignificant in its contribution to flood inundation.

The extent of flooding simulated for a 200 year plus climate change event is more extensive as shown in Appendix A, however this event is extremely unlikely to occur during the construction or operational phase of the proposed works. As with the 200 year event, based on available evidence, the flood risk posed by coastal water levels propagating up the Barry Burn, is more substantial and would not be significantly increased by the simulated breach in the rock revetment which is the focus of this study.

Therefore, in summary, the potential flood risk posed by the removal of the rock revetment is deemed insignificant, with a small area of low vulnerability golf course being inundated during the 1 in 200 year event. An event of this nature is considered highly unlikely to occur during the eight week period in 2020 in which the trench in the rock revetment is open. Once the rock revetment has been reinstated the risk of inundation is significantly reduced. As such, specific flood risk mitigation measures are not considered necessary. It is prudent however to consider the risk of erosion to the dune system and danger to construction operatives should a storm event occur during construction. The recommendations below aim to provide protection to the exposed dunes and therefore further reduce the potential flood risk during the construction phase, as well as reduce the risk to any on-site personnel.

7.1.1 Recommendations

1. Flood risk due to a breach during a 200 year extreme water level event is deemed to be insignificant, particularly when compared to likely flooding from the Barry Burn to the north of the landfall location which would be expected to inundate a considerably larger area than any breech of the rock revetment. In addition, the likelihood of such an event occurring during the eight week period in 2020 that the works are undertaken is considered to be extremely low. Therefore, no additional flood risk mitigation measures are considered necessary.
2. A localised coastal flood warning system could be implemented during construction works in consultation with SEPA. This may include information exchange prior to commencement of the works and agreement whether predicted conditions are suitable for the works to proceed and the risk of future storms is sufficiently low. Daily updates from SEPA can then be provided on the potential risk of a coastal flood event occurring in order to ensure the works can be undertaken during a suitable period.
3. Where possible, the works will not be carried out during a coastal flood or storm event.

8 REFERENCES

Seagreen (2019). Seagreen Alpha and Bravo Offshore Wind Farms Alternative Landfall Cable Installation Marine Licence Application – Environmental Report. LF000009-CST-OF-REP-0021

United Kingdom Hydrographic Office (2019). Admiralty Tide Tables – NP201B Volume 1B 2019

Environment Agency (2019). Coastal flood boundary (CFB) conditions for UK mainland and islands - SC060064

Environment Agency (2011). Coastal Flood Boundary Conditions for UK Mainland and Island; Practical Guidance Design Sea Levels SC060064/TR4.

SEPA (2015). Technical Flood Risk Guidance for Stakeholders

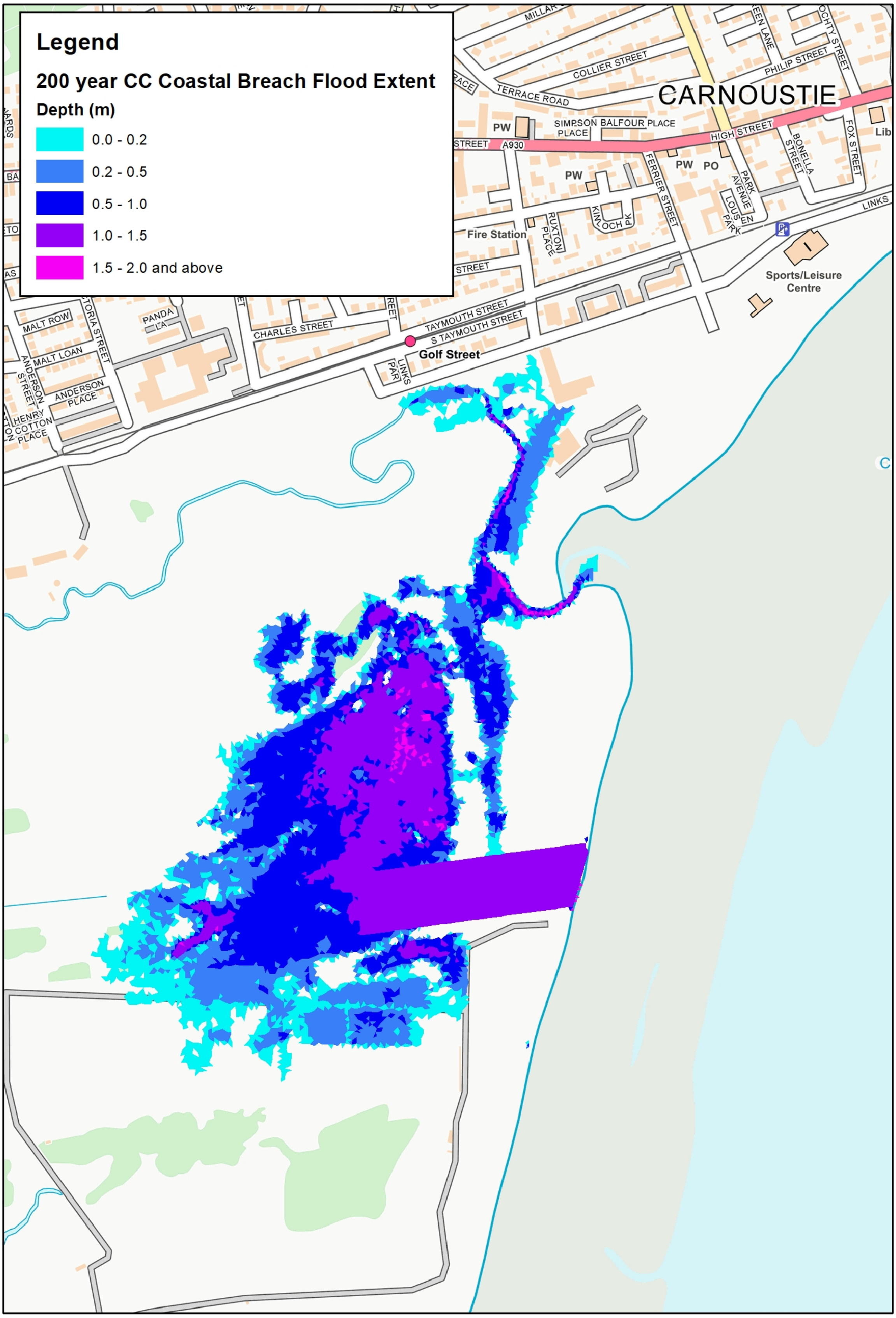
SEPA (2019). Climate change allowances for flood risk assessment in land use planning

Environment Agency (2010). Environment Agency Anglian Region Northern Area Tidal Modelling. Volume 4: Breach Hazard Mapping.

Scottish Natural Heritage (2011) A methodology to assess the causes and rates of change to Scotland's beaches and sand dunes – Phase 1. SNH Commissioned Report No. 364

Appendix A

200 Year Plus Climate Change Extent


Legend
200 year CC Coastal Breach Flood Extent
Depth (m)
0.0 - 0.2
0.2 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0 and above
CARNOUSTIE
COLLIER STREET
PHILIP STREET
TERRACE ROAD
HIGH STREET
A930
SIMPSON PLACE
BALFOUR PLACE
PW
PO
Fire Station
FERRIER STREET
KINLOCH PK
RUXTON PLACE
PARK AVENUE
LOUSEN PARK
BONELLA STREET
FOX STREET
LINKS
Sports/Leisure Centre
TAYMOUTH STREET
S TAYMOUTH STREET
Golf Street
CHARLES STREET
PANDA LA
MALT ROW
MALT LOAN
ANDERSON STREET
ANDERSON PLACE
HENRY COTTON PLACE
LINKS PARADE

Appendix B - Alternative Landfall Cable Installation Marine Licence Application – Beach Drawdown Assessment

SEAGREEN ALPHA AND SEAGREEN BRAVO OFFSHORE WIND FARMS

Alternative Landfall Cable Installation Marine Licence Application – Beach Lowering Assessment

IBE1596
Alternative Landfall Cable Installation Marine Licence Application – Beach Lowering Assessment
Rev04
19 June 2019

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
00	Review	Adrian Bell	Pippa Van Kuijk / Adam Payne	Andrew Jackson	31/05/19
01	Issue to client	Adrian Bell	Adam Payne	Adam Payne	31/05/19
02	Updated with comments	Pippa van Kuijk	Andrew Sloan	Adam Payne	06/06/19
03	Editing methodology section	Adam Payne	Pippa Van Kuijk	Adam Payne	13/06/19
04	Addressing legal comments	Pippa van Kuijk	Adam Payne	Adam Payne	19/06/19

Approval for issue

Adam Payne		19 June 2019

Prepared by:

RPS

Adrian Bell

Technical Director – Coastal Engineering and Environment

Elmwood House

74 Boucher Road, Belfast

Co. Antrim BT12 6RZ

T +44 2890 667 914

E adrian.bell@rpsgroup.com

Prepared for:

Seagreen Wind Energy Limited

Tamsin Watt

Consents Manager

One Waterloo Street

Glasgow

G2 6AY

T +44 7812 588 032

E tamsin.watt3@sse.com

Contents

Figures

1 INTRODUCTION

Seagreen Wind Energy Ltd ("Seagreen") is progressing the Seagreen Alpha and Seagreen Bravo offshore wind farms (OWFs) off the east coast of Scotland in the outer Firth of Forth and Firth of Tay area (the "projects"). The projects received consent under S36 of the Electricity Act 1989 (as subsequently varied) together with three Marine Licences from the Scottish Ministers in 2014, one for the Seagreen Alpha offshore wind farm, one for Seagreen Bravo offshore wind farm, and one for the Offshore Transmission Asset (OTA). Together the projects comprise up to 150 wind turbines with associated infrastructure and array cables. The consented export cable corridor makes landfall at Carnoustie.

