FOREWIND

DOGGER BANK
TEESSIDE A & B

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Deadline IX Appendix 1 Disposal Scenario Statement

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1. Disposal Scenario Statement

1.1. Introduction

1.1.1. In order to provide further clarification to Natural England on the potential environmental impacts from spoil material resulting from the installation of offshore foundations within the Dogger Bank SCI, Forewind prepared some potential installation scenarios and their associated spoil material quantities. In the Issue Specific Hearing of 02-04 December 2014, the Examining Authority requested that Forewind submit a copy of these scenarios as part of the examination process. This was further referenced in the Hearing Action Points List 3 – point 2.8.

1.1.2. The following document provides a description of spoil material that may be generated for different foundation types from either drill arisings or seabed preparation for a range of different installation scenarios. It should be noted that given the range of foundations and installation methodologies currently available, and anticipated as a result of future development, there are numerous variations on the scenarios listed within this document.

1.1.3. The scenarios described are based upon monopile and gravity base foundations, as these generate the worst case impacts for drill arisings and seabed preparation based upon their ES parameters. The scenarios only include spoil material generated as a result of installation of wind turbine and meteorological monitoring station foundations. For the meteorological monitoring stations only drilling as an installation method has been considered as this is a worst case for spoil material.

1.1.4. Offshore platforms have not been included as part of the scenarios as drilling as a means for installing platform foundations has not been considered within the Environmental Statement. Depending on foundation type, offshore platforms may require seabed preparation, but this is considered to have less of an impact than spoil material arising from drilling (maximum of 60,525 m^3 per project – see Table 3.14 of Chapter 5 of the ES). Regardless of the chosen foundation type, drilling will not be required to install the offshore platforms

1.1.5. The document is only relevant to DMLs 1 & 2 as Forewind is not seeking authority to construct turbines or meteorological masts in DMLs 3 & 4, and offshore platforms are not included in this document, as stated above.

1.1.6. The scenarios inform advice provided by Natural England regarding appropriate monitoring or mitigation measures that may be required dependent on the final design. For each scenario, Natural England's advice is provided as a Red-Amber-Green (RAG) rating according to the potential impacts on the Dogger Bank SCI.

1.1.7. Any references to the DCO or DMLs relate to version 7, submitted at Deadline IX.

1.2. Wind Turbine Piled Monopile Foundations

1.2.1. To date steel monopile foundations have been the most common type of foundations used for offshore wind turbines. These foundations are typically installed using impact piling, where a large hammer is dropped, or driven, onto the top of the pile, thereby driving it into the seabed. There are a number of alternative pile installation methodologies current under development, such as HiLo and Vibration piling but these have not yet reached the stage of being proven techniques for offshore foundations.

1.2.2. Installation of monopiles using a conventional impact piling should result in no drill arising, this is shown in scenario WT-01 in **Table 1**.

1.2.3. However, in some instances, even though a hammer is being used, it may necessary to drill a number of piles in the wind turbine array. Challenging geotechnical conditions may result in the pile reaching the point of refusal. At the point of refusal, also referred as the termination criterion, the resistance to piling is so great that the pile cannot reasonably be driven further without risking damaging the pile. When refusal is reached it is possible to drill our some or all of the volume of material within the core to reduce the resistance to piling and allow the pile installation to be completed.

1.2.4. The need to drill piled monopile foundations can be anticipated or unanticipated. During the detailed design phase of the projects the tendency will be to avoid areas with more challenging geotechnical conditions. However, to maintain the integrity of the wind turbine array a small number may be placed in more challenging areas, as a result a combination of drilling and piling would be anticipated from the beginning. Alternatively a larger number may require drilling from the outset dependent upon soil conditions, pile diameter and target depth requirement.

1.2.5. On a number of projects drilling has been required after geotechnical conditions were found to be more difficult than anticipated. The requirement to drill on these projects is a reactive response to unforeseen circumstances.

1.2.6. Forewind has undertaken driveability studies for the Dogger Bank Zone based upon the borehole sample collected as part of the geotechnical studies. These studies concluded that for the largest hammer sizes, contained within the consent envelope, refusal was unlikely, even when using the most challenging borehole data available. However, further geotechnical surveys are still required for the site, any limitations on hammer energies and variances between forecasts and actual performance may increase the possibility of refusal. The surveys will inform the amount and predominant sediment type of the arisings and inform the best course of action for disposal.

