13 Physical Environment (Offshore)

13.1 Hydrodynamics (Wave Climate and Tidal Regime)

13.1.1 Summary

13.1.1.1 A summary of the likely significant cumulative impacts is provided in Table 13.1-1 below. The cumulative effect of the Project and the Beatrice Offshore Wind Farm on the wave and tidal regimes are found to be **not significant**. This assessment is consistent with the results of the Beatrice Offshore Wind Farm Environmental Statement (BOWL, 2012). The development of up to 500 MW of the total capacity in the WDA instead of within the three wind farms sites does not result in any further additive effect over that previously assessed.

13.1.1.2 The developments cause no measurable change to the tidal range or to the speed or directions of tidal currents. Gravity Base Structure (GBS) foundations are conservatively assessed to cause a maximum local reduction in instantaneous significant wave height in a small area within the application site boundary (associated with individual foundations of up to 21 % (but more typically 5 to 10 %) and up to only 5 % in the far-field, which is of the same order as inter-annual and inter-decadal variability in storm intensity. Jackets will have little or no measurable effect (< 1 %) on wave height. Neither GBS nor jacket foundations will measurably affect wave period or direction.

Table 13.1-1 Cumulative Impact Summary

Effect	MORL Total Project	BOWL (generating station and associated transmission infrastructure)	WDA	Sensitivities for Telford, Stevenson and MacColl, and OfTI	Mitigation Method (if required)
Construction/decommissioning					
(Partial impacts only)	Not significant	Not significant	No significant additive effect	Not applicable	Not required
Overall CIA for partial impacts during construction/ decommissioning)	Not significant				
Operation					
Changes to the tidal regime	Not significant	Not significant	No significant additive effect	Not applicable	Not required
Overall CIA for changes to the tidal regime	Not significant				
Changes to the wave regime	Not significant	Not significant	No significant additive effect	Not applicable	Not required
Overall CIA for changes to the wave regime	Not significant				

13.1.2 Assessment of Cumulative Effects

13.1.2.1 This chapter presents the results of assessment of the likely significant effects on the wave climate and tidal regime, arising from the Project in conjunction with other existing or reasonably foreseeable marine and coastal developments and activities. MORLs approach to the assessment of cumulative impacts is described in Chapter 1.3 (Environmental Impact Assessment).

13.1.2.2 The geographical scope of the cumulative assessment is focused in the Moray Firth area because (with the exception of the WDA and the Beatrice Offshore Wind Farm and associated infrastructure), all other developments or activities initially considered (as shown in Figure 13.1-1, Volume 6 a) have no potential for cumulative interaction for one or more of the following reasons.

- It is located more than one tidal excursion from the three proposed wind farm sites;
- It has no direct fetch for wave effects to interact with that from the three proposed wind farm sites (i.e. there is no pathway connecting the wind farm sites and the other source of effect);
- Its dimensions are so small that it will not conceptually have any measurable effect on the tidal, wave or sedimentary regimes.

13.1.3 Methodology

13.1.3.1 The assessment methodology for the detailed cumulative assessment (with the exception of the WDA) has followed that outlined in the Moray Firth Offshore Wind Developers Group Discussion Document (ERM, 2011; see Technical Appendix 1.3 D).

13.1.3.2 To assess cumulative effects upon the wave climate and tidal regime, the effect of different layouts and types of turbine foundations was simulated within calibrated and validated numerical models. The relative difference between the two sets of results was found and used to describe and assess the relative effects. By testing the realistic worst cases and testing the effect as the difference between scheme and baseline results, any uncertainties in either the design of the development or the absolute accuracy of the numerical modelling are minimised; this approach complies with the best practice guidance in this regard (COWRIE, 2009).

Worst Case Scenario for Projects Where Detailed Assessment is Possible

13.1.3.3 The worst case layout of the Project in conjunction with the BOWL Wind Farm is 139 x 3.6 MW turbines in Telford and 100 x 5 MW turbines in each of Stevenson and MacColl. This distribution places the greatest density of turbines closest to the nearest coastline and therefore results in the greatest predicted far-field effects.

13.1.3.4 A summary of the worst case parameters of wind farm design for the BOWL in terms of the wave climate and tidal regime is provided below in Table 13.1-2 below. These parameters were provided by BOWL during the development of this Environmental Statement (ES); they are also consistent with the descriptions and assessments contained in the Beatrice Offshore Wind Farm Environmental Statement (BOWL, 2012). The worst case parameters for the Telford, Stevenson and MacColl wind farms and the OFTI are as provided in Chapter 6.1 and Chapter 9.1 (Hydrodynamics: Wave Climate and Tidal Regime) respectively.

