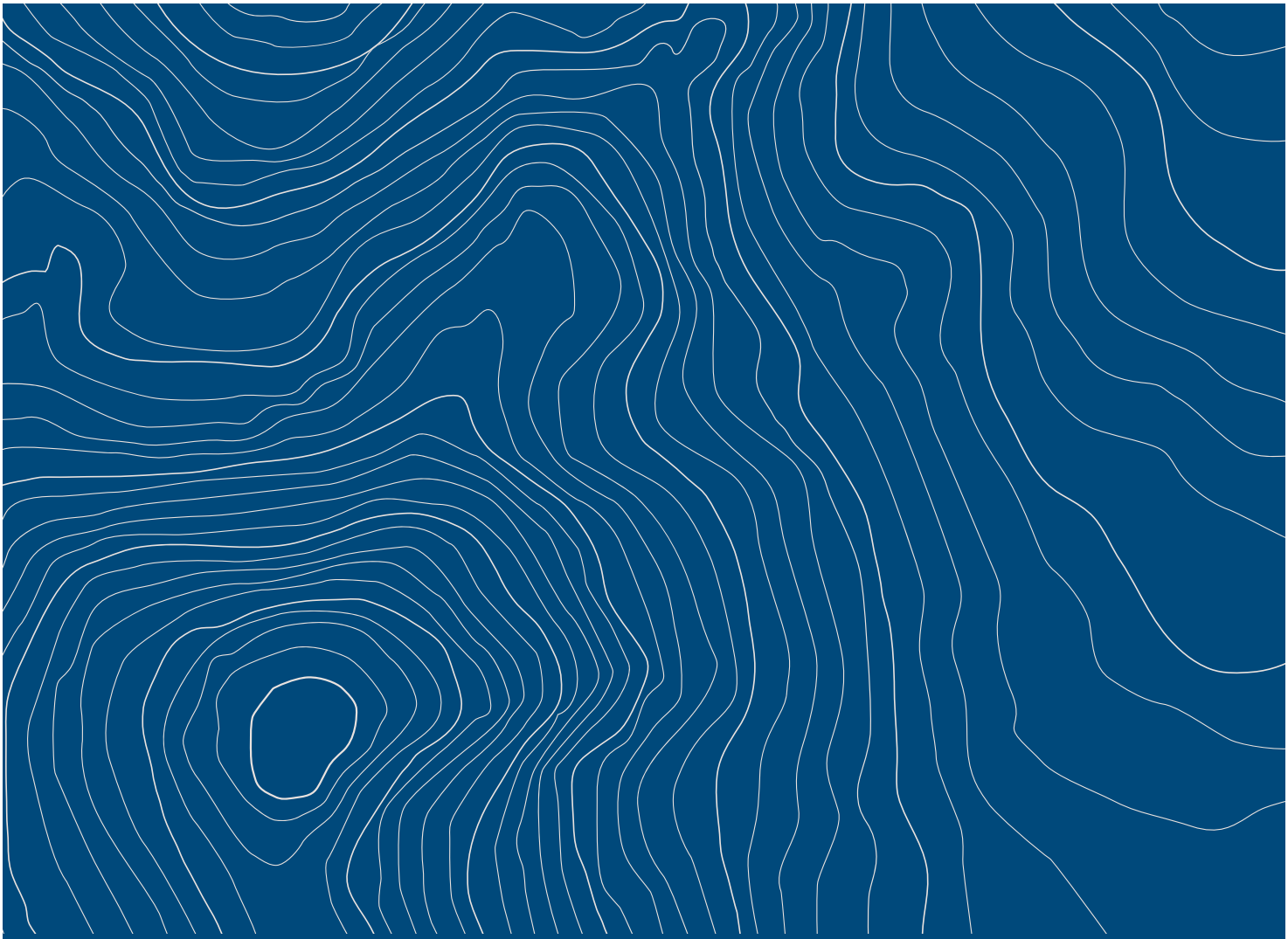

DublinArray
Generation for generations

Part 4: Habitats Directive Assessment Volume 2: Flexibility and Maximum Design Option

Kish Offshore Wind Ltd.

RWE SLR GoBe
APEM Group

www.dublinarray-marineplanning.ie

Dublin Array Offshore Wind Farm

Habitats Directive Assessment

Volume 2: Flexibility and Maximum Design Option

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Acronyms

Term	Definition
AA	Appropriate Assessment
ABP	An Bord Pleanála
Dublin Array	Dublin Array Offshore Wind Farm
MAC	Maritime Area Consent
MAPA	Maritime Area Planning Act 2021
MARA	Maritime Area Regulatory Authority
Maximum DS	Maximum Design Scenario
Minimum DS	Minimum Design Scenario
NIS	Natura Impact Statement
O&M	Operations and maintenance

Glossary

Term	Definition
An Bord Pleanála (ABP)	Competent authority as defined by the Planning Acts to determine the application for development consent for Dublin Array and carry out the EIA and AA of the proposed development.
Applicant	Kish Offshore Wind Limited. Kish Offshore Wind Limited is making the application on behalf of and/or with the consent of the joint holders of the MACs for the maritime area to which the proposed development relates: Kish Offshore Wind Limited, Bray Offshore Wind Limited and DLRCC.
Design Flexibility Opinion	An opinion issued by An Bord Pleanala under section 287A of the Planning Acts, setting out the details which may be unconfirmed in the application for development consent,
Application for Development Consent	The planning application to An Bord Pleanála for the construction, operation and decommissioning of Dublin Array under Section 291 of the Planning Act
Maritime Area Consent (MAC)	State consent which grants the holder a right to occupy a specific part of the maritime area for the purposes of a proposed maritime usage as set out in the MAC and subject to such conditions (if any) as may be attached.