RPS was engaged to provide a desk study, making best use of the information available, to assess the estimated beach lowering rates at the landfall site at Carnoustie. The assessment has been developed to help understand the requirements for the depth of cable burial at the landfall site, to reduce the risk of erosion exposing the cables in the future. This followed a request made by SNH during EIA Screening to undertake a study to understand the lowering of the beach at the landfall. In response to this request Seagreen commissioned RPS to undertake a study to investigate the potential rate of change to the beach profile, assess the potential risk of exposure of the High Density Polyethylene (HDPE) pipes in which the cables are installed in trenches through the beach at Carnoustie and, based on the result, make recommendations with regards to any measures that could be implemented to avoid future exposure.

This report provides an overview of the methodology and data collection activity and the approach to the beach lowering assessment that was developed based on the available data, presents the results of the study and provides recommendation of management measures to be implemented (if required) by the project, to reduce any potential risks from lowering of the beach resulting in exposure of the HDPE pipes and the cables which they contain.

1.1 Background to the Project

Seagreen is applying for a marine licence for an alternative cable landfall installation methodology to be implemented at Carnoustie, as a potential alternative to Horizontal Directional Drilling (HDD) installation methodology, which has already gained consent as part of the existing marine licence (reference 04678/14/0, as varied in 2019 (04678/19/0)) (the "Existing Marine Licence"). This alternative method is for ploughing or mechanical trenching (also termed 'open cut' trenching) between the original proposed entrance points of the HDD, through the rock revetment. Trenching will continue across the intertidal area as set out within the Existing Marine Licence, down to the 2.5 m depth contour (Lowest Astronomical Tide (LAT)) (approximately 190 m seaward of charted MLWS), to meet the offshore cable installation works.

The alternative landfall methodology proposed in the Environmental Report (to which this report is appended) proposes the removal of a portion of rock revetment (a coastal protection feature) in the vicinity of Carnoustie. This is proposed to enable trenching and the burying of the HDPE pipes through which the cables will be pulled through beneath the beach, to connect with the onshore cable (see Section 1.2). Following initial consultation with Marine Scotland, Seagreen requested an EIA Screening Opinion, seeking their opinion on the alternative cable landfall Marine Licence. Scottish Natural Heritage (SNH) were consulted on the EIA Screening Opinion by Marine Scotland and in their response, raised the question of beach lowering and potential exposure of the cables due to storm erosion of the beach. SNH also requested consideration of proposed actions to deal with a possible future re-exposure of the cables, in particular, to consider the need for any rock armour protection to the exposed cables in the future.

This document has been prepared to address SNH’s concerns regarding potential beach lowering and future re-exposure of buried cables. Figure 1.1: indicates the location of the proposed onshore and offshore working corridors, the area of rock revetment proposed to be removed and replaced and the area of the intertidal region based on existing OS map data.

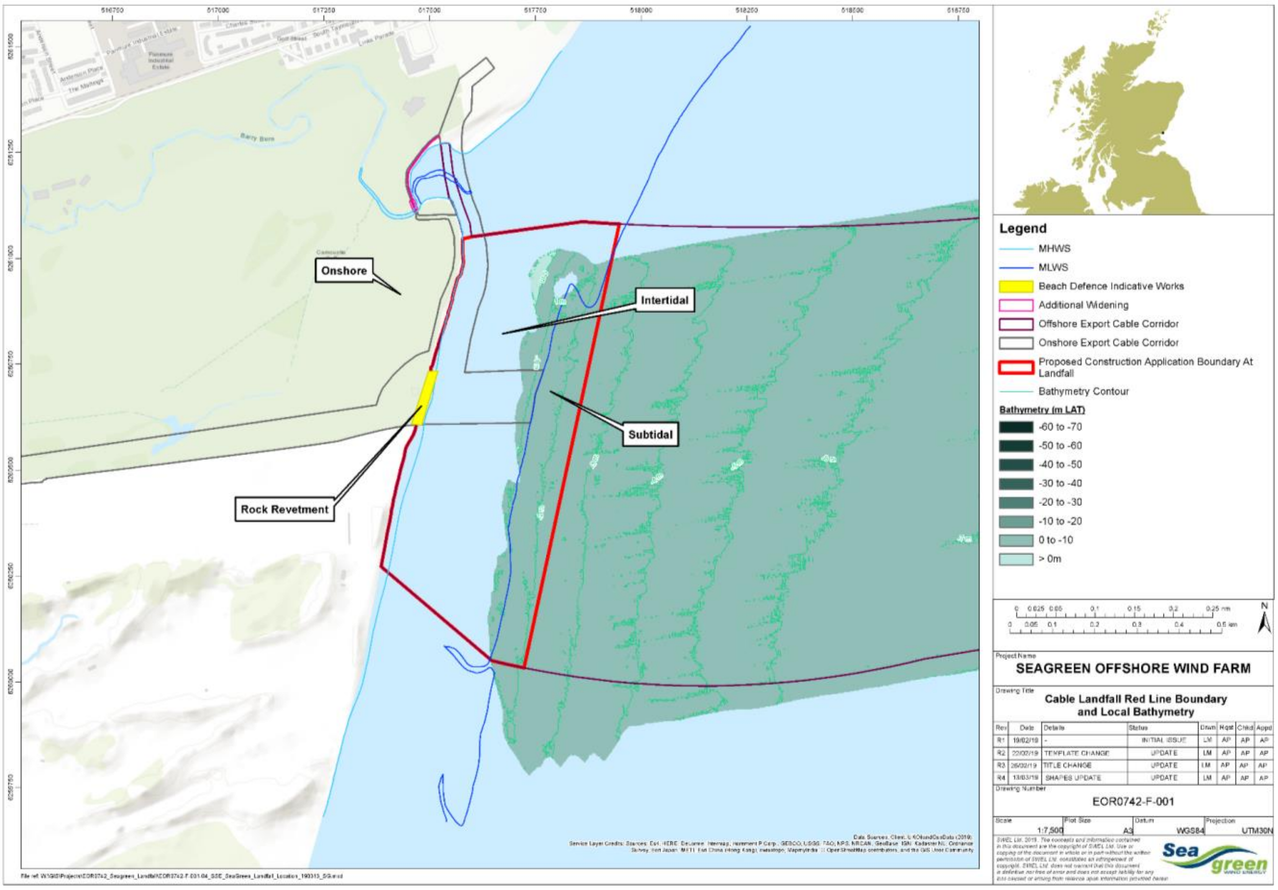


Figure 1.1: Landfall location and working corridor locations

1.2 Intertidal and Subtidal Cable Installation

The installation methodology proposed for alternative cable installation, as part of alternative cable landfall Marine Licence application across the intertidal area, is set out in detail within the Seagreen (2019) Consenting Approach Document submitted to Marine Scotland in April 2019 and the Environmental Report to which this study is appended. This is summarised here for context for this study.

From the toe of the rock revetment, up to three HDPE pipes will be installed across the intertidal and subtidal zones down to a depth of 2.5 m (LAT) (total length of section 360 m) in either a single trench (Option 1) or up to three trenches (Option 2), as follows:

- Option 1: installation of up to three High Density Polyethylene (HDPE) pipes within a single trench excavated to 3 m deep, 20 m wide at base and 30 m wide at top. The trench will be excavated to provide a minimum of 2 m cover to the three HDPE pipes at 5 m minimum spacing. Option 1 may require approximately 200 m of sheet piling either side of the trench (400 m in total) in the subtidal zone (which may also extend into the intertidal zone) and working areas 30 m wide either side of the trench (60 m wide in total); or
- Option 2: installation of up to three HDPE pipes within up to three trenches excavated to 3 m deep, 2 m wide at base and 3 m wide at the top. The trenches will be excavated to provide a minimum of 2 m cover to the three HDPE pipes at 25 m spacing. Option 2 may require approximately 200 m of sheet piling either side of each trench (400 m per trench, 1,200 m in total) in the subtidal zone (which may also extend into the intertidal zone) and working areas 30 m wide on the outer trenches only with 25 m working areas in between each trench (110 m wide in total).