Table 13.1-2 Summary of BOWL Worst Case Parameters

Realistic Worst case parameters	Scenario assessed
Changes to the Tidal Regime	
Installation of 277 turbines	60 m diameter Gravity Base Structures (GBS)
Changes to the Wave Regime	
Installation of 277 turbines	60 m diameter GBS

Western Development Area

13.1.3.5 The Western Development Area (WDA) comprises part of the MORL Zone, within which the three proposed wind farm sites (Telford, Stevenson and MacColl) are located. The maximum capacity to be installed in the entire Zone is 1.5 GW and MORL has applied for a maximum of 1.5GW within three proposed wind farm sites.

13.1.3.6 The WDA may be developed for a maximum of 500 MW of capacity if less than 1.5GW of capacity is delivered by the Project in the EDA. In total the consented capacity of the Project and the WDA will not exceed 1.5GW.

13.1.3.7 The connection between the WDA and the three proposed wind farm sites necessitates a slightly different approach to assessment, as the effects arising from the "worst case" for the Project cannot simply be added to the "worst case" scenario for the WDA. Instead, assessment of the likely significant cumulative effects of the Project and the WDA will therefore follow a similar format to that undertaken for the sensitivity assessments of the individual wind farm proposals in the Offshore Generating Station Impact Assessment chapters.

13.1.3.8 The total capacity of the MORL zone is capped at 1.5 GW and so the additional placement of 139 x 3.6 MW or 100 x 5 MW turbines in the WDA would be offset by an equivalent reduction in the number of turbines elsewhere in the zone.

13.1.3.9 The worst case parameters for the WDA in terms of the wave climate and tidal regime is provided below in Table 13.1-3 below.

Table 13.1-3 Summary of MORL WDA Worst Case Parameters

Realistic Worst Case Parameters	Scenario Assessed
Changes to the Tidal Regime	
Installation of 139 turbines	65 m diameter GBS
Changes to the Wave Regime	
Installation of 139 turbines	65 m diameter GBS

13.1.4 Detailed Impact Assessment

13.1.4.1 This assessment considers the cumulative effect of the three proposed wind farms, including associated OfTI and the BOWL Wind Farm, including associated OfTI, collectively referred to as 'the combined wind farm developments'.

13.1.4.2 The potential effects that will be considered in this cumulative impact assessment on are:

- Changes to the tidal regime
- Changes to the wave regime

13.1.4.3 These are considered in relation to the construction, operation and decommissioning phases of the combined wind farm developments.

Construction

13.1.4.4 At times and locations where individual items of wind farm infrastructure are not yet installed, there is no potential for any significant modification to the baseline wave and tidal regimes. The worst case scenarios of all wind farm infrastructure installed during the operational phase is considered in the following section. The effect of less than the total amount of infrastructure at an intermediate stage in the construction process is less than that reported in the following section for the operational phase of the combined wind farm developments.

13.1.4.5 Therefore, these effects are not considered explicitly during the construction phase.

Operation

13.1.4.6 This section considers the cumulative effect of the combined wind farm developments on the wave and tidal regimes during the operational phase of both developments. More details of this assessment may be found in Technical Appendix 3.4 C ABPmer (2011c). The subsequent effect on the sedimentary environment, of changes to these regimes, may be found in Chapter 13.2.

Changes to the Tidal Regime

Sensitive Receptor: Smith Bank

13.1.4.7 As illustrated in Figure 13.1-2, Volume 6 a neither GBS nor jacket foundations in the combined wind farm developments will have a measurable effect on tidal water levels or tidal current directions.

13.1.4.8 Jacket foundations will also not have any measurable effect on tidal current speed.

13.1.4.9 As illustrated in Figure 13.1-3, Volume 6 a, GBS foundations will only have a (nearly) measurable effect on tidal currents during spring tidal periods. The main effect is a phase shift, simply advancing the current peak in time by 5 to 10 minutes. The peak flow speed in the region of the wind farms will also be reduced by approximately 0.03 m / s (not a measurable effect). Given the similarity in the controlling physical processes, a similarly low order of effect on non-tidal (surge) water levels is inferred.

13.1.4.10 The effects of the combined wind farm developments on water levels and currents will persist for the operational lifetime of the developments but are of low magnitude, have only a local effect and do not directly affect any of the identified sensitive physical environmental receptors beyond the range of natural variability.

13.1.4.11 A low magnitude of change within the range of natural variability is therefore assessed to arise in an area of low sensitivity. The resulting significance of effect is **not significant**.

