# *9 PHYSICAL PROCESSES AND GEOMORPHOLOGY*

## *9.1 INTRODUCTION*

1. This section of the ES Addendum presents an evaluation of the likely significant effects of the Amended Project on physical processes and geomorphology associated with the amendments presented in Section 4: Amended Project Description. In addition, this section presents a discussion of the effects which may occur as a result of the most likely scenario. The assessment has been undertaken by ABP marine environmental research Ltd (ABPmer).

2. Specifically, this section of the ES Addendum assesses the effects associated with:

- The Amended OfTW Corridor; and
- Changes to the jack-up vessel footprints associated with the Wind Farm.

3. This section of the ES Addendum is supported by the following documents from Volume 4: Technical Annexes of the Original ES:

- Annex 9A: Physical Processes Baseline Assessment.

4. This section of the ES Addendum is also supported by the following documents in Volume 4: Technical Annexes of this ES Addendum:

- Annex 9A: Physical Processes Consultation Marine Scotland Science; and
- Annex 9B: Physical Processes Consultation Surfers Against Sewage.

5. This section presents an addendum to Section 9: Wind Farm Physical Processes and Geomorphology and Section 21: OfTW Physical Processes and Geomorphology of the Original ES. Where applicable, reference is made in this assessment to the Original ES.

6. This section includes the following elements:

- Consultation;
- Scope of Assessment;
- Baseline;
- Assessment Methodology;
- Assessment of Potential Effects;
- Mitigation Measures and Residual Effects;
- Assessment of Cumulative Effects;
- Statement of Significance;
- Habitats Regulations Assessment; and
- References.

## *9.2 CONSULTATION*

7. Following the submission of the Original ES in April 2012, Beatrice Offshore Windfarm Ltd (BOWL) has received consultation responses, via Marine Scotland Licensing Operations Team (MS-LOT), from various statutory and non-statutory consultees. A summary of these responses in relation to Physical Processes and Geomorphology is presented in Table 9.1. Reference is also provided as to where these issues are addressed within this ES Addendum, if applicable.

***Table 9.1: Summary of Original ES Consultation Responses and Project Response***

| Consultee | Summary of Consultation Response | Project Response | Consultation Response Addressed |
|---|---|---|---|
| Marine Scotland Science (MSS) | Provide more information concerning the methodology, standards and data processing used in the geophysical survey (specifically in relation to the multibeam swath bathymetry and sub-bottom geophysical data). | The geophysical survey report was provided. | Letter to MSS dated 11th December 2012, included in Annex 9A of this ES Addendum.<br><br>No further environmental information required in this ES Addendum. |
| | Are (the sub-bottom geophysical) data included in the ES? (It is noted that) this would be a very useful layer of information that would assist in the identification of the most appropriate foundation design for different parts of the lease area. | Confirmed that the sub-bottom geophysical data are included in the Original ES and will be accounted for in engineering design. | |
| | Question whether scour will be taken into consideration at an engineering level i.e. factor in the extent of the predicted scour into the foundation design? | Confirmed that scour will be taken into account in engineering design. | |
| | Information request for any scour observations around the Beatrice Demonstrator Turbines. | Routine surveys were most recently carried out on each of the Beatrice Demonstrator Turbine jacket foundations using a remotely operated vehicle (ROV) between September and October 2012. The surveys also checked for the development of seabed scour both visually and using spot bathymetry measurements. No evidence of scour was reported. | |

| Consultee | Summary of Consultation Response | Project Response | Consultation Response Addressed |
|---|---|---|---|
| Surfers Against Sewage (SAS) | Request for further consultation with SAS and other groups. | The specific concerns of SAS were discussed with them and a response was provided to their satisfaction.<br><br>Further consultation was sought with SAS only as an appropriate and representative stakeholder in this regard. | Telephone and email correspondence with SAS (Andy Cummins, Campaign Director), 30th November to 14th December, 2012.<br><br>This correspondence is provided in Annex 9B of this ES Addendum. |
| | Consider (un-specified, additional) other locations used for recreational surfing in the assessment. | Further information concerning effects on other recreational surfing locations was provided. Effects at these other locations were consistent with the assessment already provided (i.e. not likely significant effect). | |
| | SAS suggest monitoring of the landfall location to ensure that development is not going to affect the coastal processes there. | The cable landfall location is contained within a Site of Special Scientific Interest (SSSI), an area which is already subject to an elevated level of both monitoring and protection. The proposed method of cable landfall via an underground conduit precludes any direct or indirect effects on coastal processes. | |
| | Concern regarding impacts on surfing wave quality at Fraserburgh. | Confirmed that effects on surfing waves at Fraserburgh will be negligible. | |
| | Concern that interference [of the cable at the landfall] with the waves and the installation and decommissioning of the cables process could restrict access [even for short times]. | Provided a clearer description of the landfall, demonstrating that local effects on surfing waves and the ability to surf will be negligible. | |

## *9.3 SCOPE OF ASSESSMENT*

8. As shown in Section 9.2, consultation responses to MSS and SAS have been issued to address queries raised by these organisations. These are included in Annex 9A and 9B respectively.