1.2.7. Scenario WT-03 within **Table 1** represents either a project that anticipated placing some of its turbines in more challenging geotechnical conditions or unexpectedly encountered more challenging geotechnical conditions.

1.3. Wind Turbine Gravity Base Foundations

1.3.1. A gravity base foundation is a large diameter steel, concrete or steel and concrete combination foundation which sits on the seabed. These foundations rely on their size and weight to maintain their stability. Whilst not as prevalent as piled monopile foundations they are an established foundation type for wind turbines.

1.3.2. Installation of gravity foundations will result in no drill arisings as the foundation is placed on the seabed. This is represented in scenario WT-02 in **Table 1**.

1.3.3. However, it may be necessary to prepare the seabed foundation prior to the installation of the gravity base foundation. This to ensure that the foundation is based upon a surface capable of supporting its weight and to ensure that the turbine stands vertically. The nature and form of any seabed preparation depends upon the specific site characteristics. It may only be necessary to undertake seabed preparation for a proportion of turbines within an array depending on the conditions.

1.3.4. Seabed preparation typically affects the top 0.5-0.75m of the seabed. Preparation works may involve the removal or levelling out of uneven sediments. Seabed preparation may require laying a thin layer of aggregate material, similar to scour protection material, directly under the planned gravity base foundation location to provide load bearing capacity. Seabed preparation would typically take place over an area slightly larger than the base footprint of the gravity base foundation. Materials from seabed preparation may be backfilled into the foundation to provide ballast, depending on the material and foundation type.

1.3.5. For the purposes of this document, and following Natural England's advice, it is assumed that seabed preparation is only required for smoothing of undulations in the seabed as a result of sandwaves or sandwave like features. As noted in Table 1, if other material is required to be levelled or smoothed, these will be reviewed on a case-by-case basis, when Natural England is consulted on the construction method statement, as these may require further monitoring or management measures.

1.3.6. The scenario WT-04 within **Table 1** is based upon the assumption that all the GBS foundations within an array require seabed preparation to a depth of 0.75m and use the maximum dimensions within the consent envelope.

1.4. Wind Turbine Drilled Monopile Foundations

1.4.1. Alternatives solutions to steel monopiles foundations installed using impact piling are currently being developed. Amongst these proposed alternatives are foundations that use drilling rather than impact piling. Drilled foundations may offer economic benefits with savings due to reduced steel quantities and environmental benefits due to significantly reduced noise levels during installation. It is anticipated that little or no impact piling will be required during the installation of a drilled monopile foundation.

1.4.2. Current drilled monopile foundations can be divided into two broad categories, steel and concrete. Drilled steel monopiles are similar to piled monopiles, with the variations mostly occurring in wall thicknesses and top flange design. The scenario WT-05 is based upon the assumption that all the wind turbine foundations used are drilled steel monopiles. Impact piling may be used prior to or after the drilling operation has been completed.

1.4.3. Proposed concrete monopile designs typically have larger diameters, and thicker walls than equivalent piled steel monopiles. At present no form of impact piling could be used in conjunction with a concrete monopile. WT-06 is based upon the assumption that all the wind turbine foundations used are concrete monopiles.

1.4.4. Currently these foundation concepts are still at the developmental stage and are not considered proven techniques for offshore foundations. However, given the timescales of the Dogger Bank projects, and the need to reduce project costs whilst reducing environmental impacts, Forewind consider them to be feasible options to include within the consent application.

1.5. Meteorological Mast Foundations

1.5.1. Each of the Dogger Bank Teesside A & B projects may have up to five meteorological monitoring stations, each of which will be mounted on a fixed or floating structure. To date fixed structures are the current standard within the offshore renewables industry, but a number of newer concepts using floating structures are in the developmental phase. In future, wind farms may opt to use a mixture of fixed and floating structures.

1.5.2. The range of fixed foundation structures available for meteorological structures is comparable to those already discussed for wind turbines. The foundations utilised for a meteorological monitoring station will be smaller than those used for a wind turbine as it will be supporting a much smaller structure.

1.5.3. For the final four installation scenarios described in Table 1 it has been assumed that in addition to the wind turbines there are five meteorological stations with drilled steel monopiles. This is considered a worst case for the meteorological stations and will result in a further 18,457m^3 of spoil material in addition to the spoil material generated by the wind turbine foundations.