Sensitive Receptor: Designated Coastal Habitats

13.1.4.12 No measurable effect on the tidal regime is predicted to occur further than one tidal excursion (order 7 km) outside of the extent of the combined wind farm developments.

13.1.4.13 A low magnitude of change within the range of natural variability is therefore assessed to arise in an area of low sensitivity. The resulting significance of effect is **not significant**.

Sensitive Receptor: Stratification Fronts

13.1.4.14 No measurable effect on the tidal regime is predicted to occur further than one tidal excursion (order 7 km) outside of wind farms. As these features are the product of regional fresh water / saline patterns (unaffected by the combined wind farm developments) and the tidal regime (water depth and current speed), there will be no consequential effect on the strength or location of stratification fronts.

13.1.4.15 A low magnitude of change within the range of natural variability is therefore assessed to arise in an area of low sensitivity. The resulting significance of effect is **not significant**.

Changes to the Wave Regime

Sensitive Receptor: Smith Bank

13.1.4.16 Wave conditions naturally vary from calm conditions to maximum wave heights of 4 to 9 m depending upon the strength of the wind and its direction; further natural variability in the order of 10 % is also expected on the basis of historical trends and the generally predicted effects of climate change.

13.1.4.17 In relation to wave height and period, the cumulative assessment finds that for jackets:

- Jacket foundations used in the combined wind farm developments do not measurably affect wave height or period. i.e. differences in significant wave height are < 0.1 m (1.5 %) and in wave period are < 0.1 s (1 to 1.5 %) in the near-field (and even less in the far-field).

13.1.4.18 For GBS (as illustrated in Figure 13.1-4 and Figure 13.1-5, Volume 6 a):

- The main effect of GBS foundations in the combined wind farm developments is to reduce the height of waves passing through developments within the combined wind farm developments;
- The maximum reduction in wave height within the combined wind farm developments varies between 0.4 and 1.6 m or 6 to 24 % of the incident wave height (which varies between 4 and 9 m) for all directions and return periods. The greatest absolute effects are on the largest waves (i.e. from 90°N). The greatest absolute and proportional effects are for the largest waves passing through the longest axis of the combined sites (i.e. from 45 to 90°N, the smallest proportional effects are on waves from 270°N);

- The area of maximum effect on wave height is relatively small (length scale of order 1 km) and is located where waves have transitioned through the greatest width of the wind farm developments in that orientation;
- The effect gradually develops in proportion to the distance travelled through the site (i.e. 50 % of the combined wind farm developments will experience less than 50 % of the maximum level of effect reported above, and 25 % will experience less than 25 % of the maximum effect etc.);
- Behind the combined wind farm developments relative to the wave coming direction, the near-field reduction in wave height recovers towards ambient values at a non-linear rate (i.e. recovering quickly over small distances but smaller magnitude effects can persist over greater distances);
- These residual effects extend in the direction of wave travel (with some lateral spreading); and
- The maximum effect on wave period in all cases is approximately 0.3 s (3 to 5 %). The spatial pattern of the effect is not well defined and the small magnitude of the effect is not measurable in practice.

13.1.4.19 In relation to wave direction, the assessment finds that:

- There is no measurable effect on instantaneous wave direction (i.e. differences are < ±1°) as a result of either the jacket or GBS scenarios in the near- or far-field.

13.1.4.20 The near-field effects of GBS used in the combined wind farm developments on waves are of a low magnitude relative to the range of naturally occurring variability on annual and decadal timescales and do not cause the range to be exceeded. The far-field reduction in wave height is of a relatively small magnitude (likely not measurable in practice in most areas).

13.1.4.21 The near-field (and far-field) effects of the jacket array on waves are of a low magnitude relative to the range of naturally occurring variability (and do not cause it to be exceeded). Effects are so small that they would not be measurable in practice.

13.1.4.22 A low magnitude of change, typically within the range of natural variability is therefore assessed to arise in an area of low sensitivity. The resulting significance of effect is **not significant**.

Sensitive Receptor: Designated Coastal Habitats

13.1.4.23 In relation to wave height and period outside of the wind farms, the assessment finds that for jackets:

- Jacket foundations do not affect waves by more than 0.05 m (1 %) significant wave height or 0.1 s (1 to 1.5 %) wave period in the far-field.