1 Introduction

1.1.1 Dublin Array Offshore Wind Farm (Dublin Array) is a proposed offshore wind farm on the Kish and Bray Banks. The full project description is set out in Volume 1 of the Habitats Directive Assessment. The planning application is being submitted to ABP under Section 291 of the Planning and Development Act 2000 (as amended) ("**Planning Act**").

1.2 Design Flexibility

1.2.1 In accordance with section 287A of the Planning Act, the Applicant requested a meeting with ABP on the details of the proposed development that would be unconfirmed in the application for permission under section 291 of the Planning Act.

1.2.2 The Opinion of ABP under section 287B of the Planning Act ("Flexibility Opinion") is included in Part 1A Planning Particulars, Schedule 10, of the planning application. The Flexibility Opinion confirms that the application under section 291 may be made and decided before the Applicant has confirmed certain details of the proposed development. These details are summarised in the table below:

Table 1 Summary of Design Flexibility Opinion

Primary Requirement	Associated Flexibility
Wind Turbine Generator (model)	Number of turbines Maximum rotor diameter Minimum rotor diameter Maximum blade tip height Lower blade tip height
Offshore Substation Platform	Height (m above LAT) Width Length
Array Layout (wind turbine generators and offshore substation platform)	Layout Options Locational Limits of Deviation
Foundation Type and Dimensions (wind turbine generator and offshore substation platform)	Foundation types and dimensions Foundation Scour Protection techniques
Offshore Cables (inter-array and export cables)	Length and layout Locational Limits of Deviation

1.2.3 Under section 293(4) of the Planning Act, ABP may attach such conditions to the permission as it considers appropriate. Furthermore, under section 293(4A), ABP must attach one or more conditions relating to the Flexibility Opinion provided under section 287B. These conditions require the final details of the development to remain within the options and parameters specified in the application, ensuring consistency with the Flexibility Opinion provided. Furthermore, the developer must notify ABP of these details prior to the commencement of the development or the specific part of the development to which the details apply.

1.3 Approach to Maximum and Alternative Design Options

1.3.1 To ensure a robust, coherent, and transparent assessment of the proposed Dublin Array project for which development consent is being sought, inclusive of the details which are the subject of the Flexibility Opinion, the Applicant has identified and defined a Maximum Design Option (MDO) and Alternative Design Option(s) (ADO), relevant to each effect, for the purpose of assessing against.

- The MDO represents the design / combination of details which will give rise to the *greatest magnitude of effect*. The MDO is chosen, having regard to the effect in question. For example, the greatest noise effect may be generated by design option A relevant to marine mammals and fish, whereas the greatest effect associated with habitat loss (from seabed preparation) may be generated by design option B. Hence, the MDO may be different depending on the effect in question. Importantly, the MDO always represents the design / combination of details which will give rise to the greatest magnitude of effect.

- The ADO represents the design / combination of details which will give rise to the lowest magnitude of effect.

1.3.2 Both the MDO and ADO represent (a) the design details subject to flexibility, and (b) the confirmed details, so that the full project is assessed in the SISAA and NIS.

1.3.3 Accordingly, the SISAA and NIS represent a comprehensive environmental assessment of *all aspects* of the project which could, either alone or in combination with other plans or projects, give rise to (a) likely significant effects on European sites, in view of their conservation objectives, (which analysis is contained within the SISAA) and (b) adverse effects on the integrity of the European sites screened in, in view of their conservation objectives, (which analysis is contained within the NIS).

1.3.4 For clarity, having regard to the precautionary approach taken to defining the MDO and ADO, the Applicant confirms that the following:

1.3.5 Insofar as Stage 1 AA is concerned, the SISAA identifies all aspects of the project which could, either alone or in combination with other plans or projects, give rise to likely significant effects on European sites, in view of their conservation objectives, and in respect of each likely significant effect identified, it considers the greatest magnitude of the effect that could occur.

1.3.6 Insofar as Stage 2 AA is concerned, the NIS identifies all aspects of the project which could give rise to adverse effects on the integrity of the European sites screened in, in view of their conservation objectives. It concludes that no adverse effects are likely. It does so having considered the greatest magnitude of the effect that could occur.

1.3.7 No effects of greater magnitude, or other likely significant effects, or other adverse effects on integrity, than those which have been assessed can arise from the project.

Table 2 Maximum Design Option and Alternative Design Options

Maximum design option	Alternative design options	Justification
Construction		
Underwater noise		
Underwater noise from pile driving **Offshore construction programme** Construction period lasting a maximum of **30 months**. Spatial MDO: WTG Monopiles - Max pile diameter: 13 m - Max hammer energy: 6,372 kJ - One monopile foundation installed in a 24-hour period OR WTG pin-piles - Max pile diameter: 5.75 m - Max hammer energy: 4,695 kJ - Four pin-piles installed in a 24-hour period	**Underwater noise from pile driving** **Offshore construction programme** Construction period lasting a minimum of **18 months** or a mean of **24 months** Foundation installation using alternative methods such as drilled piles and suction-installed buckets piles would result in lower underwater noise levels compared to impact pile driving.	The potential impact relates to construction activities that generate underwater noise including piling, cable laying, dredging, drilling, rock placement, trenching, vessel movements, operational WTG noise and unexploded ordnance (UXO) clearance. On this basis the MDO relates the maximum spatial extent of noise propagation generated by largest pile diameter and blow energy imparted on the pile and the longest duration of piling for piling and for all other construction activities the MDO reflects the greatest level of activity spatially and temporally. The justification for MDO is supported through noise modelling of piling activity using the INSIPRE model and use of a model approach that draws upon existing data to quantify other construction activities (methodology and approach outlined within Appendix 4.3.5-7 of the EIAR). The modelling is designed to be precautionary in nature and adopts project specific maximum design parameters and worst-case assumptions for hammer blow energies, strike rate and duration of piling across all options.
Temporal MDO: **WTG pin piles** - Max pile diameter: 5.75 m - Max hammer energy: 4,695 kJ - Max 4 piles installed per day (12 hours active piling time per 24 hours)	**Temporal MDO:** Alternative turbine sizes will result in fewer WTGs installed resulting in fewer piling days compared to the MDO	