9. There are no amendments to methodologies or receptors which need to be presented in this section.

10. The further cumulative information relating to the Moray Firth Round 3 Zone does not require any amendment to the assessment of physical processes or geomorphology receptors.

11. The scope of this Section has therefore been determined by considering the changes to the Project presented in Section 4: Amended Project Description. Specifically, as stated in Section 9.1 above, the effects associated with:

- The Amended OfTW Corridor; and
- Changes to the jack-up vessel footprints associated with the Wind Farm.

12. The changes to the OfTW cable installation times bear no relevance to the assessment of effects on physical processes and geomorphology and hence do not fall within the scope of this section of the ES Addendum.

13. Section 9.6 considers the effects on physical processes and geomorphology associated with the Amended Project. The conclusions of this assessment are supplemental to those of the Original ES and this section must be read alongside Section 9: Wind Farm Physical Processes and Geomorphology and Section 21: OfTW Physical Processes and Geomorphology of the Original ES. Section 9.6.2 discusses the 'most likely' scenario.

14. The only receptor with the potential to receive likely significant effects as a result of the amendments to the Project is the Smith Bank, and the assessments presented in Section 9.6.1.1 supplement those presented in Section 9.5.4 of the Original ES in light of the revised worst case scenario for jack-up vessels. All other receptors discussed in Section 9: Wind Farm Physical Processes and Geomorphology and Section 21: OfTW Physical Processes and Geomorphology of the Original ES would be beyond the geographical extent of effects arising from these amendments.

## *9.4 BASELINE*

### 9.4.1 STUDY AREA

15. The Study Area for the assessment of effects on physical processes and geomorphology was presented in Section 9.2.3 and Section 21.2.3 of the Original ES. The Amended OfTW Corridor is within the original Study Area. The Study Area therefore remains unchanged.

### 9.4.2 BASELINE CONDITIONS

16. A detailed list of physical environmental receptors is provided in Section 9.3 and Section 21.3 of the Original ES, including Smith Bank, designated areas of seabed or coastline and key areas for recreational surfing. For the reasons set out in Section 9.3, only the Smith Bank is relevant to the additional area associated with the

amendments outlined in Section 4: Amended Project Description. The baseline conditions of Smith Bank remain unchanged from those outlined in Section 9.3, Annex 9A and Section 21.3 of the Original ES, although supplementary baseline information in relation to further geophysical data collected within a 4 $km^2$ area within the additional area created by the amendment to the Original OfTW Corridor is presented in Section 9.4.2.1.

*9.4.2.1 Smith Bank*

17. The baseline oceanographic and sedimentological conditions relating to the wider Study Area are presented in Section 9.3 and Section 21.3 of the Original ES and these remain unchanged. Baseline conditions for the additional area created by the amendment to the Original OfTW Corridor are included in the scope of the original baseline description. This statement is supported by geophysical survey data collected within the additional area, as described below.

18. Of relevance to the OfTW is the description of the local sedimentological and morphodynamic characteristics of this small amendment to the Original OfTW Corridor. A local consideration of these parameters is informed by geophysical survey data recently collected by Gardline Geosurvey Ltd in 2007 for Ithaca Energy (UK).

19. Geophysical survey data was collected over an area measuring 2 kilometres (km) x 2 km within the additional area using multi-beam echo sounder, sidescan sonar and sub-bottom profiler. It should be noted this survey was not undertaken specifically for the Amended Project and does not cover the entirety of the additional area but does cover the majority of it. The survey also supplied further seabed imagery and benthic data covering a representative proportion upon which to base the amended assessment.

20. Environmental samples were collected at 10 locations within the additional area using a day grab. Seabed imagery and video footage were attained using still photography and drop down camera at these locations. One core penetration test (CPT) was also taken to determine the geotechnical engineering properties of sub seabed sediments and stratigraphy and the log provided for assessment.