The trench(es) will be excavated by elevated or barge/jack-up mounted backhoe excavators allowing excavation work to be carried out at all states of the tide. In some cases (i.e. within areas permanently submerged), temporary sheet piling may be required to maintain safe working conditions until the trench work is completed and backfilled. Sheet piling will be installed using vibro-piling (as opposed to impact piling). For the sections of trench which are dry at low tide, excavation could be undertaken with the trench sides supported with trench boxes. Trench boxes are used as a temporary earth retaining structure to shore up the sides of a trench while material is excavated from within and can allow the sides of a trench to be cut vertical or near vertical.

During excavation of the trenches within the intertidal zone, to aid successful reinstatement of the as found sediment layers, each layer of material will be removed and stored in berms to the side of the trench with individual layers kept separate, to aid reinstatement once works are complete. The berms created to the side of the trenches will be flattened on a regular basis to ensure they do not become too high.

HDPE pipe sections (800 mm in diameter) will be preassembled and floated to site, lowered into position in the trench and then joined to the previous section. The pipes may then be secured using concrete collars before the trenches are backfilled, to ensure the HDPE pipes stay in position and are buried at the correct depth. In the intertidal zone, the trench section will be backfilled using the excavated material maintaining any original sediment layering and profile as far as reasonably practicable and compacted where necessary to avoid subsidence. In the subtidal zone, the trench will be allowed to backfill naturally.

On completion, the seaward end of the pipes (at a depth of 2.5 m LAT, approximately 190 m from charted MLWS) will be fitted with a messenger line and left temporarily capped on the seabed to allow cable pull-in later. Temporary ballast (e.g. concrete bags/clamps or rock nets/bags of gravel) may be attached to the pipe ends for stabilisation. The pipe ends will be fully buried to a depth allowing 2 m of material above the top of the pipe following cable pull-in and completion of cable installation.

2 METHODOLOGY

2.1 Data Collection

Prior to undertaking the study it was believed that the National Coastal Change Assessment ("NCCA") dataset would contain beach profile data for the study area and this would provide a suitable indication of historic changes in beach profile.

On commission of the desk study, a data collection exercise was undertaken to explore potential datasets available to inform the beach lowering assessment. This included review of the National Coastal Change Assessment (NCCA) datasets. Through this process it was established that the data from the NCCA did not allow for an assessment of estimated beach change due to a lack of existing data collated during the preparation stages of the NCCA regarding the location of the landfall and the coastline at Carnoustie. Therefore, other suitable data was required in order to undertake the study.

A discussion with the local onshore planning authority, Angus Council, concluded that there is no recent beach profile data available for the site. However, this discussion identified a beach study completed by HR Wallingford (1991) that provided beach profile data for the period 1979 - 1990. This report was sourced and has been used as the baseline for the assessment of the beach lowering at the landfall site.

Available OS maps were also accessed for the years 1858, 1900 and 1938, to provide an indication of the processes that occurred at the site before the installation of the rock revetment in 1978 (Wright, 1981; SNH, 2011). The most recent information pertaining to water level during the tidal cycle is taken from the Admiralty Tide Maps (UKHO, 2019).

2.2 Approach

2.2.1 Beach Profiles

The beach profiles collated from HR Wallingford (1991) have been reviewed from 1979 to 1989. In order to understand the beach profiles and its evolution over time, a comparison based on the levels recorded in the beach profiles has been made to establish the magnitude of change in the beach profiles over time.

It is acknowledged that ten years of data is a relatively limited dataset to determine the changes in the profiles over time and the age of the data means that best estimates of beach lowering are made over the data period (1979-1989). However, the data does provide an indication of the changes in beach profile over time and while the rock revetment is in place and therefore can be used to make an estimate of potential beach drawdown rates. The rate of change in beach profile has also been compared with site photographs taken during a very low tide in February 2019 in order to provide data validation of the estimates of beach profile change.

2.2.2 Mean High Water Levels

Mean High Water Spring (MHWS) data has been taken from the relevant OS map data for Carnoustie and has been compared with the historical OS maps accessed from the National Laboratory for Scotland (NLS) to understand coastal processes at this location before the rock revetment was installed in 1978. In conjunction with the HR Wallingford (1991) study this data provides some indication of how the rock revetment may now affect coastal processes within Carnoustie Bay. These maps are freely available on the NLS website[1].

[1] https://maps.nls.uk/geo/find/#zoom=12&lat=56.4877&lon=-2.8478&layers=102&b=1&point=56.4772,-2.7350

2.2.3 Wave Modelling

In order to model the wave activity in the study area of Carnoustie the MIKE 21 Spectral Wave (SW) model was used. This model is part of the DHI MIKE suite of software developed at the Danish Hydraulics Institute (DHI) and is recognised worldwide as state of the art software for the simulation of coastal processes.

The MIKE 21 SW model is a spectral wind-wave model which models sea state through the simulation of the growth, decay and transformation of wind-generated waves and swells in offshore and coastal areas. MIKE 21 SW accounts for the following coastal processes:

- Wave growth by wind action (the increase in wave size due to the action of wind on the sea surface);
- Non-linear wave-wave interactions;
- Dissipation due to white-capping (dissipation of energy due to a wave breaking in deep water);
- Dissipation due to bottom friction (dissipation due to interaction of a wave with the seabed);
- Dissipation due to depth-induced wave breaking (waves breaking in shallower water);
- Refraction (a wave bending due to propagation over different depths) and shoaling (a change in wave height as a wave enters shallower water) due to depth variations;
- Diffraction (the bending of a wave around an obstacle or through an aperture);
- Wave-current interaction; and
- Effect of time-varying depth and flooding and drying (the effects of changes in depth and the flooding and drying of intertidal areas).

3 HISTORICAL COASTAL EVOLUTION

To inform the beach lowering assessment, historical OS maps have been obtained for the years 1858, 1900 and 1938[2]. The purpose of this was to provide a long term review of changes to the beach and to understand the processes prior to the rock revetment being in place. Changes in the coast are long term and historical data can confirm the trend of sediment processes and in this case the processes present before the installation of the rock revetment in 1978. This data shows that prior to the rock revetment installation, the beach was dynamically stable as it both erodes and accretes over time (through removal and replenishment of beach sediment and dunes during extreme storm events or through the action of wind). The more recent mean high water level with the rock revetment in place is captured in the assessment of beach profiles as taken from the HR Wallingford (1991) report.

The maps have been georeferenced and the mean high water marks from these maps transferred on to the current OS map available for the Carnoustie and Barry Sands area (see Figure 3.1). The data from 1858, 1900 and 1938 has been used to show how the height of MHWS changed historically over time. Unfortunately, the NLS did not have any additional data of mean high water levels other than for this 80 year period at the end of the 19th and beginning of the 20th centuries

It can be seen from Figure 3.1 that the shoreline in the area has generally retreated between 1858 and 1900 before accreting between 1900 and 1938. In the area of the proposed landfall at Carnoustie there was virtually no change in the mean high water mark between 1858 and 1900[1]. By 1938 the shoreline in this area had accreted seaward of the current position. This was followed by a period of erosion post 1938 before the shoreline became “locked” in position due to the construction of a rock revetment in 1978 (Wright, 1981, SNH, 2011).

This available historical information indicates that prior to the construction of the rock revetment the major part of the shoreline was under a system of dynamic equilibrium whereby the coast would erode and accrete around a mean level over a period of 30 to 40 years. Along the southern portion of the peninsula, the shoreline has been progressively retreating since 1858, until the construction of the rock revetment in this area (see Figure 3.1:. As there are no beach profiles from this earlier time period, accurate readings of water levels, or maps between 1938 and time period of the HR Wallingford (1991) study, an estimate of the erosion rates cannot be made.