Maximum design option	Alternative design options	Justification
Other structures - One offshore platforms - Max hammer energy: 4,695 kJ	As for MDO	To account for local site conditions of relevance to the NIS, modelling for WTG foundation impact piling has been undertaken at two representative locations covering the extents of the Dublin Array site. Of note, the Northeast (NE) location was chosen as the deeper water compared to other locations on the northern boundary and the turbine that would generate the greatest potential for overlap with the Rockabill to Dalkey Island SAC
Underwater noise from geophysical surveys Pre and post construction surveys will be undertaken using a combination of DP and anchored vessels across the array area and offshore ECC. The same surveys will be required for Option A: 50 WTG, Option B: 45 WTG, and Option C: 39 WTGs. Surveys may require the use of the following equipment: - Multi-Beam Echo Sounder (MBES) - Side Scan Sonar (SSS) - Sub Bottom Profiler (SBP) - 2D / 3D UHR Seismic reflection profiling - Seismic refraction - Ultra-short Baseline (USBL) - underwater positioning - Drop-Down Video (DDV) - Magnetometer (MAG) - Passive measurement - Additional survey activities may also be required including Remotely Operated Vehicle (ROV) or diver inspections of cable routes and identified seabed anomalies.	Alternative options include the potential for varying spatial areas requiring survey, however all survey operations of this type will include the equipment listed in the maximum design option and will take place using a combination of DP and anchored vessels across the array area and offshore ECC. Note that the same surveys will be required for Option A: 50 WTG, Option B: 45 WTG, and Option C: 39 WTGs.	

Maximum design option	Alternative design options	Justification
Underwater noise from UXO A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present. The MDO is for up to four high order detonations in the assessment, which could take place anywhere within the array area, offshore ECC and wider temporary occupation area. Only one detonation will take place at any one time.	**Underwater noise from UXO** As for the MDO, the type, size and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present. The alternative design option for UXO disposal involve avoidance of any targets by project routing and micrositing of infrastructure, relocation of UXO to a safe area within the development boundary or in situ detonation using low order. The Alternative Design Option (ADO) will be for up to four low order detonations in the assessment, which could take place anywhere within the array area, offshore ECC and wider temporary occupation area. Only one detonation will take place at any one time.	(See previous page)
For all detonations standard mitigation will be applied (bubble curtain or other suitable alternative). Confirmation of the most appropriate mitigation to be applied will be dependent on the consideration of further site-specific data (including, but not limited to; ground conditions, sea conditions, location of UXO, status of UXO).	For all detonations standard mitigation will be applied (bubble curtain or other suitable alternative). Confirmation of the most appropriate mitigation to be applied will be dependent on the consideration of further site-specific data (including, but not limited to; ground conditions, sea conditions, location of UXO, status of UXO).	
Other construction noise: Noise emitted from construction vessels and arising during construction activities (e.g., cable laying, dredging, rock placement and trenching), consistent with the longest construction programme of 30 months on site.	**Other construction noise**: Noise emitted from construction vessels and arising during construction activities (e.g., cable laying, dredging, rock placement and trenching), consistent with the shortest construction programme of 18 months on site.	

Maximum design option	Alternative design options	Justification
Construction Vessels: Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time. Up to **813** round trips to port from construction vessels and an additional **1,825** round trips from small vessels such as CTVs during construction period.	Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period.	
Collision risk (vessels)		
Full build out of the array area Construction period lasting a maximum of **30 months**	All design option layouts represent similar spatial use of the array area Construction period lasting **18 months**	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk with the larger WTGs resulting in the greater number of vessel movements. The risk of collision with vessels would be directly influenced by the type of vessel and the speed with which it is travelling (Laist et al., 2001). The potential for collision is considered more likely with vessels in transit to/from the site rather than vessels engaged in construction activity (eg jack up vessels), as such the MDO considers the number of round trips to port from all vessels, The MDO represents the option that generates the largest number of vessels transiting to site over the longest construction period.
Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time. Up to **813** round trips to port from construction vessels and an additional **1,825** round trips from small vessels such as CTVs during construction period	Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period.	
Vessel disturbance		
Construction Vessels: Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time. Up to **813** round trips to port from construction vessels and an additional **1,825**	Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period.	As above, the maximum numbers of vessels and associated vessel movements represents the maximum potential for disturbance with the larger WTGs resulting in the greater number of vessel movements transiting to site over the longest construction period

Maximum design option	Alternative design options	Justification
round trips from small vessels such as CTVs during construction period.		
Effects on prey		
Effects on prey may arise where the loss of habitats and the loss/disturbance of invertebrate species and displacement of fish from fishing grounds (and associated effects on reductive success and survival), the MDO for impacts on prey species of fish correlates with that outlined for all other effects identified for migratory species.		
Accidental pollution		
Accidental pollution may result from construction vessels with up to 813 round trips to port from construction vessels and 1,825 round trips from crew transfer vessels during construction period.	Accidental pollution may result from any of the up to 774 round trips to port from construction vessels and 538 round trips from crew transfer vessels during construction period.	The potential impact relates to pollution events as a direct or indirect result of construction, through the physical disturbance of the seabed during cable and foundation installation, that can result in the disturbance of contaminated materials or through accidental spillages from project infrastructure or vessels. For accidental spillages from vessels the MDO relates to the maximum number of vessel movements of any vessel type during construction activities
The number of vessel round trips is based on fewer larger generating capacity WTGs.	The number of vessel round trips is based on the smaller generating capacity WTGs.	
No chemicals (with the exception of drilling mud) are proposed to be discharged into the environment as part of construction activities.	No chemicals (with the exception of drilling mud) are proposed to be discharged into the environment as part of construction activities.	
Physical habitat loss / habitat disturbance		
Seabed preparation prior to foundation installation: - Option B: Up to 45 WTGS - 100% requiring seabed preparation - One OSP	**Dredging prior to foundation installation:** Seabed preparation in advance of foundation installation may not be required at any location. Foundations would be installed onto the seabed in its existing condition and so no dredging or similar methodologies would be employed, therefore resulting in the creation of no SSC plumes. This approach would represent the design option with	Physical habitat loss will be restricted to discrete areas only within the footprint of project infrastructure or temporary works (eg jack up vessels). The MDO aligns with the option that generates the largest footprint associated with seabed preparation and sandwave clearance. The assessment has been considered to ensure all