21. The data demonstrate a clear similarity between seabed characteristics in the additional area and that described in Section 21.3 of the Original ES. Local features are summarised in the following paragraphs.

22. Surface sediments are shown to be composed of a layer of up to 12 m of gravelly, fine to medium sand with shells and pebbles present. This overlies clay sediments containing silt and sand fractions with both pebbles and shell fragments present (Gardline Geosurvey Ltd, 2007).

23. Evidence of bedforms is given in the geophysical survey, with localised patches of megaripples present in the north of the surveyed area. These features are orientated along a north – south axis with wavelengths and heights less than 5 m and 0.3 m, respectively (Gardline Geosurvey Ltd, 2007).

24. The observed regional and local scale uniformity of the seabed and underlying geology from the geophysical surveys undertaken by BOWL and Ithaca Energy (UK) suggest that seabed characteristics will be similar in the small remaining areas which have not been directly surveyed.

25. The baseline descriptions of wind, waves, and tidal processes only vary on spatial scales larger than that of the additional area created by the amendment to the Original OfTW Corridor. Therefore, the original baseline descriptions remain valid.

## *9.5 ASSESSMENT METHODOLOGY*

26. The assessment methodology remains unchanged from that presented in Section 9.2.6 and Section 21.2.5 of the Original ES.

### 9.5.1 WORST CASE SCENARIO

*9.5.1.1 Wind Farm*

27. An updated project description in relation to the Wind Farm is presented in Section 4: Amended Project Description. The only change in the worst case scenario assessed in Section 9: Wind Farm Physical Processes and Geomorphology of the Original ES relates to the footprint of the jack-up vessels associated with construction. The worst case scenario for total footprint is a jack-up vessel with six legs, each leg having a footprint of 200 m² (approximately 14 m square or 16 m diameter), leading to a total footprint per jack-up operation of 1,200 m². Two separate jack-up operations are required at each of up to 283 foundation locations (277 turbines, three meteorological masts, two Alternating Current (AC) offshore substation platforms (OSPs) and one Direct Current (DC) OSP) during the construction phase. As shown in Table 9.2, the total area of seabed affected represents only a small proportion (0.517%) of the Wind Farm Site and a much smaller proportion again of the wider Moray Firth. The Original ES assessed a maximum footprint of up to 30 m² per foot, with six feet per vessel and two vessel jack-up operations at each of the 277 turbine foundations, equating to 0.101 km², or 0.075% of the Wind Farm Site.

***Table 9.2: Worst Case Scenario for Jack-up Vessel Footprint***

| Parameter | Worst Case |
|---|---|
| Number of foundations | 283 |
| Number of visits to install one foundation and turbine | 2 |
| Area of effect from one leg (m²) | 200 |
| Number of legs | 6 |
| Total area per foundation per visit (m²) | 1,200 |
| Total area per foundation for all visits (m²) | 2,400 |
| Total area for all foundations for all visits (m²) | 679,200 |
| Proportion of total site area (%) | 0.517 |

28. As the jack-up foot is inserted into the seabed, sediments will be both compacted downwards, and pushed outwards and upwards, creating localised areas of raised

seabed. As the foot is later withdrawn, loose sediment from around the perimeter will avalanche back into the pit until a stable slope angle is achieved. An assessment of the likely dimensions of the pit that will initially remain after removal of the foot was provided in Section 9.5.4 of the Original ES for the originally assumed footprint and embedment depth (a conical pit 6 m diameter and 1.9 m deep from a foot 30 $m^2$, approximately 6 m diameter, and penetrating to 5 m). A time-scale for the remaining pit to be infilled by natural sediment transport was also estimated (in the order of six months to four years under background tidal conditions, or less if the influence of storm activity is accounted for).

29. The larger footprint area of the 200 $m^2$ jack-up legs will spread the load more effectively and so is conservatively expected to correspond to a (smaller) maximum embedment depth of approximately 2 m. Initial avalanching of loose sediment around the edges of the pit will leave a flat bottomed depression approximately 16 m diameter at the top and 9.5 m diameter at the base.

*9.5.1.2 OfTW*

30. A description of the Amended OfTW Corridor is presented in Section 4: Amended Project Description.

31. The worst case scenario is dependant only upon the local dimensions of the trench (which remain unchanged) and not the cable corridor, and so the worst case scenario remains unchanged from that presented in Section 21.2.5.1 of the Original ES. Effects relating to increases in suspended sediment concentrations as a result of OfTW cable installation activities and scour effects due to the exposure of the cable, and cable protection measures are presented in Table 9.3 for clarity.