[2] https://maps.nls.uk/geo/find/#zoom=12&lat=56.4877&lon=-2.8478&layers=102&b=1&point=56.4772,-2.7350

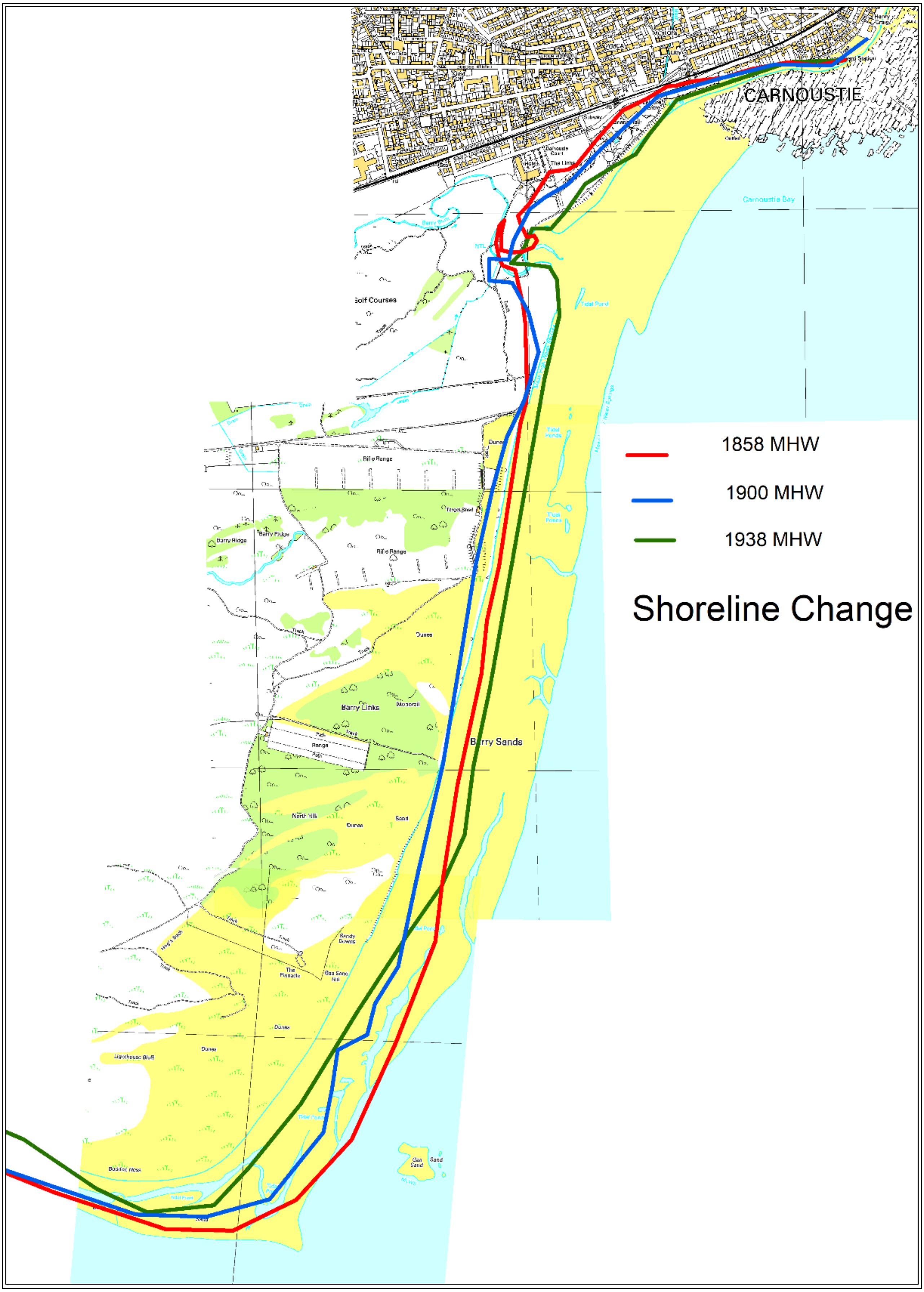


Figure 3.1: Mean high water lines from OS maps of 1858, 1900 and 1938.

4 COASTAL PROCESSES

4.1 Overview

Tides, tidal current, waves and sediment transport processes for the study area have been reviewed. These all contribute to developing an understanding of the coastal processes at the site in order to understand the erosion and accretion and general net direction of sediment at Carnoustie.

4.2 Tides and Tidal Current

The tides in the area of the proposed landfall are semi-diurnal with a mean spring range of 4.5 m and a mean neap range of 2.3 m. Towards the seaward entrance to the Tay Estuary (along the 20 m contour) the tidal stream flows approximately parallel to the coast, with a spring velocity of about 1.2 knots. However, the combination of the ebb from the Tay Estuary and the coastal ebb tide is such that the outer end of the Abertay Spit is deflected to the north (see Figure 4.1). The effect of the Abertay Spit, the Bar and the Gaa Sands results in an anti-clockwise eddy that forms to the north of the Gaa Sands on the ebb tide. Thus, during the ebb tide the tidal drift off the beach at the landfall site tends to be from north to south.

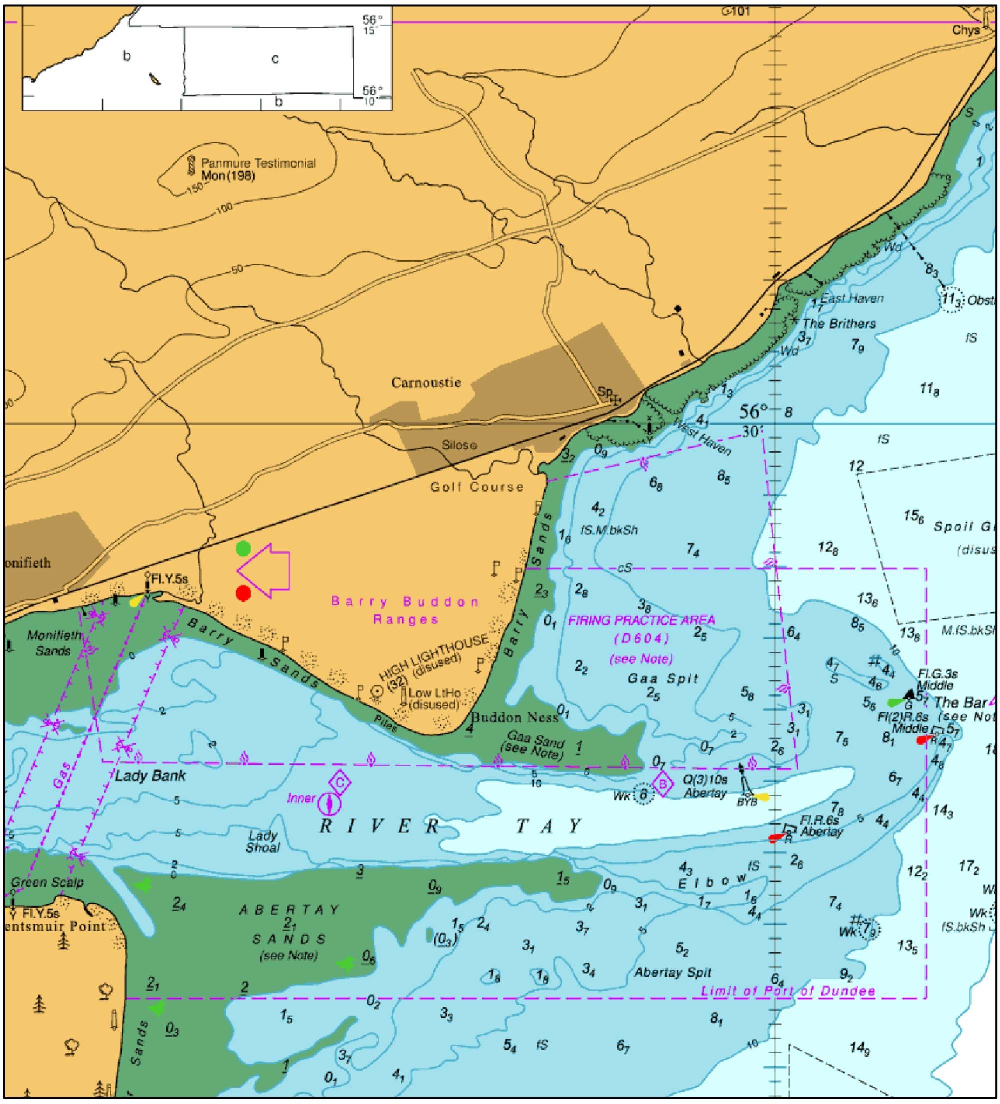


Figure 4.1: Admiralty chart around Carnoustie and the entrance to the Tay.

4.3 Waves

Figure 4.2 shows the offshore wave rose for waves in excess of 2 m significant wave height for the Barry Sands at Carnoustie. This diagram is based on 39 years of wave climate data from the UK Met Office Wavewatch III hindcast model[3] for the period 1980 to 2018. It demonstrates that the wave climate for the larger waves is dominated by waves from the North East and the East to East South East.