Maximum design option	Alternative design options	Justification
	the minimum scale of effect, i.e. 0 m^2 of seabed. Alternative options include the potential for varying percentages of locations between 0% and 100% requiring seabed preparation. All seabed preparation operations of this type will take place using TSHD.	impacts associated with direct overlap of SAC and ex situ habitat are captured therefore the MDO with the greatest footprint inherently incorporates the largest area of direct impact relevant.
Jack up and anchoring operations: - Option A: 50 WTGs - WTG/OSP installation jack up vessel (JUV) footprint - 6 jack-up operations required per turbine - WTG/OSP installation of foundation vessel anchor footprints	**Jack up and anchoring operations:** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option. However, lower number of WTGs will reduce the number of operations and reduce the level of seabed disturbance.	
IAC Sandwave Clearance (excluding Sandbank Crossing): Dredging using THSD to undertake sandwave clearance - Total length of IAC = 120 km, up to 50% requiring seabed preparation; - 40 m (maximum width of disturbance)	**IAC Sandwave Clearance (excluding Sandbank Crossing):** Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring sandwave clearance than the MDO resulting in lower area of seabed disturbance. Similarly, lower number of WTGs will have concomitantly reduced overall length of IAC cable.	
IAC Sandbank Crossing Dredging using THSD to undertake sandwave clearance, in two locations with three cables at each site, to allow the IAC cables to cross the sandbank. Maximum area of seabed affected:	**IAC sandbank crossing** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	

Maximum design option	Alternative design options	Justification
6 x 1,000 m crossings, 100% of which requiring seabed preparation;		(See previous page)
IAC Pre-Lay Grapnel Run (PLGR): - 50 m (maximum width pre-sweeping disturbance) - 120 km (length of IAC)	As for the MDO	
IAC Seabed preparation: - 40 m (maximum width of disturbance) - 120 km (length of IACs) - 50% (proportion of array cable length subject to seabed preparation	Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring seabed preparation than the MDO resulting in lower area of seabed disturbance.	
IAC Cable installation - Ploughing: - 12 m (width of seabed disturbance) - 95% of 120 km total length of IAC	**IAC - Cable installation:** Alternative options for cable installation involve the use of different cable installation methodologies including jet trenching, rock cutting and mechanical chain excavating in addition to ploughing and MFE (which are outlined within the maximum design option). **Method**: The alternative option will result in the smallest are of disturbance with simultaneous lay and burial (ploughing).	
IAC Cable installation MFE: - 15 m (width of seabed disturbance) - 5% of 120 km total length of IAC		
Export Pre-Lay Grapnel Run: - 50 m (maximum width seabed disturbance) - 18.35 km (length of cable route B)	As for the MDO	
Export cable seabed preparation: - 40 m (maximum width of seabed disturbance - 18.35 km (length of cable route B) - 70% subject to seabed preparation)	**Export cable seabed preparation** Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring seabed preparation than the	

Maximum design option	Alternative design options	Justification
	MDO resulting in lower area of seabed disturbance.	
Export Cables Dredging using THSD to undertake sandwave clearance - Two cables; - Total length of export cable = 18.35 km, - up to 70% requiring seabed preparation.	**Export Cables** Dredging using THSD to undertake sandwave clearance - Two cables - Total length of export cable = 18.35 km - up to 25% requiring seabed preparation	
Landfall methodology: Trenchless techniques will be used beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. - Drilling punch-out location: Subtidal; - Up to one per cable; - Excavation pits: Up to one per cable; - Maximum excavation pit dimensions: 25 m (long) x 5 m (wide)	**Landfall methodology:** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
Increased suspended sediment and deposition		
Dredging prior to foundation installation: Trailer suction hopper dredger (TSHD). - Option B: Up to 45 WTGs - One Offshore Substation Platform (OSP) requiring seabed preparation	**"Dredging prior to foundation installation:** Alternative options include the potential for fewer locations requiring seabed preparation. All seabed preparation operations of this type will take place using TSHD. Preparation for alternative foundation types and WTG options may also give rise to varying areas of seabed affected and volumes of sediment disturbed, all less than those which arise from the maximum design option "	The potential impact relates to construction activities that generate the greatest level of disturbance to sediments arising in sediment plumes and sediment deposition. For all construction activities listed, the MDO represents the largest volume of fine sediments released into the water column over the shortest interval which then has the potential for greatest volumes of SSC within a plume that advects away from the point of discharge

Maximum design option	Alternative design options	Justification
100% of WTGs requiring seabed preparation	"Alternative options include the potential for varying percentages of locations requiring seabed preparation. All seabed preparation operations of this type will take place using TSHD. Preparation for alternative foundation types and WTG options may also give rise to varying areas of seabed affected and volumes of sediment disturbed, all generating less SSC than the maximum design option.	The justification for MDO is supported through site specific modelling that includes a Hydrodynamic (HD) model, a Spectral Wave (SW) model and a Particle Tracking (PT) model. To assess the construction impacts of the offshore infrastructure for Dublin Array the PT model is used driven by the underlying hydrodynamics derived from the calibrated HD model methodology and approach outlined within Appendices 4.3.1-2, 4.3.1-3 and 4.3.1-4 of the EIAR).
Disposal: For all options where seabed preparation prior to foundation installation will take place, the material is dredged by a TSHD.	**Disposal:** For all options where seabed preparation prior to foundation installation will take place, the material is dredged by a TSHD with drilling spoil released at, or above the water surface.	
Foundation installation Option C: 39 WTGs with four-legged jacket foundations; Jacket pin-piles foundations for one OSP Drilling required at 100% of foundations	**Foundation installation** There will be no drill arisings generated with foundation installation using driven piles and vibro-piles. This approach would not result in the creation of any SSC plumes and would therefore represent the minimum scale of effect. Alternative options include the potential for varying percentages, less than 50%, of foundation locations requiring drilling.	