***Table 9.3: Worst Case Scenarios (parameters are the same as the Original ES)***

| Potential Effect | Worst Case Scenarios Assessed |
|---|---|
| **OfTW: Construction and Decommissioning Phases** | |
| Increase in suspended sediment concentrations as a result of OfTW cable installation activities. | Trenching by energetic means (e.g. jetting). Single trench with cross-section of disturbance 3 m wide by 2.5 m deep in a 'V' shaped profile. All material is resuspended. Three cable trenches but not simultaneously laid. |
| **OfTW: Operational Phase** | |
| Scour effects due to the exposure of cable and cable protection measures. | Exposure of the cable or the presence of cable protection measures. |

## 9.5.2 MOST LIKELY SCENARIO

*9.5.2.1 Wind Farm*

32. The most likely scenario for the Wind Farm (compared to the worst case scenario) is presented in Section 4: Amended Project Description. The most likely scenario would result in a smaller footprint and associated spatial and temporal scales of disturbance to the seabed as a result of having fewer turbines, smaller jack-up vessel footprints and a shorter length of inter-array cabling.

*9.5.2.2 OfTW*

33. The only difference between the worst case scenario and the most likely scenario in relation to physical processes and geomorphological receptors is the cable burial depth which is reduced from 2.5 m to 1.7 m, as summarised in Table 9.4.

***Table 9.4: Most likely Scenarios Considered***

| Potential Effect | Most Likely Scenarios Considered |
|---|---|
| **OfTW: Construction and Decommissioning Phases** | |
| Increase in suspended sediment concentrations as a result of OfTW cable installation activities. | Trenching by energetic means (e.g. jetting). Single trench with cross-section of disturbance 3 m wide by 1.7 m deep in a 'V' shaped profile. All material is resuspended. Three cable trenches but not simultaneously laid. |
| **OfTW: Operational Phase** | |
| Scour effects due to the exposure of cable and cable protection measures. | Exposure of the cable or the presence of cable protection measures. |

## *9.6 ASSESSMENT OF POTENTIAL EFFECTS*

### 9.6.1 WORST CASE SCENARIO

*9.6.1.1 Wind Farm*

34. With the exception of the effect of jack-up vessel footprints, all aspects of the worst case scenario remain as per those assessed in the Original ES, and therefore the assessment of effects presented in Section 9: Wind Farm Physical Processes and Geomorphology of the Original ES remains valid for all elements of the Wind Farm, except the footprint of effect from jack-up vessels. These are assessed below.

*Smith Bank - Operational Phase: Footprint of Effect from Jack-Up Vessels and Anchors*

35. The dimensions and persistence of individual indentations left following the temporary insertion of jack-up legs or anchors into the seabed is estimated and assessed in Section 9.5.4 of the Original ES. The assessment shows that such a small magnitude of temporary disturbance to local morphology on Smith Bank (as a potentially sensitive physical processes receptor) will not affect its form or function.

36. Section 9.5 of this Addendum provides further complementary information regarding the total footprint of seabed directly affected by jack-up legs or anchors according to the worst case and most likely scenarios. Smith Bank and all other physical process receptors identified in Section 9: Wind Farm Physical Processes and Geomorphology of the Original ES remain insensitive to this type of effect. An further assessment of significance in relation to effects on ecological receptors is provided in Section 10: Benthic Ecology.

37. The worst case scenario for total footprint is a jack-up vessel with six legs, each leg having a footprint of 200 $m^2$ (approximately 14 m square or 16 m diameter), leading to a total footprint per jack-up operation of 1,200 $m^2$. Two separate jack-up operations are required at each of 283 foundation locations during the construction

phase. As shown in Table 9.2, the total area of seabed affected represents only a small proportion (0.517%) of the Wind Farm Site and a much smaller proportion again of the wider Moray Firth.

38. Following the original methodology and assessment, infilling of the larger pit will take longer (18 months to 12 years under background tidal conditions, or less if the influence of storm activity is accounted for). After this time the resulting slope angles will be less than or equal to the naturally observed range for the local bedforms and other bed features and thus disruption to sediment transport would not be anticipated.