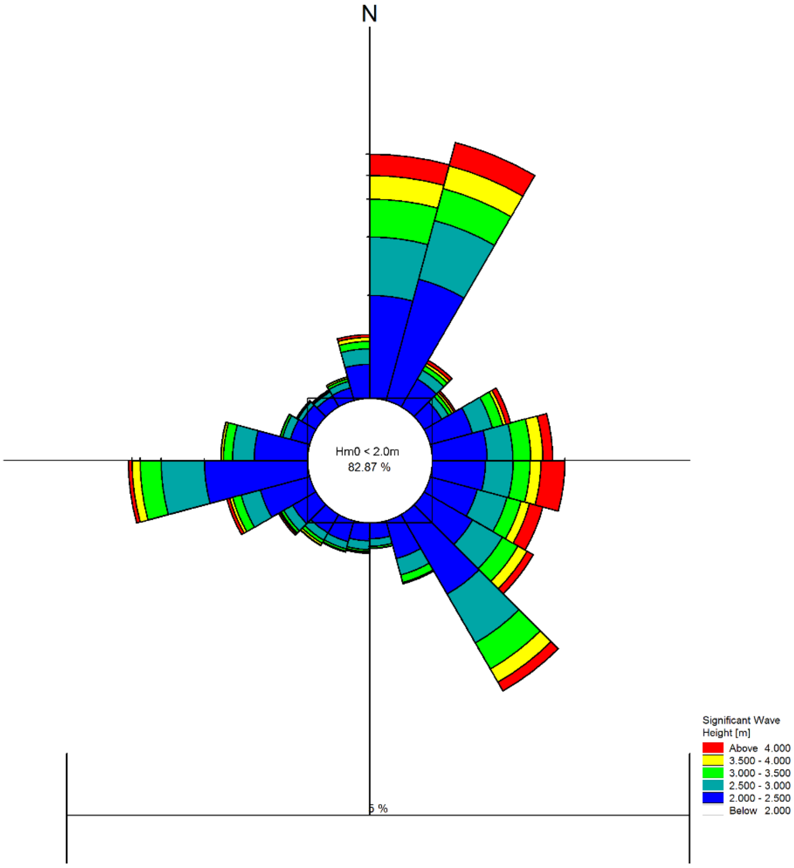


Figure 4.2: Offshore wave rose for waves in excess of 2 metres significant wave height

Waves approach the shoreline to the north east (Figure 4.2) of Carnoustie obliquely such that it can be deduced that a longshore current is generated from north east towards the south west which also concurs with the general north to south current direction shown within the Seagreen Offshore ES (Seagreen, 2012, Chapter 7: Physical Environment). The height of waves approaching the site of the proposed landfall will be influenced by the height of the tide (plus storm surge if any) at the time of the storm. Figures 4.3 and 4.4 show the significant wave heights and mean wave directions of the storm waves approaching the beach during 1 in 1 year and 1 in 50 year return period easterly storms, respectively.

The wave climate approaching the rock revetment at the landfall site will have a significant wave height of 2.6 m with spectral peak wave period of 10 seconds during a 1 in 1 year return period storm, at a water level equivalent to Highest Astronomical Tide (HAT). During a 1 in 50 year storm, with a water level of +6m CD, the significant wave height of the waves approaching the rock revetment will be 2.9 m with a peak spectral wave period of 11.5 seconds. As presented in Figures 4.3 and 4.4, the height of the storm waves crossing the intertidal area and approaching the rock revetment are controlled by the depth of the water. Thus, any drop in beach level will result in a corresponding increase in the storm wave heights approaching the toe of the rock

[3] https://www.metoffice.gov.uk/research/weather/ocean-forecasting/ocean-waves

revetment. This has the potential to result in increased pressure on the rock revetment with a subsequent decrease in the life of the rock revetment and an increase in the rate of beach lowering over time.

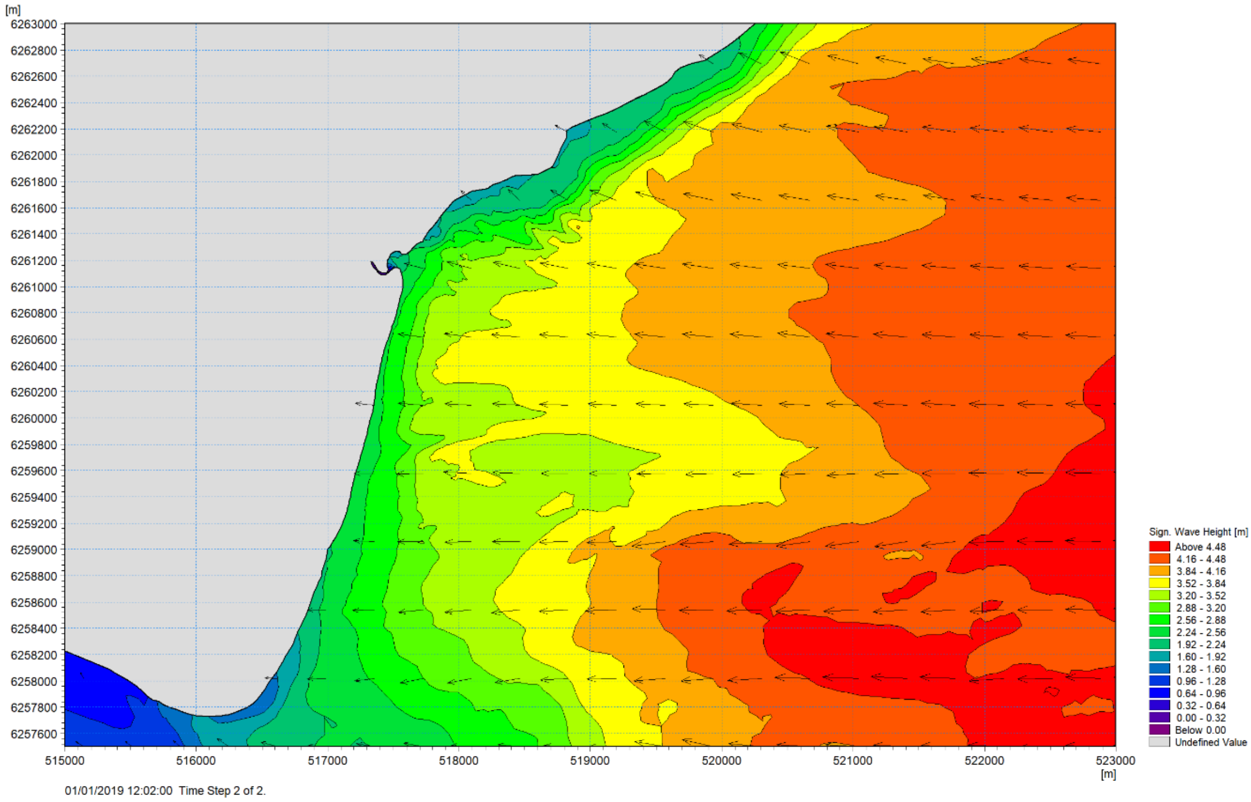


Figure 4.3: Significant wave height and mean wave direction - 1 in 1 year return period easterly storm

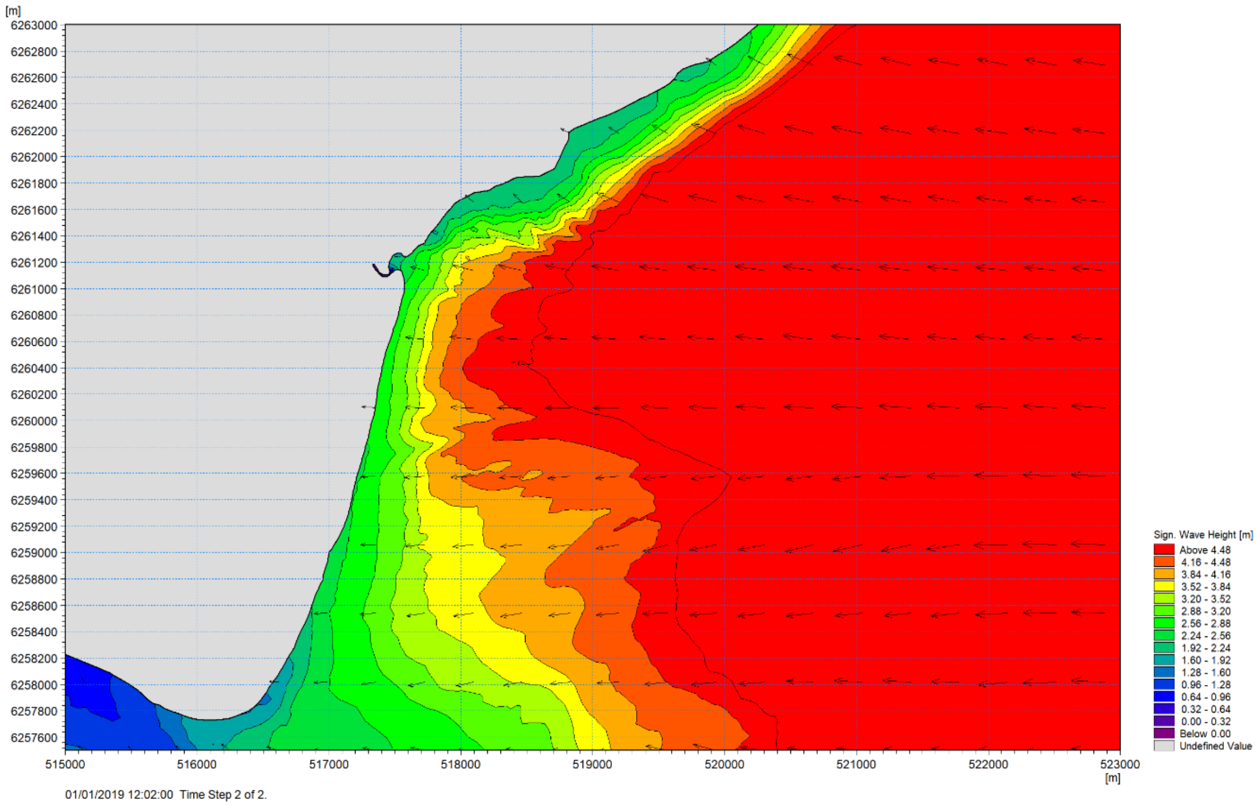


Figure 4.4: Significant wave height and mean wave direction - 1 in 50 year return period easterly storm