13.1.4.24 And for GBS:

- The main effect of the GBS foundations is to reduce the height of waves passing through the combined wind farm developments and on to other receptor locations;
- When the combined wind farm developments are present, the maximum magnitude of effect on wave height for the following designated sites are:

  - East Caithness Cliffs SAC: of the order 0.4 to 0.5 m (4 to 5 % of the incident wave condition) for waves from the east or south east (occurring 29 % of the time), of the order 0.2 to 0.3 m (2 to 3 % of the incident wave condition) for waves from the north east or south (41.4 % of the time) and < 0.1 m (1 % of the incident wave condition) for other directions (29.6 % of the time);
  - Moray Firth SAC and Open Coastal Sites: of the order 0.1 to 0.2 m (2 to 3 % of the incident wave condition) for waves from the north, north east or east (54 % of the time) and < 0.1 m (up to 2 % of the incident wave condition) for other directions (46 % of the time); and
  - Inner Moray Firth and Enclosed Water Bodies: < 0.05 m (< 1 % of the incident wave condition, i.e. no measurable effect) for all wave coming directions.

- Effects are only apparent in locations where waves have previously passed through the wind farm site boundary(s) – this condition only applies 29 % of the time for the East Caithness Cliffs SAC and 54 % of the time for the Moray Firth SAC and other open coastal sites (for any wave height). These are the proportions of time during which any effect might potentially arise - the maximum effects described above will occur even less frequently (for a few hours every 10 to 50 years);
- GBS foundations do not affect wave period by more than 0.1 s (1 to 1.5 %) outside of the combined wind farm developments - this is not a measurable effect in practice;
- Beyond the extent of the three proposed wind farms, values recover towards ambient values at a non-linear rate (i.e. recovering relatively quickly over small distances but smaller magnitude effects can persist over greater distances); and
- These residual effects extend in the direction of wave travel (with some lateral spreading).

13.1.4.25 In relation to wave direction, the assessment finds that:

- There is no measurable effect on instantaneous wave direction (i.e. differences are < ±1°) as a result of either the jacket or GBS scenarios in the far-field.

13.1.4.26 The relative effect on extreme wave conditions is shown to be of a low magnitude in relation to the range of natural variability. The assessed magnitude of the maximum levels of effects found within the three wind farm sites remains low due to the limited spatial extents and infrequent nature of the effect at any given location. The effect on less extreme (more frequently occurring) conditions will be correspondingly smaller in both magnitude and extent.

13.1.4.27 The greatest relative and absolute effects will be felt by the East Caithness Cliffs SAC as it is closest to the combined wind farm developments and the source of the effect. However, any level of effect will only occur for 29 % of the time and this coastline is characterised by:

- Rocky cliffs that are not subject to significant erosion by waves on the timescale of the development;
- Morphology that is not dependent upon rates and directions of alongshore sediment transport; and

- Designation corresponding to the aerially exposed cliffs, which are above the high water elevation and therefore not dependent upon wave action.

13.1.4.28 The effects on other designated sites are low in magnitude both in absolute and relative terms.

13.1.4.29 The cumulative effects of the wind farms on waves at the designated coastal sites identified are of low magnitude relative to the range of naturally occurring variability and have no potential to cause any effect on any given site 50 to 70 % of the time. The coastal environments exposed to the relatively higher levels of effect are of a morphological type not sensitive to changes in the wave regime.

13.1.4.30 A low magnitude of change but within the range of natural variability is therefore assessed to arise in areas of low sensitivity and a low magnitude of change within the range of natural variability is also assessed to arise in areas of potentially medium sensitivity. The resulting significance of effect is **not significant**.

Sensitive Receptor: Recreational Surfing Venues

13.1.4.31 This assessment of likely significant effects to the wave regime is based upon the analysis of wave model results with and without GBS present in the combined wind farm developments over a two year period. Time series of wave conditions have been extracted from the model results immediately offshore of the identified surfing beaches in the study area (Figure 3.1-1 and Figure 3.4-6, Volume 6 a). The same statistical and frequency analysis has been applied to each data set to obtain baseline values and the difference in the frequency of occurrence of key event types resulting from the presence of the combined wind farm developments. A more detailed description can be found in Technical Appendix 3.4 A.

13.1.4.32 Considering the cumulative effects of the combined wind farm developments, GBS foundations were found to have no effect > 0.01m wave height or > 0.1 s wave period at eight out of 18 venues. Of the remaining ten venues, effects were typically limited to a 0.02 to 0.09 m decrease in wave height (only one site, Lossiemouth, was higher at 0.14 m), but no effect on wave period or the frequency of occurrence of any representative conditions.

13.1.4.33 A low magnitude of change within the range of natural variability is therefore assessed to arise in areas of low sensitivity. The resulting significance of effect is **not significant**.

Decommissioning

13.1.4.34 Where and when wind farm infrastructure is no longer present, there is no potential for any modification to the baseline wave and tidal regimes. The worst case scenario of all wind farm infrastructure present is considered in the preceding section. The effect of less than the total amount of infrastructure present at an intermediate stage in the decommissioning process will be (proportionally) less than that reported (as not significant) for the operational phase of the development (i.e. of a small magnitude and within the range of natural variability).