Maximum design option	Alternative design options	Justification
IAC - Cable Installation: - Inter-array cable: 120 km maximum total length. Although the total length may be less than this, depending on final routeing options yet to be decided, the total value will not exceed 120 km. **- Method**: ploughing of a V shaped trench 12m width x 3m depth; -Controlled displacement of sediment onto the seabed with approximately 15% of sediment ejected from trench; - **Method**: mass flow excavator (MFE); Assumes up to 100% of material elevated above the seabed with up to two backfill passes expected (for spoil mounds either side of the trenches).	**IAC - Cable installation:** Alternative options for cable installation involve the use of different cable installation methodologies including jet trenching, rock cutting and mechanical chain excavating in addition to ploughing and MFE (which are outlined within the maximum design option). **Method**: The alternative option will result in the smallest volume of fine sediment release into the water column is simultaneous lay and burial (ploughing).	(See previous page)
IAC - Sandwave Clearance (excluding Sandbank Crossing): - Method: TSHD - Total length of IAC = 120 km, - Up to 50% requiring seabed preparation; - 40 m (maximum width of disturbance);	**IAC (excluding Sandbank Crossing)** -Method: THSD - Total length of IAC = 120 km, - Up to 25% requiring seabed preparation; - 40 m (maximum width of disturbance)	
IAC - Sandbank Crossing Method: TSHD Dredging to be undertaken for sandwave clearance across the Kish and Bray sandbanks at two locations with three cables at each site, to allow the IAC cables to cross the sandbank. 6 X 1000 m crossings with 100% requiring seabed preparation	**IAC: Sandbank Crossing** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	

Maximum design option	Alternative design options	Justification
Export Cables Dredging using THSD to undertake sandwave clearance and disposal - Two cables; - Total length of export cable = 18.35 km; - up to 70% requiring seabed preparation.	**Export Cables** Dredging using THSD to undertake sandwave clearance and disposal - Two cables; - Total length of export cable = 18.35 km; - Up to 25% requiring seabed preparation.	(See previous page)
Landfall methodology: Trenchless installation (via HDD or direct pipe) beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. Excavation pits to be excavated and reinstated using back hoe dredge. Material will be stored to minimise loss of sediment as far as is reasonably practicable. - Drilling punch-out location: Subtidal; - Up to one per cable: - Excavation pits: Up to one per cable; -Maximum excavation pit dimensions: 30 m (long) x 5 m (wide) x 2.5 m (depth).	No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
"Use of drilling fluid (landfall): Trenchless installation The drilling fluid is anticipated to be a low concentration bentonite/water mixture. Drill exit head to will stop short of punch out, flush bentonite, and complete the final 10 m in order to mitigate bentonite release on punch out.	No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	

Maximum design option	Alternative design options	Justification
Introduction of invasive species		
Up to 813 round trips to port from construction vessels and an additional 1825 round trips from small vessels such as CTVs during construction period.	Up to 774 round trips to port from construction vessels and an additional 538 round trips from small vessels such as CTVs during construction period	The movement of construction vessels and other project traffic to and from site has the potential to impact upon species and habitats by contributing to the risk of introduction or spread of invasive alien species. On this basis, the MDO relates to the maximum number of vessel movements of any vessel type during construction activities.
Disturbance (non-physical)		
Array Area and Temporary Occupation Area **Construction period:** Maximum of **30 months**.	**Array Area and Temporary Occupation Area** **Construction period:** Minimum of **18 months.**	The spatial area where disturbance and displacement could arise is consistent for all scenarios with activity ongoing across the array area, and temporary occupation area. Temporal extent: The longest construction period will lead to the greatest period of disturbance and therefore the maximum design option results in the greatest displacement.
Full build out of the array area. Option A: 50 WTGs, and one OSP	All design option layouts represent similar spatial use of the array area. Option B: 45 WTGs and one OSP; or Option C: 39 WTGs and one OSP.	Applying the alternative design option would result in impacts that are the same or less than impacts associated with the maximum design option.
Buoyed construction area around array area.	All design scenario layouts may entail similar buoyed construction areas given similar build out scenarios.	

Maximum design option	Alternative design options	Justification
Jack up and anchoring operations: - Option A: 50 WTGs - WTG/OSP installation jack up vessel (JUV) footprint - 6 jack-up operations required per turbine - WTG/OSP installation of foundation vessel anchor footprints Construction vessels will comprise of installation vessels and smaller support vessels. Installation vessels include those for foundation, WTG and OSP installation and cable lay vessels. The foundation, WTG and OSP installation vessels will include cranes, which when fully extended will be **220 m** in height. Up to three large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time.	**Jack up and anchoring operations:** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option. However, lower number of WTGs will reduce the number of operations and reduce the level of seabed disturbance. Construction vessels will comprise of installation vessels and smaller support vessels. Installation vessels include those for foundation, WTG and OSP installation and cable lay vessels. The foundation, WTG and OSP installation vessels will include cranes, which when fully extended will be **220 m** in height. Up to three large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time; and	(See previous page)
Up to **813** round trips to port from construction vessels and an additional **1,825** round trips from small vessels such as CTVs during construction period (CTVs likely to be to/from Dún Laoghaire).	Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period (CTVs likely to be to/from Dún Laoghaire).	
<u>Offshore ECC</u>	**<u>Offshore ECC</u>** All crew transfers undertaken by vessel.	Temporal extent: The longest construction period will lead to the greatest period of disturbance and therefore the maximum design option results in