1.6. Wind Turbine and Meteorological Mast Installation Scenarios

Table 1: Wind Turbine and Meteorological Mast Installation Scenarios

Scenario	Description	Foundation Type	Percentage Drilled/ Prepared	Volume of Spoil Material	Comments	Natural England RAG Rating[i]
WT-01	A 1.2GW project consisting of 200 6MW turbines and 5 meteorological masts with steel monopile foundations. Foundations are installed using conventional impact piling techniques.	Steel Monopile	0%	$0m^3$	Assumed no issues (i.e. refusal) encountered during the piling installation.	Green. No further mitigation required.
WT-02	A 1.2GW project consisting of 200 6MW turbines and 5 meteorological masts with gravity base foundations. Foundations are transported to site and filled with ballast.	GBS	0%	$0m^3$	Assumed seabed is level and no uneven sediments.	Green. No further mitigation required.
WT-03	A 1.2GW project consisting of 200 6MW turbines and 5 meteorological masts with steel monopile foundations. Foundations are installed using conventional impact piling techniques.	Steel Monopile	Up to 20%	Up to $209,457m^3$ of drill arisings	Necessary to drill a number of foundations due to either unforeseen geotechnical conditions resulting in resistance to piling or to ensure array integrity. 'Drive, Drill Drive' method Necessary to drill all met mast foundations.	Amber. Arisings can be sidecast next to the foundation sites but monitoring of any mounds is required throughout the lifetime of the project (DML 1&2 condition 23(2)(e), DML 3&4 condition 19(2)(c)).

Scenario	Description	Foundation Type	Percentage Drilled/ Prepared	Volume of Spoil Material	Comments	Natural England RAG Rating[i]
WT-04	A 1.2GW project consisting of 200 6MW turbines and 5 meteorological masts with gravity base foundations. Foundations are transported to site and filled with ballast. Seabed preparation of sandwaves / sandwave like features required.	GBS	Up to 100%	Up to 648,165m^3 of seabed preparation	Necessary to prepare the seabed for all the GBS foundations. Assumed that no material is used as ballast and that only sandwaves / sandwave like features are affected / prepared. Necessary to drill all met mast foundations.	Green. No further mitigation required. It may be the case that other substrate, such as gravel, is required to be smoothed as part of seabed preparation. If this is the case, Natural England's RAG rating of 'Green' may not apply and these will be reviewed on a case-by-case basis, as further management may be required. More detail on this will be provided in the construction method statement.
WT-05	A 1.2GW project consisting of 200 6MW turbines and 5 meteorological masts with steel monopile foundations. Foundations are installed using a drill.	Steel Monopile	100%	Up to 803,957m^3 of drill arisings	Impact piling may be used to commence/complete installation of pile. Necessary to drill all met mast foundations.	Red.[ii] Any arisings should be deposited in a suitable disposal area for the predominant substrate type contained within the arisings (DMLs 1&2 condition 16(1)(c)(i)). Monitoring of any mounds should also take place throughout the lifetime of the project (DML 1&2 condition 23(2)(e), DML 3&4 condition 19(2)(c)).

Scenario	Description	Foundation Type	Percentage Drilled/ Prepared	Volume of Spoil Material	Comments	Natural England RAG Rating[i]
WT-06	A 1.2GW project consisting of 200 6MW turbines and 5 meteorological masts with concrete monopile foundations. Foundations are installed using a drill.	Concrete Monopile	100%	Up to 968,789m^3 of drill arisings	Impact piling is not used. Necessary to drill all met mast foundations.	Red.[ii] Any arisings should be deposited in a suitable disposal area for the predominant substrate type contained within the arisings (DMLs 1&2 condition 16(1)(c)(i)). Monitoring of any mounds should also take place throughout the lifetime of the project (DML 1&2 condition 23(2)(e), DML 3&4 condition 19(2)(c)).

[i] RAG Ratings are based on Natural England advice in relation to the Dogger Bank SCI, which was provided formally at Deadline VII [REP-449].

[ii] Natural England also recognises that there is the possibility for further 'Amber' scenarios to be identified for scenarios 5 and 6 once pre construction surveys have been undertaken. These 'Amber' scenarios will be dependent upon the number of foundations that will need to be drilled and the percentage of clay in the arisings; the implications of which will need to be discussed with the MMO and the relevant SNCB prior to construction.