13.1.5 Assessment of WDA

13.1.5.1 The effect of locating 500 MW capacity (a maximum of 139 turbines) into the WDA instead of in the three wind farm sites has also been considered. More details of this sensitivity assessment may be found in Technical Appendix 3.4 C (ABPmer, 2012b). The WDA has been assessed on the basis of a 3.6 MW layout (i.e. the largest number and closest spacing of turbine foundations and the largest corresponding potential effect on sedimentary processes). It is noted that there is presently no decision or indication as to which of the three sites might be built with less than the presently planned capacity.

13.1.5.2 The results of the sensitivity assessment in terms of both magnitude and extents of effect, and the resulting levels of significance, are the same as reported previously for developments in the EDA including the three wind farms in Chapter 6.1 and for the OfTI in Chapter 9.1. Other consequential (indirect) effects are also considered, where relevant, in other chapters (Chapter 14.1: Benthic Ecology; Chapter 14.2: Fish and Shellfish Ecology; and Chapter 15.5: Archaeology).

13.1.6 Habitats Regulations Appraisal

13.1.6.1 Effects from the construction, operation and decommissioning of the generating station on the physical marine environment do not give rise to Habitats Regulations Appraisal concerns.

13.1.7 References

ABPmer, 2011c. Moray Firth Round 3 Zone: Physical Processes Scheme Impact Assessment. ABPmer Report R1894.

BOWL, 2012. Beatrice Offshore Wind Farm Environmental Statement.

ERM, 2011. Cumulative Impacts Assessment Discussion Document. For the Moray Firth Offshore Wind Developers Group, April 2011. 181pp.

COWRIE, 2009. Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guidance.

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13.2 Sedimentary and Coastal Processes

13.2.1 Summary

13.2.1.1 A summary of the likely significant effects is provided in Table 13.2-1 below. The cumulative effect of the Project and BOWL on the wave and tidal regimes are found to be **not significant** or of **minor significance**. This assessment is consistent with the results of the Beatrice Offshore Wind Farm Environmental Statement (BOWL, 2012). The development of up to 500 MW of the total capacity in the WDA instead of within the three wind farms sites does not result in any further additive effect over that previously assessed.

13.2.1.2 Increased levels of suspended sediment and any resulting sediment deposits from the developments have limited or no potential to interact and raise levels above the range of natural variability. The cumulative effect of the developments on sediment transport is also no greater than that of the developments considered separately (i.e. of low magnitude and within the range of natural variability). Scour effects may arise in a greater cumulative number of locations. However, the relative proportion of the seabed affected (by scour or scour protection) remains the same (i.e. very small, less than one percent of the licensed development areas and a much smaller proportion of the wider Moray Firth).

Table 13.2-1 Cumulative Impact Summary

Effect	MORL Total Project	BOWL (generating station and associated transmission infrastructure)	WDA	Sensitivities for Telford, Stevenson and MacColl, and OFTO	Mitigation Method (if required)
Construction / decommissioning					
Increase in Suspended Sediment Concentrations	Minor Significance	Minor Significance	No significant additive effect	N / A	Not required
Overall CIA for Increase in Suspended Sediment Concentrations	Not significant				
Sediment accumulation and change of sediment type at the seabed	Minor Significance	Minor Significance	No significant additive effect	N / A	Not required
Overall CIA for Sediment accumulation and change of sediment type at the seabed	Not significant				

Effect	MORL Total Project	BOWL (generating station and associated transmission infrastructure)	WDA	Sensitivities for Telford, Stevenson and MacColl, and OFTO	Mitigation Method (if required)
Operation					
Changes to the Sediment Transport Regime	Negligible Significance	Negligible Significance	No significant additive effect	N / A	Not required
Overall CIA for Changes to the Sediment Transport Regime	Not significant				
Scour Effects	Minor Significance	Minor Significance	No significant additive effect	N / A	Not required
Overall CIA for Scour Effects	Not significant				

13.2.2 Assessment of Cumulative Impacts

13.2.2.1 This chapter presents the results of assessment of the likely significant cumulative impacts upon sedimentary and coastal processes, arising from the Project in conjunction with other existing or reasonably foreseeable marine and coastal developments and activities. MORLs approach to the assessment of cumulative effects is described in Section 1, Chapter 1.3 (Environmental Impact Assessment).