39. As no sediment is added or removed by the jack-up operation, the volume of sediment needed to fill the depressions will be similar to the volume displaced upwards locally around each depression. Evolution of the pits back to the baseline condition is therefore a matter of local sediment redistribution, rather than one of sediment importation from more distant locations. Furthermore, the sedimentary composition of the seabed within the footprint of the pits will either: (a) not be affected (in the case of already sandy soils); or (b) may become finer (if a coarse sediment or rocky seabed is depressed and then filled with sand). In all cases, only 0.5% of the site area can be affected in this way and provided the longer-term (decadal) external hydrodynamic conditions do not change, the remaining area will continue to transport sediment at the present day natural rate and direction. Therefore, no measurable effects on regional sediment transport pathways are anticipated.

40. Anchors individually present a much smaller footprint of impact (order of 2 to 5 $m^2$). This is one to two orders of magnitude smaller than that of a single jack-up leg as described above. Given the same number of vessels, anchors per vessel, operations and turbines, anchors present a proportionally smaller total footprint than jack-ups.

41. The result is that a small magnitude of change to the surficial sediments of Smith Bank is assessed to arise from the total footprint of jack-up vessels in an area of low sensitivity. This results in a negative effect which is of negligible significance and is therefore not a likely significant effect in terms of the EIA Regulations, which is the same level of significance presented in Section 9.5.4 of the Original ES. This further information supplements the conclusions of the related assessment of individual footprints in Section 9.5.4 of the Original ES.

*9.6.1.2 OfTW*

42. The worst case scenario is assessed in Section 21.5 of the Original ES. As the amendments to the Original OfTW Corridor do not change this worst case scenario and the baseline conditions have not materially altered, the potential effects remain unchanged in all instances.

### *9.6.2* CONSIDERATION OF MOST LIKELY SCENARIO

*9.6.2.1 Wind Farm*

***43.*** All effects presented in Section 9: Wind Farm Physical Processes and Geomorphology of the Original ES were considered to be not likely significant

effects in terms of the EIA Regulations (i.e. all of minor or negligible significance) and would remain not likely significant effects should the most likely scenario be realised, as effects will be even lower in magnitude given the smaller footprint of the Wind Farm and associated construction.

*9.6.2.2 OfTW*

*Construction Phase: Increase in Suspended Sediment Concentrations and Deposition of Sediments*

44. In comparison to the potential effects for the worst case scenario assessment presented in Section 21.5.1 of the Original ES, the most likely scenario will lead to a reduction of 32% in the sediment volume released during installation works based on the assumptions set out in Section 9.5.2.2. As per the worst case assessment, increases in suspended sediment concentrations will remain local and temporary in nature and may be of a (32%) smaller magnitude.

45. This difference (given that all other assumptions remain the same) will reduce the volume of sediment disturbed per metre of trenching by 32%. The rate of sediment resuspension and the thickness of locally redeposited sediment will therefore be correspondingly smaller. The duration and lateral extent of the (reduced magnitude) effect are rather dependant on the operational methodology and the sediment grain size, which do not change, so are assumed to remain the same as originally assessed. The extent of deposition effects will likely remain unchanged but the thickness of any resulting sediment deposits would be reduced also by 32%.

***46.*** As per the original assessment presented in Section 21.5.1 of the Original ES, this effect remains not a likely significant effect in terms of the EIA Regulations (originally assessed as minor significance) but is of lower magnitude.

## *9.7 MITIGATION MEASURES AND RESIDUAL EFFECTS*

47. Mitigation measures remain unchanged from those presented in Section 9.6 and Section 21.6 of the Original ES.

48. Residual effects remain unchanged from those presented in Section 9.6 and Section 21.6 of the Original ES.

## *9.8 ASSESSMENT OF CUMULATIVE EFFECTS*

49. Cumulative effects for physical processes and geomorphology are presented in Section 9.7 of the Original ES. Cumulative effects remain unchanged from those presented in the Section 9.7 of the Original ES.

## *9.9 STATEMENT OF SIGNIFICANCE*

50. As the findings of the Original ES remain unchanged, the statement of significance remains unchanged from that presented in Section 9.8.1 and Section 21.9.1 of the Original ES.

## *9.10 HABITATS REGULATIONS ASSESSMENT*

51. Annex 3B presents a report to inform an appropriate assessment in respect of Natura 2000 designations for which physical processes or geomorphology receptors form part of the qualifying interest or conservation objectives of the designation.

## *9.11 REFERENCES*

52. References remain unchanged from those presented in Section 9.10 and Section 21.10 of the Original ES, with the exception of the following further source:

53. Gardline Geosurvey Ltd (2007) UKCS 12/26c. Polly Rig Site, Habitat Assessment and Environmental Baseline Survey. Survey Report.

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