4.4 Sediment Transport

The sediment transport regime is driven by a combination of the littoral currents (combination of tidal, wind and wave driven currents), waves and the nature of seabed sediments (predominantly sand, (Seagreen, 2012, Chapter 7: Physical Environment)). As noted previously there is a general drift from north east to south west at Carnoustie, due to the combination of the tidal eddy and the wave driven currents. However, there are also significant wave driven currents along the shore to the north east of Carnoustie, mostly along the rock shelf on which the waves break. Thus, as a result of the difference in these two flows, it can be deduced that the amount of sediment moving along this section of the shore towards the beach to the south of Carnoustie is limited.

While there is sufficient sediment transport to maintain the beach around the mouth of the Barry Burn, there is a slight deficit in the sediment supply during storms, when sediment will be dragged offshore by the steep breaking storm waves. In a given dune beach system, it is generally understood that dunes will erode during storms, therefore sand is fed on to the beach (due to the storm waves pulling sediment away from the dunes or due to wind blowing sand from the dunes onto the beach) to replenish the sand pulled offshore. During the subsequent calmer weather sand can then return to the beach and dunes through the action of swell waves and wind transport. However, it is also understood that if a rock revetment is installed along the dunes, as is the case along the Carnoustie beach, the normal interaction between beach and dune is interrupted. If there is no alternative source of sand to maintain the beach during storm events, then the beach will be progressively lowered allowing larger waves to erode the rock revetment and further lower the beach, in a feedback mechanism.

4.5 Summary of Findings

The review of the coastal processes has identified the following key points:

- Tidal drift at the site is from north to south;
- The wave climate for the larger waves is dominated by waves from the North East and the East to East South East;
- The longshore current is from north east to south west;
- The beach is exposed to a fairly strong wave climate even during typical annual storm events; and
- General sediment transport is north east to south west, however there are also wind driven currents observed, that drive local sediment transport to the north east.

5 BEACH LEVELS AND COVER OF HDPE PIPES

5.1 Beach Profiles and Changes in Beach Levels

HR Wallingford undertook beach surveys and level change assessments at Barry Sands in 1990 for the MoD site that lies immediately to the south of the proposed landfall site (the Barry Buddon firing range complex, PEXA D604) (HW Wallingford, report EX2201, 1991). This assessment examined survey profiles over the period 1979 – 1990 and used these to develop a rate of beach level decline which included the effect of a rock revetment which was in place over the northern section of their study area during the study period. Through review of data collection and discussion with Angus Council (see Section 2.1) this is considered the latest available beach profile data for the area.

The locations of the available beach profiles are shown in Figure 5.1.

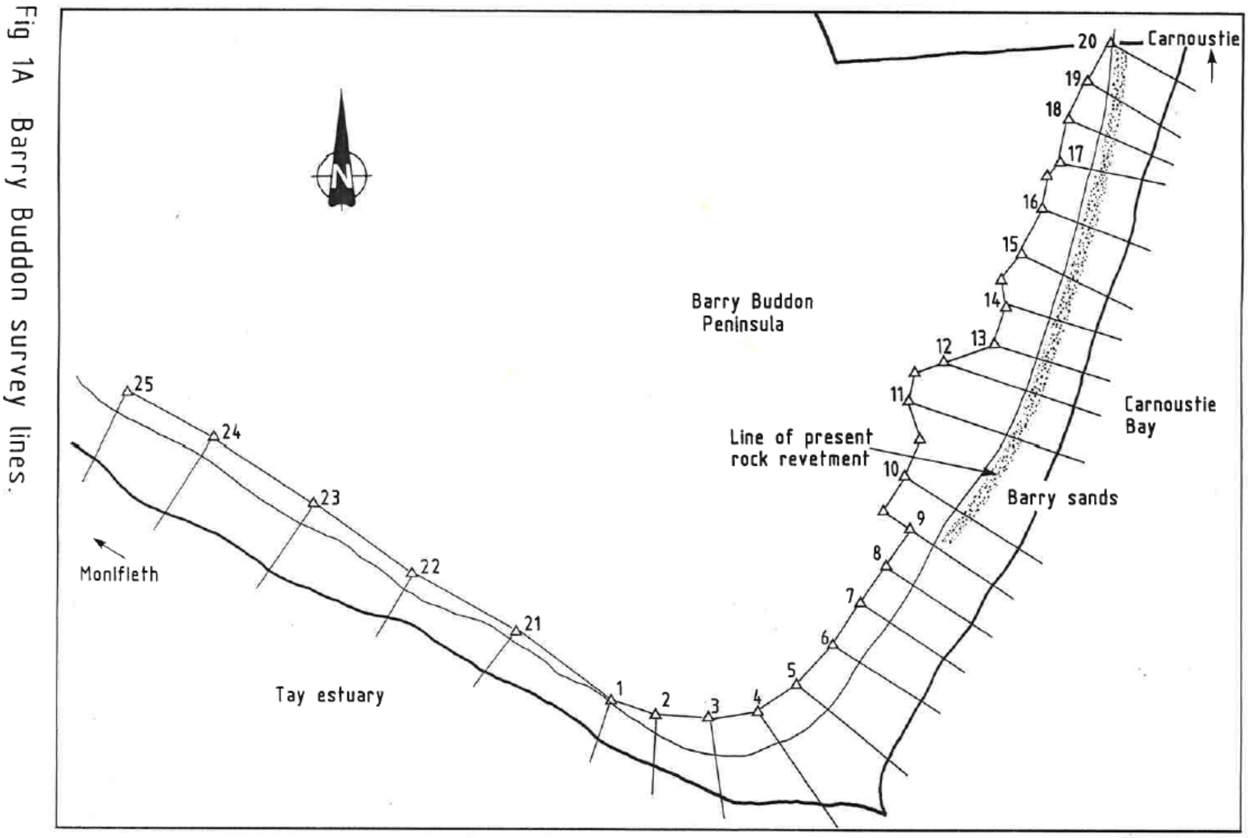


Figure 5.1: Survey locations from HR Wallingford report

Of the profiles assessed by HR Wallingford, profiles 19 and 20 are the closest to the proposed landfall and are therefore considered to be the most relevant profiles to inform this study. Beach profile surveys for profile 19 is shown in Figure 5.2 and beach profile surveys for profile 20 is shown in Figure 5.3. It should be noted that the profile levels are given to Ordnance Datum (OD) which is some 2.9 metres above Chart Datum (CD) at Carnoustie. Both Figure 5.2 and Figure 5.3 show a gradual decrease in beach profile over the available time series.

The HR Wallingford (1991) report also provided estimated beach lowering rates based on the profiles collated between 1979 and 1990. This is shown in Figure 5.5. It is noted that while this data identifies historical beach lowering rates in the period immediately after the rock revetment was installed, it does not provide an accurate estimate of current beach lowering rates. However, the data does provide an estimate that can be utilised in projecting forward to understand present beach lowering rates.