13.2.2.2 The geographical scope of the cumulative assessment is focused in the Moray Firth area because (with the exception of the WDA and the Beatrice Offshore Wind Farm and associated infrastructure), all other developments or activities are considered to have no potential for cumulative interaction for one or more of the following reasons:

- It is located more than one tidal excursion from the three proposed wind farm sites;
- It has no direct fetch for wave effects to interact with that from the three wind farm sites (i.e. there is no pathway connecting the wind farm sites and the other source of effect); and
- Its dimensions are so small that it will not conceptually have any measurable effect on the tidal, wave or sedimentary regimes.

13.2.2.3 The developments and activities considered within the cumulative impact assessment are listed below.

Cumulative Considerations

- Offshore wind:
  - MORL Western Development Area (WDA); and
  - Beatrice Offshore Wind Farm Ltd. (BOWL) wind farm and associated infrastructure.

13.2.3 Methodology

13.2.3.1 The assessment methodology has followed that used for the assessment of the individual wind farms (Chapter 6.1: Hydrodynamics) and transmission infrastructure (Chapter 9.1: Hydrodynamics), and as previously outlined in the Moray Firth Offshore Wind Developers Group Discussion Document (ERM, 2011; see Appendix 1.3 D).

Worst Case Scenario for Projects Where Detailed Assessment is Possible

13.2.3.2 The worst case layout of the Project in conjunction with the BOWL Wind Farm is 139 x 3.6 MW turbines in Telford and 100 x 5 MW turbines in each of Stevenson and MacColl. This distribution places the greatest density of turbines closest to the nearest coastline and therefore results in the greatest far-field effects.

13.2.3.3 A summary of the worst case parameters of wind farm design for BOWL in terms of sedimentary and coastal processes are provided below in Table 13.2-2. These parameters were provided by BOWL during the development of this Environmental Statement; they are also consistent with the descriptions and assessments contained in the Beatrice Offshore Wind Farm Environmental Statement (BOWL, 2012). The worst case parameters for the proposed wind farm sites and the transmission infrastructure are as provided in Table 6.2-2, Chapter 6.2 (Sedimentary and Coastal Processes) and Table 9.2-2, Chapter 9.2 (Sedimentary and Coastal Processes) respectively.

Table 13.2-2 Summary of BOWL Worst Case Parameters

Worst case parameters	Scenario assessed
Increase in Suspended Sediment Concentrations	
Installation of 277 turbines	Dredging for GBS bed preparation. Drill arisings from jacket pin pile installation.
Inter array and transmission cable burial	Energetic trenching tool, 'V' shaped trench 3m wide and up to 3m deep, 100 % resuspension.
Sediment accumulation and change of sediment type at the seabed	
Installation of 277 turbines	Dredging for GBS bed preparation. Drill arisings from jacket pin pile installation.
Changes to the Sediment Transport Regime	
Installation of 277 turbines	60 m diameter GBS
Scour Effects	
Installation of 277 turbines	60 m diameter GBS

Western Development Area

13.2.3.4 The Western Development Area (WDA) comprises part of the MORL Zone, within which the three proposed wind farm sites (Telford, Stevenson and MacColl) are located. The maximum capacity to be installed in the entire Zone is 1.5 GW and MORL has applied for a maximum of 1.5 GW within three proposed wind farm sites.

13.2.3.5 The WDA may be developed for a maximum of 500 MW of capacity if less than 1.5 GW of capacity is delivered by the Project in the EDA. In total the consented capacity of the Project and the WDA will not exceed 1.5 GW.

13.2.3.6 The connection between the WDA and the three proposed wind farm sites necessitates a slightly different approach to assessment, as the effects arising from the "worst case" for the Project cannot simply be added to the "worst case" scenario for the WDA. Instead, assessment of the likely significant cumulative effects of the Project and the WDA will therefore follow a similar format to that undertaken for the sensitivity assessments of the individual wind farm proposals in the Offshore Generating Station Impact Assessment chapters.

13.2.3.7 A summary of the worst case parameters of wind farm design for the WDA in terms of sedimentary and coastal processes are provided below in Table 13.2-3.

Table 13.2-3 Summary of MORL WDA Worst Case Parameters

Worst case parameters	Scenario assessed
Increase in Suspended Sediment Concentrations	
Installation of 139 turbines in the WDA (instead of in the EDA)	Dredging for GBS bed preparation. Drill arisings from jacket pin pile installation.
Sediment accumulation and change of sediment type at the seabed	
Installation of 139 turbines in the WDA (instead of in the EDA)	Dredging for GBS bed preparation. Drill arisings from jacket pin pile installation.
Changes to the Sediment Transport Regime	
Installation of 139 turbines in the WDA (instead of in the EDA)	65 m diameter GBS
Scour Effects	
Installation of 139 turbines in the WDA (instead of in the EDA)	65 m diameter GBS

13.2.4 Impact Assessment

13.2.4.1 This assessment considers the cumulative effect of the three proposed wind farms and the BOWL Wind Farm, including associated OfTI, collectively referred to as 'the combined wind farm developments'.