Maximum design option	Alternative design options	Justification
Use of helicopter for crew transfer to 3 installation vessels, with 2 flights occurring to each vessel every two weeks		the greatest displacement. Applying the alternative design option would result in impacts that are the same or less than impacts associated with the maximum design option.
Export cable seabed preparation: - 40 m (maximum width of seabed disturbance) - 18.35 km (maximum length of one cable; cable route B) x 2 cables - 70% subject to seabed preparation)	**Export cable seabed preparation** Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring seabed preparation than the MDO resulting in lower area of seabed disturbance.	
Export Pre-Lay Grapnel Run: - 50 m (maximum width seabed disturbance) - 18.35 km (maximum length of one cable; cable route B) x 2 cables	As for the MDO	
<u>Intertidal Study Area</u> **Landfall methodology**: Trenchless installation beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. Excavation pits to be excavated and reinstated using back hoe dredge. Material will be stored to minimise loss of sediment as far as is reasonably practicable.	**<u>Intertidal Study Area</u>** **Landfall methodology:** No alternative options have been considered for this operation, as trenchless techniques are considered the most appropriate option.	Temporal extent: The longest construction period will lead to the greatest period of disturbance and therefore the maximum design option results in the greatest displacement. Applying the alternative design option would result in impacts that are the same or less than impacts associated with the maximum design option.

Maximum design option	Alternative design options	Justification
Landfall methodology: Trenchless techniques will be used beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. - Drilling punch-out location: Subtidal; - Up to one per cable; - Excavation pits: Up to one per cable; - Maximum excavation pit dimensions: 25 m (long) x 5 m (wide)	**Landfall methodology:** No alternative options have been considered for this operation, as trenchless techniques are considered the most appropriate option.	(See previous page)
Use of drilling fluid (landfall): Trenchless installation The drilling fluid is anticipated to be a low concentration bentonite/water mixture. Drill exit head to will stop short of punch out, flush bentonite, and complete the final 10 m in order to mitigate bentonite release on punch out. For the purposes of the assessment this is assumed to be an instantaneous release as this is the most conservative assumption for the purposes of the study/assessment model.	**Landfall methodology:** No alternative options have been considered for this operation, as trenchless techniques are considered the most appropriate option.	

Maximum design option	Alternative design options	Justification
Operation and Maintenance		
Vessel disturbance		
O&M vessel noise Potential vessels: O&M vessel, SOV, CTV, lift vessel/ jack-up vessel, cable maintenance vessel, auxiliary vessels (e.g. survey vessels, tugs, cargo vessels, passenger vessels, scour replacement vessels etc)	**O&M vessel noise** Potential vessels: O&M vessel, SOV, CTV, lift vessel/ jack-up vessel, cable maintenance vessel, auxiliary vessels (e.g. survey vessels, tugs, cargo vessels, passenger vessels, scour replacement vessels etc)	As for construction, the maximum numbers of vessels and associated vessel movements represents the maximum potential for disturbance (round trips to port from routine and unplanned O&M vessels)
Three daily CTV trips with the addition of up to **100** vessels trips to support scheduled routine and non-routine maintenance per year.	**2** daily CTV trips with the addition of up to **75** vessels trips to support scheduled routine and non-routine maintenance	
Collision risk (Vessels)		
As above for vessel disturbance	As above	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk with the larger WTGs resulting in the greater number of vessel movements. The risk of collision with vessels would be directly influenced by the type of vessel and the speed with which it is travelling (Laist et al., 2001). The potential for collision is considered more likely with vessels in transit to/from the site rather than vessels engaged in O&M activity (e.g. jack up vessels), as such the MDO considers the number of round trips to port from all vessels,
Disturbance and displacement (bird QIs only)		
Lifetime of the proposed development: 35 years (operating life)	**Lifetime of the proposed development:** 35 years (operating life)	The MDO for disturbance and displacement will arise from the presence of the greatest number of vessels on site and the presence of the greatest
Three daily CTV trips with the addition of up to **100** vessels trips to support scheduled routine and non-routine maintenance per year.	Two daily CTV trips with the addition of up to **75** vessels trips to support scheduled routine and non-routine maintenance.	

Maximum design option	Alternative design options	Justification
Full build out of the array area.	All design option layouts represent similar spatial use of the array area.	number of infrastructure. Evidence from existing offshore wind farms indicates that if there is displacement that it will be limited to within 2 km of the wind farm boundary for the majority of species of concern for the development. For red-throated diver, UK SNCB advice is to consider potential displacement effects out to 10 km from the array area, while for great northern diver and common scoter, advice is to consider displacement effects out to 4 km and this has been applied here (SNCBs, 2022a&b).
Option A: 50 WTGs, and one OSP, comprising **51** structures.	Option B: 45 or Option C: 39 WTGs and one OSP, comprising **46** or **40** structures	
For displacement, the assessment is based on displacement occurring over the array area and out to 2 km, for most seabird species.	The alternative design options will have the same scale of effects as the MDO, as displacement assessment considers the whole of the array area and surrounding buffers.	
For common scoter and great northern diver, a combined array area plus 4 km buffer was applied while for red-throated diver, a combined array area plus 10 km buffer was applied.		
Physical habitat loss and disturbance		
Lifetime of the proposed development: 35 years (operating life)	**Lifetime of the proposed development:** 35 years (operating life)	Physical habitat loss will be restricted to discrete areas only within the footprint of project infrastructure or temporary works (eg jack up vessels). The MDO aligns with the option that generates the largest footprint associated with seabed preparation and sandwave clearance. The assessment has been considered to ensure all impacts associated with direct overlap of SAC and ex situ habitat are captured therefore the MDO with the greatest footprint inherently incorporates the largest area of direct impact relevant.
The WTG/OSP foundation and scour protection: - Option B: 45 foundations with 4 suction feet multileg WTGs presents the largest turbine foundation footprint with scour protection; - OSP maximum scour protection area for site	**WTG/OSP foundation and scour protection:** Alternative foundation types and WTG options will give rise to varying areas of scour protection, all less than the maximum design option. Option C: 39 WTGs with monopile foundations presents the minimum scour protection area	
IAC cable protection Cable protection measures secured to the seabed if considered necessary and subject to license approval; - Length of IAC cable requiring additional protection where optimum burial is not achieved = 24.6 km; - Total footprint of all IAC cable crossings includes footprint of the berm and mattresses x two crossings.	**IAC Cable protection:** Cable protection measures may not be required at any location, if the desired burial depth is achieved at all points. This approach would represent the design option with the minimum scale of effect. Alternative options include the potential for varying percentages of the cable routes to require cable protection, ranging from 0% up to that assessed as the maximum design option. Alternative options for cable crossings include the	