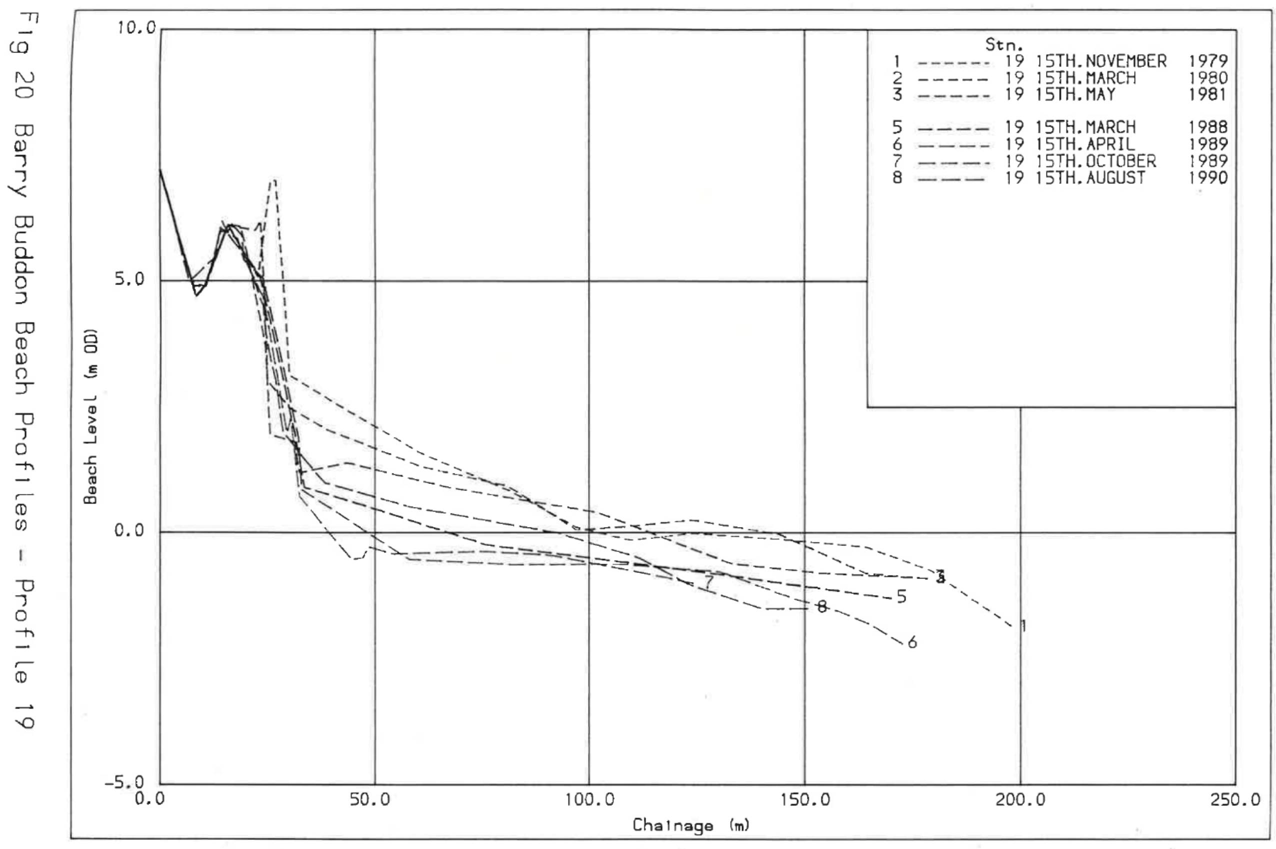


Figure 5.2: HR Wallingford surveyed profiles 1979 to 1990 for Beach Profile 19

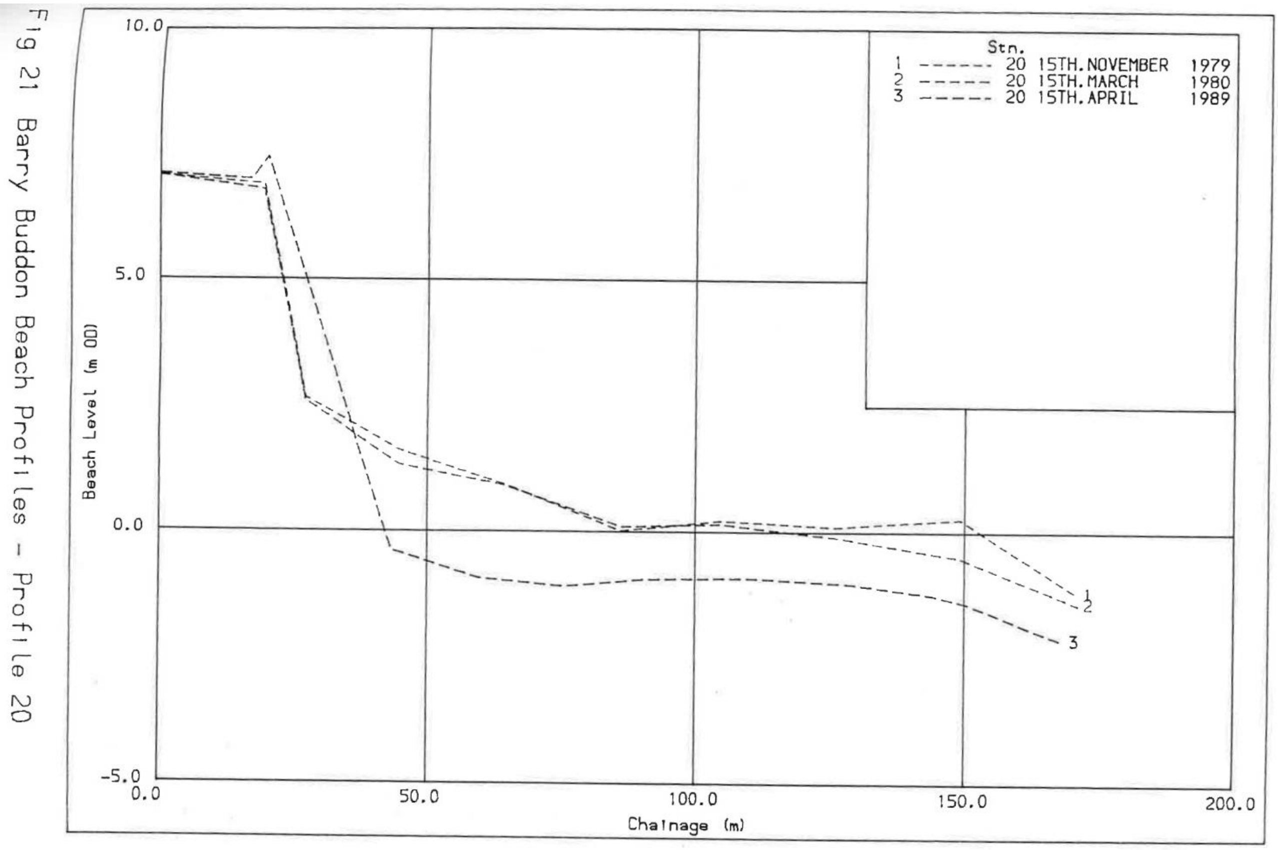


Figure 5.3: HR Wallingford surveyed profiles 1979 to 1989 for Beach Profile 20

As presented by these profile surveys, by 1989 the level of the beach at the toe of the rock revetment was typically between about +0.5m and -0.5m to OD (+3.4 to 2.4m CD). The drawn down profile consisted of a relatively short (approximately 30m) steeper slope coming away from the toe of the structure and then a wider flat section of about 75 m in width at a level of about 0.5m below the toe. These profiles are consistent to that of the beach slope photographed during a very low tide in February 2019, shown in Figure 5.4.

Figure 5.4: Photo of Low Water at Landfall Location on 20th February 2019, water level 0.78 m CD

The beach level at the toe of the revetment has been estimated based on the water level at the time of the photo was taken. Based on this assessment the beach level at the toe of the rock revetment is approximately +1.0m CD. Based on this estimate, the decline in the beach level over the period 1989 to 2019 is in the range 2.4 m to 1.4 m, which provides an average beach lowering rate of 0.08 m/year. This figure compares favourably with the HR Wallingford upper bound estimate of 0.111m/year shown in Figure 5.5. The estimated beach lowering rates provide good comparison and are therefore considered to provide a good estimate of potential beach lowering rates for the area of Carnoustie, particularly over such an extended time period.