13.2.4.2 The types of effects that will be considered in this cumulative impact assessment on are:

- Increase in suspended sediment concentrations (SSC);
- Sediment accumulation and change of sediment type at the seabed;
- Changes to the sediment transport regime; and
- Scour effects.

13.2.4.3 These are considered in relation to the construction, operation and decommissioning phases of development.

Construction

13.2.4.4 The cumulative effects of the combined wind farm developments on the sedimentary regime and morphological features during the construction phase of the developments are now considered. More details of this assessment may be found in Technical Appendix 3.4 C ABPmer (2011c).

Increase in Suspended Sediment Concentrations

Sensitive Receptor: Smith Bank

13.2.4.5 Cumulative effects of multiple and simultaneous sources of sediment release may potentially arise due to:

- The Project and BOWL foundation installation (drilling for pin piles or bed preparation for GBS);
- The Project and BOWL inter-array cable burial; and
- The Project and BOWL export cable burial.

13.2.4.6 Impact assessment has previously been provided for the individual sources of sediment release considered for the Project. As already reported in the Beatrice Offshore Wind Farm Environmental Statement (BOWL, 2012), the type and scale of effects from similar operations undertaken by other developments will be of a similar nature and magnitude to that previously provided in Chapter 6.2 (Sedimentary and Coastal Processes) for the three proposed wind farms.

13.2.4.7 The maximum cumulative result of interaction between sediment plumes is an additive increase in SSC.

13.2.4.8 If foundation installation activities occur simultaneously at multiple adjacent locations, there is a potential that plumes of increased SSC will interact. However, given the minimum spacing of the turbines and the width of the plume, if the adjacent locations are not aligned along the direction of the tidal current, there is no potential for the plumes to interact. If the adjacent locations are aligned to the tidal axis, turbine foundations are located a minimum of 600 m (crosswind) or 840 m (downwind) apart so the downstream level of SSC in the sediment plume from the upstream source will have decreased to 20 mg / l or less. At most, this may cause the levels of SSC adjacent to the downstream source to increase from 30 to 40 mg / l, to 50 to 60 mg / l. The SSC level of the more disperse effects (1 to 5 mg / l) outside of the main plume during operations and in the area of plume following cessation of operations are unlikely to be changed as a result of cumulative effects.

13.2.4.9 Foundation installation will be completed before the local inter-array cables are laid. For operational safety, it is also unlikely that cables will be simultaneously buried less than 10s of metres from each other or from any other operation. Therefore, only the low-level dispersal effects from dredging or drilling activities (order of 1 to 5 mg / l) have the potential to combine with the higher-level effects of cable burial site (1,000s to 10,000s of mg / l). Therefore, there is no potential for (measurable) interaction between cable burial and foundation installation activities.

13.2.4.10 The cumulative effects of plume interaction from a variety of sources are of a magnitude consistent with the natural range of variability (order 1,000 to 10,000 mg / l nearbed and order 10 to 100 mg / l higher in the water column). Local effects around cable burial machines may be potentially in excess of the natural range of variability but will also be only localised and temporary.

13.2.4.11 A low to medium magnitude of change that may locally and temporarily exceed the range of natural variability is therefore assessed to arise in an area of low sensitivity, resulting in a temporary negative cumulative effect of **minor significance.**

Sediment Accumulation and Change of Sediment Type at the Seabed

Sensitive Receptor: Smith Bank

13.2.4.12 Relatively thick (up to several metres) sediment accumulation will occur in the near-field vicinity of jacket foundations where pin piles are installed by drilling. These deposits will be localised and therefore will not coalesce between foundations or between wind farm sites, posing no cumulative effect.

13.2.4.13 The maximum thickness of sediment accumulation in the far field is less than 1 mm, associated with the deposits from the three proposed wind farms and OfTI. Additional deposits from the development of the BOWL Wind Farm site and OfTI are transported equally far and in the same direction, but to a location west of the deposit from the three proposed wind farms. This occurs as the two sites are located side by side, rather than in line, in relation to the tidal axis.

13.2.4.14 The effects of dredging as part of bed preparation for GBS foundations in terms of thickness of accumulation are generally of a magnitude consistent with the natural range of variability and so will not affect total water depths. The accumulation of a variable thickness of fine sediment to areas presently indicated to be mostly sands or sandy-gravels outside of the combined wind farm developments may temporarily change the sediment surface texture in that area; however, these fine sediment accumulations are expected to be reworked and dispersed to background concentrations by storms on short to medium time-scales.