Maximum design option	Alternative design options	Justification
	use of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option.	(See previous page)
Export cable protection: - Maximum footprint of cable protection = 12 km (up to 6km per cable) - Total footprint of all export cable crossings includes footprint of the berm and mattresses x six crossings	**Export cable protection:** The alternative option involves no cable protection required; Cable protection measures may not be required at any location, if the desired depth of cover is achieved at all points. This approach would represent the design option with the minimum scale of effect. Alternative options include the potential for varying percentages of the cable routes to require cable protection, ranging from 0% up to that assessed as the maximum design option	
Cable crossings - Assumes a maximum of two cable crossings of Dublin Array cables; - Assumed to be constructed of both concrete mattresses (six per crossing) and rock berm	**Cable crossings:** Alternative options for cable crossings include the use of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option.	
Permanent vessel moorings Two moorings permanently moored to the seabed	**Permanent vessel moorings** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	

Maximum design option	Alternative design options	Justification
Effects on prey		
Effects on prey may arise where the loss of habitats and the loss/disturbance of invertebrate species and displacement of fish from fishing grounds (and associated effects on reductive success and survival), the MDO for impacts on prey species of fish correlates with that outlined for all other effects identified for migratory species.		
Accidental pollution		
Accidental pollution may also result from the three daily CTV trips with the addition of up to 100 vessels trips to support scheduled routine and non-routine maintenance per year.	Accidental pollution may also result from the two daily CTV trips with the addition of up to 75 vessels trips to support scheduled routine and non-routine maintenance.	The potential impact relates to pollution events as a direct or indirect result of O&M activity, through the physical disturbance of the seabed during cable repairs, that can result in the disturbance of contaminated materials or through accidental spillages from project infrastructure or vessels. The MDO for disturbance of contaminated sediments references the MDO outlined above for physical habitat loss as this presents the greatest volume of sediment disturbed. The MDO for accidental spillages is based on the maximum volumes of contaminants which may be contained with the infrastructure during the O&M phase. For accidental spillages from vessels the MDO relates to the maximum number of vessel movements of any vessel type during construction activities
The number of vessel round trips is based on fewer larger generating capacity WTGs.	The number of vessel round trips is based on the smaller generating capacity WTGs.	
No chemicals (with the exception of drilling mud) are proposed to be discharged into the environment as part of construction activities.	No chemicals (with the exception of drilling mud) are proposed to be discharged into the environment as part of construction activities.	

Maximum design option	Alternative design options	Justification
Increased suspended sediment and deposition		
Cable Repairs: - Methodology: remedial burial of cables including rock dumping and / or concrete mattress installation/rock bags installation; - Array and ECC cable repairs 600m (length repaired) x 10 m (trench width) x - 7 (events/lifetime) Array and ECC cable remedial reburial 10 km (length reburied) - x 5 (reburial events/lifetime) Array and ECC cable repairs will be 2000m x 10 m (trench width) - x7 (repairs/lifetime)	**Cable repairs:** Method: Jetting tools potentially followed by rock dumping and / or concrete mattress installation Remedial burial of cables: 10 km per event ; x 3 reburial events assumed over the project lifetime; Array and ECC cable repairs will be 600 m (cable length of repair) x 10 m (trench width) -x4 (repairs/lifetime)	The potential impact relates to O&M activities that generate the greatest level of disturbance to sediments arising in sediment plumes and sediment deposition. For all activities listed, the MDO represents the largest volume of fine sediments released into the water column over the shortest interval which then has the potential for greatest volumes of SSC within a plume that advects away from the point of discharge
Introduction of invasive species		
Presence of foundations and scour protection: - Option B: 45 WTGs on monopile foundations (diameter of up to 13 m) plus scour protection; and - One OSP on 4-legged multi-leg foundations plus scour protection. - **46 structures in total** within the array area.	**Presence of foundations and scour protection:** Alternative options include the use of different foundation types for the range of WTG Options. These will result in different scour areas with the minimum areas affected by scour occurring from the following - Option A: 50 WTGs on 3-leg multi-leg foundations with pin-piles (pile diameter of up to 4.75 m); and - One OSP on monopile foundations. - **51 total structures** within the array area.	The movement of O&M vessels and other project traffic to and from site has the potential to impact upon species and habitats by contributing to the risk of introduction or spread of invasive alien species. On this basis, the MDO relates to the maximum number of vessel movements of any vessel type during O&M activities. The presence of project infrastructure represents a change in substrate with potential for colonisation of species, as such the MDO represents the option with the largest footprint.
3 daily CTV trips with the addition of up to 100 vessels trips to support scheduled routine and non-routine maintenance per year.	2 daily CTV trips with the addition of up to 75 vessels trips to support scheduled routine and non-routine maintenance.	