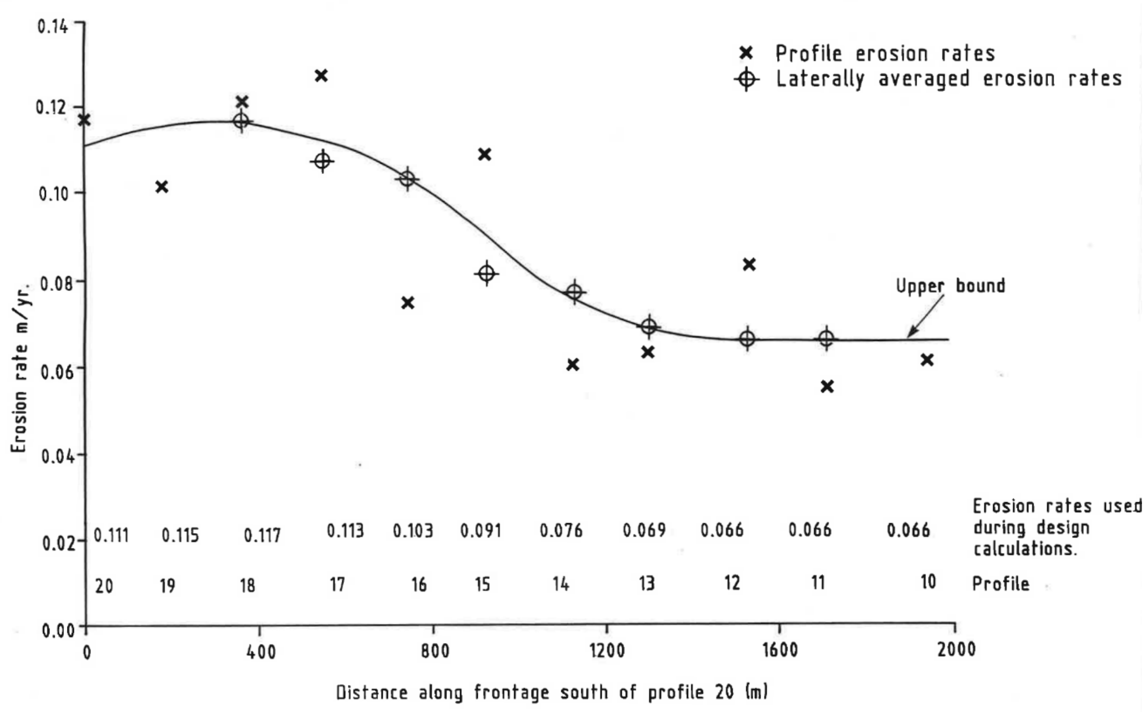


Figure 5.5: HR Wallingford derived (1990) beach lowering rates from profile surveys 1979-1990

5.2 HDPE Pipe Burial Depth and Potential Exposure

As part of the alternative cable installation methodology, Seagreen proposes to install up to three cables, either in a single large trench or three smaller trenches across the intertidal area out to the -2.5m LAT contour to a depth of 3 m below the current beach levels (refer to Section 1.2). The diameter of the High Density Polyethylene (HDPE) pipes in which the cables will be installed is approximately 0.8 m giving a cover depth at 2019 beach levels and within a 3m deep trench of 2.2 m. If the beach levels continue to lower at the average beach lowering rate estimated over the last 30 years (0.08 m/year), (an average of 2.0 metres over 25 years) then the HDPE pipes will not become exposed over the lifetime of the installation.

However, it is possible that, due to the effects of climate change and potential increased storminess (i.e. the frequency and severity of storms), the rate of beach lowering may increase to a rate similar to, or greater than the upper bound values derived by HR Wallingford (1991). Should the upper bound of the HR Wallingford (1991) report for beach lowering be used (0.11m/yr), the risk of exposure of the cables is reduced to approximately 18 years. In view of the uncertainty regarding the future rate of beach lowering, it is proposed that the HDPE pipes installed beneath the beach should be monitored on an annual basis during the operation of the projects and the HDPE pipes re-buried if they become exposed due to an increased rate of beach lowering.

In its EIA Screening response, SNH also requested that rock armour to protect the HDPE pipes should be considered. However, due to the coastal process that are present across this area, the use of rock armour protection of the ducts on the surface of the beach is not recommended. The resulting structure has the potential to act as a groyne and could affect the beach levels to the south of the cable landfall area. Should rock armour be used, perpendicular to the shore, it will interrupt the sediment flow from north to south and affect the coastal processes that occur across the beach when the beach is covered with water. Should a rock armour structure be put in place this could result in an excess of sediment building up behind the rock and a shortage of sediment in front of the rock, further increasing the risk of beach erosion and potentially resulting in an increase in lowering of the beach profile at a greater rate to the south of the rock armour structure. Burial of the cable has the least impact on the environment as below the level of the beach it will not affect coastal processes that occur along the beach and will not interfere with sediment transport. While the potential remains for the HDPE pipes to become exposed during the lifetime of the project, annual monitoring of the HDPE pipes and re-burial should they become exposed will mitigate any risk. This will be a more appropriate mitigation than the introduction of a more permanent structure above the level of the beach which could affect coastal processes over a much longer period of time and may exacerbate any lowering of the beach profile.

As noted in Section 3, the beach is exposed to a fairly strong wave climate even during typical annual storm events. Thus, there is a risk that the top layer of the sand may liquefy for part of the time during the passing of each individual storm wave. This could result in the HDPE pipes being gradually floated up to the surface of the beach once the cover depth has reduced and result in a premature exposure of the ducts. It is therefore proposed that the ducts should be weighted with collars in the intertidal region, to prevent any risk of being pumped up to the surface of the beach by storm wave action. The use of such collars is noted in the Environmental Report, to which this Assessment is appended.

6 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Findings

This Assessment comprises a desk-based review of historical data regarding the shoreline alignment at the proposed cable landfall location at Carnoustie. This Assessment has been undertaken further to a consultation response received from SNH as part of the screening process undertaken for a Marine Licence application for an alternative cable landfall for the Seagreen OTA landfall at Carnoustie. The results of the Assessment indicate that there was a gradual retreat of the shore line at this location until 1938 after which no further data was collected prior to the installation of a rock revetment coastal defence constructed along the dune line in 1978 (see Wright, 1981, SNH, 2011). The construction of the rock revetment effectively locked the shoreline in its current position.

The coastal processes, driving sediment exchange and sediment erosion at the site have been identified. The foreshore at the landfall site is exposed to a relatively strong storm wave climate with the wave heights being controlled by the water depth across the intertidal area. The net sediment drift at the site is from north to south. However, there is a slight deficit in the sediment supply due to the supply from the dunes (during storm events) being blocked by the presence of the rock revetment. Combined with the removal of sediment from the beach during storm events and from sediment transport processes in Carnoustie Bay this has led to a gradual reduction in the beach levels in front of the rock revetment.

Current beach levels have been compared to those surveyed by HR Wallingford over the period 1979 to 1989. Based on photographic evidence and the HR Wallingford (1991) study of beach profiles in the vicinity of the landfall, it is estimated that the average annual decline in the beach level since 1989 is approximately 0.08 m per year. This rate compares well with the HR Wallingford (1991) upper bound estimate of 0.11 m per year. Assuming that the present rate of beach lowering continues then the buried HDPE pipes will not be exposed over the lifetime of the Seagreen project.

However, due to the uncertainty of future climatic conditions, the beach levels over the HDPE pipes should be regularly monitored during the operation of the projects. Annual monitoring of the HDPE pipes at the landfall is recommended to ensure they remain buried and do not become exposed. If the HDPE pipes do become exposed then re-burial to a suitable depth for the remaining lifetime of the project will be undertaken.

The option of using rock armour protection is not recommended as the resulting structure would reduce the sediment supply to the south of the site and could potentially affect coastal processes to a greater extent, particularly to the south of any structure. Annual monitoring of the HDPE pipes and re-burial is a more appropriate mitigation in this instance.

There is a risk that if the cover to the HDPE pipes reduces, for instance as a result of increased storm events, that the sand could liquefy under severe wave action and result in the HDPE pipes gradually floating up to the surface of the beach. This risk will be mitigated by installing weighed collars along the ducts to prevent floatation.

6.2 Recommendations

As a result of this beach lowering assessment, the following recommendations have been made:

1. A topographic survey will be carried out to identify and map the contours of the seabed, beach and rock revetment prior to construction. Following reinstatement, a repeat topographical survey will be carried out to confirm that the original profiles and bathymetry have been restored.
2. The beach and adjoining sea bed levels along the line of the proposed cable landfall trench should be monitored on an annual basis during the operation of the projects, to ensure that there is adequate cover to the HDPE pipes to prevent the risk of pipe exposure.

3. In the event that the beach levels drop faster than anticipated and there is a risk that the HDPE pipes will be exposed, then the HDPE pipes will be reburied.
4. Due to potential long term affects to coastal processes and sediment transport on the beach, reburial is preferred to rock armour protection.
5. Weighted collars or other means should be used to prevent the risk of the HDPE pipes being floated up to the surface of the beach due to storm wave induced liquefication.

7 REFERENCES

Seagreen (2019). Seagreen Alpha and Bravo Offshore Wind Farms Alternative Landfall Cable Installation Marine Licence Application – Consenting Approach. LF000009-CST-OF-REP-0020

United Kingdom Hydrographic Office (2019). Admiralty Tide Tables – NP201B Volume 1B 2019

HR Wallingford, EX2201 (1991) “Barry Buddon Ranges Design of a Rock Revetment” D Herbert (2 volumes) (24/9/90 AIR 1011)

Seagreen (2012) Seagreen Alpha and Seagreen Bravo Offshore Wind Farms, Environmental Statement. A4MRSEAG-Z-DOC100-SPR-060.

Scottish Natural Heritage (2011) A methodology to assess the causes and rates of change to Scotland’s beaches and sand dunes – Phase 1. SNH Commissioned Report No. 364.

Wright, R. (1981) Beaches of Tayside. Department of Geography, University of Aberdeen, for the Countryside Commission for Scotland. Reprinted 2001 by Scottish Natural Heritage as a Commissioned Report.