Maximum design option	Alternative design options	Justification
Electric and Magnetic Fields (EMF)		
Cable burial depths: Inter array cables: Minimum depth of 0.6m with a target depth of 3m Export cables: Minimum depth of 0.6m with a target depth of 3m	**Cable burial depths:** Inter array cables: Target depth 3m Export cables: Target depth 3m	The potential impact relates to the greatest exposure of QIs to EMF. The level of EMF emitted will the same for all power cable route options, so the MDO presents the cable route with the greatest footprint (overall length). The MDO also considers the depth of cable burial, burial of the cables or use of cable protection where cables are shallow buried or surface laid will not reduce the strength of the fields, however, it moves the cables further from the receptors, and as such the receptors will be subject to reduced field strengths. The MDO for impacts from EMF is assumed to be 0 m in the event that cables cannot be buried.
IACs: Maximum total length = 120 km Nominal operating voltage **66 kV to 132 kV**	**IACs:** Maximum total length = **120 km** Nominal operating voltage **66 kV to 132 kV**	
Export cables: Maximum total length = **2 x 18.35 km** Nominal voltage **220 kV to 400 kV** with High Voltage Alternating Current (HVAC)	**Export cables:** Maximum total length = **2 x 17.95 km** Nominal voltage **220 kV to 400 kV** with (HVAC)	

Maximum design option	Alternative design options	Justification
Collision risk		
Option A: **50** turbines Rotor diameter: **236 m**	Option B: **45** turbines Rotor diameter: **250 m** Option C: **39** turbines Rotor diameter: **278 m**	The potential impact relates to the greatest risk of collision with WTGs for seabirds. The MDO relates to rotor diameter and height. Project specific collision risk modelling (CRM) was undertaken for all QI species considered at risk based on abundance within the array area and sensitivity to collision effects based on published guidance (Furness et al, 2013, Bradbury, 2014), professional judgement and experience of ornithological consultants and consultation with other Phase 1 developers. The MDO Model uses flight height data, average density of seabirds in flight for each calendar month from seabird survey data as well as turbine parameters for all options. The model incorporates site specific and published outputs to account for any uncertainties and to ensure a robust and precautionary model that accounts for species specific and site specific variables. For all species considered the MDO presents the largest theoretical collision impact risk.

Maximum design option	Alternative design options	Justification
Changes to Physical Processes		
Lifetime of the proposed development: 35 years (operating life) **Presence of foundations:** - Option B: 45 WTGs on 4-legged suction bucket foundations (with stiffeners); - One OSP on 4-legged multi-leg foundations; **Cable protection** Cable protection measures may be required, where the desired burial depth is not achieved.	**Lifetime of the proposed development:** 35 years (operating life) **Presence of foundations:** - Option C: 39 WTGs on monopile foundations; - One OSP on 4-legged multi-leg foundations; **Cable protection** Cable protection measures may not be required at any location, if the desired burial depth is achieved at all points. This approach would represent the design option with the minimum scale of effect. Alternative options include the potential for varying percentages of the cable routes to require cable protection, ranging from 0% up to that assessed as the maximum design option.	This impact is defined by any anticipated changes to physical processes as defined in Chapter 3.1: Physical Processes.
IAC: Cable protection measures may be placed alone or in combination, and may be secured to the seabed if considered necessary and subject to license approval; maximum footprint of cable protection = 34.8 km (total length requiring protection) x 6 m (width at base) **Export cables:** Cable protection measures may be placed alone or in combination and may be secured to the seabed where appropriate; Up to 6 km per cable x 2	**IAC:** No cable protection required. **Export cables:** No cable protection required.	

Maximum design option	Alternative design options	Justification
Cable crossings The MDO considered cable crossings in addition to rock berms. **IACs:** Assumes a maximum of two cable crossings of Dublin Array cables; Assumed to be constructed of both concrete mattresses (six per crossing) and rock berm; **Export cables:** Assumes a maximum of 6 cable crossings for all of the export cable **Foundation scour protection:** Maximum scour protection area for WTG foundations (50 WTGs (Option A) with 4-legged multi-leg foundations with suction buckets) and Maximum scour protection volume for WTG foundations (45 WTGs (Option B) with 3-legged multi-leg foundations with suction buckets **OSPs** Maximum scour protection area for the OSP foundation (jacket with suction bucket)	**Cable crossings** Alternative options for cable crossings include the use of alternative materials, namely that of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option. **IACs:** - Assumes a maximum of two cable crossings of Dublin Array cables; - Assumed to be constructed of concrete mattresses (18 per crossing); **Export cables:** Assumes a maximum of 6 cable crossings for all of the export cable; **Foundation scour protection:** Alternative foundation types and WTG options will give rise to varying areas and volumes of scour protection, all less than the maximum design option. Minimum scour protection area for WTG foundations (39 WTGs (Option C) with monopile foundations Minimum scour protection area for the OSP foundation (monopile): 1	(See previous page)

Maximum design option	Alternative design options	Justification
Decommissioning all effects		
Removal of structures is expected to be undertaken as an approximate reverse of the installation process;	Decommissioning activities are expected to be the same for all design options. Alternative design options are represented by varying numbers of total structures within the array area (represented by different WTG options), as shown below.	The MDO is the option with the greatest number of WTGs (50). All alternatives have lower potential for damage to assets and infrastructure during decommissioning.
It is anticipated that piled foundations will be cut at a level just below the seabed; Buried cables to be cut and left in situ but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time of decommissioning; Scour and cable protection left in situ; and Decommissioning activities lasting approximately three years for both onshore and offshore works.		
Presence of foundations: Option A: Up to 50 WTGs; and -One OSP	**Presence of foundations:** - Option C: 39 WTGs and Option B: 45 WTGs; and - One OSP.	
Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, but this will be reviewed over the design life of the project.	As for the MDO Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and - It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, but this will be reviewed over the design life of the project.	
Decommissioning Vessels: Up to 813 round trips to port vessels and an additional 1825 round trips from small vessels such as CTVs.	**Decommissioning Vessels:** Up to 774 round trips to port and an additional 538 round trips from small vessels such as CTVs.	

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