13.2.4.15 A low magnitude of change within the range of natural variability is therefore assessed to arise in areas of low sensitivity. The resulting significance of cumulative effect is therefore **not significant**.

Operation

13.2.4.16 The following paragraphs consider the cumulative impact of the combined wind farm developments. More details of this assessment may be found in Technical Appendix 3.4 C, ABPmer (2011c).

Changes to the Sediment Transport Regime

Sensitive Receptor: Smith Bank

13.2.4.17 It is the combined wave and tidal regimes that ultimately control sediment transport and therefore the seabed form within the study area (see Figure 3.1-1, Volume 6 a). It was shown in Chapter 13.1 (Hydrodynamics: Wave Climate and Tidal Regime) that the cumulative effect of the combined wind farm developments causes no significant change to the speed or directions of tidal currents. It was also shown that GBS foundations will cause a reduction in instantaneous significant wave height within the combined wind farm developments of up to 21 % (but more typically 10 % or less across most of the site area) and up to 5 % in the far-field, which is of the same order as inter-annual and inter-decadal variability in storm intensity. Jackets will have little or no measurable effect (< 1 %) on wave height. Neither GBS nor Jacket foundations will measurably affect wave period or direction.

13.2.4.18 Given no significant effect on the physical processes that control sediment transport, there can be no corresponding effect on rates and directions through the combined wind farm developments (provided that the supply of sediment is available for transport).

13.2.4.19 Other parts of this Chapter (13.2.4.12) have considered the potential for the construction of the wind farm to affect the character or abundance of surface sediments (e.g. as a result of ground preparation, drilling or cable burial activities) and found it to be not significant. Whilst some short to medium term localised increases in sediment thickness are expected, there is not expected to be a significant change in the textural properties of the sediment available for transport. This supports the further conclusion that actual sediment transport rates through the combined wind farm developments will not be affected by the planned development.

13.2.4.20 The general effect of a reduction in wave height on sediment transport pathways and resulting morphology in the combined wind farm developments is:

- The area within the combined wind farm developments may tend to accumulate sediment at a slightly rate higher than would have otherwise occurred during the operational lifetime of the development; and
- The supply of sediment to areas located further into the Moray Firth might be slightly less than would have otherwise occurred during the operational lifetime of the development.

13.2.4.21 However, as stated above, the absolute difference in sediment transport attributable to the wind farm is less than the potential for natural variability over the same period.

13.2.4.22 There will, therefore, be no effect on the form or function of Smith Bank.

13.2.4.23 A low magnitude of change within the range of natural variability is therefore assessed to arise in areas of low sensitivity. The resulting significance of cumulative effect is **not significant**.

Sensitive Receptor: Designated Coastal Habitats

13.2.4.24 It was demonstrated above that there will be no significant effect on sediment transport rates through the combined wind farm developments as a result of their presence. The main effects on tidal currents and waves are generally confined to the wind farm site extents and are of a lower magnitude elsewhere. Therefore, there willbe no corresponding effect upon the rate of sediment supply to other parts of the Moray Firth.

13.2.4.25 The effect of the combined wind farm developments on wave height, period and direction at the location of designated coastal habitats has been considered in Chapter 14.1 (Benthic Ecology), and was found to be not significant both in absolute terms and in the context of natural variability. There will, therefore, be no corresponding effect upon the rates or directions of nearshore sediment transport at these locations.

13.2.4.26 There will, therefore, be no effect on the form or function of designated coastal habitats.

13.2.4.27 A low magnitude of change within the range of natural variability is therefore assessed to arise in areas of low to medium sensitivity. The resulting significance of cumulative effect is therefore **not significant**.

Scour Effects

Sensitive Receptor: Smith Bank

13.2.4.28 There is a potential for scour to develop around obstacles to flows, where and when scour protection is not applied. Where scour protection is applied, scour might possibly occur in the interim period between installation of the object and placement of the protection.

13.2.4.29 Using empirical relationships described in Whitehouse (1998), the equilibrium scour depth for each foundation type resulting from waves and currents, both alone and in combination has been calculated for different foundation sizes. Results have also been up-scaled for the cumulative numbers of foundations in the combined wind farm developments and the total area found as a proportion of the wind farm(s) area.

13.2.4.30 The largest total footprint of scour is assessed to occur in response to the lowest rated GBS scenario (i.e. the greatest number of turbines) at 0.7 % of the total area of the three proposed wind farms and the BOWL Wind Farm. Other foundation types and rating scenarios result in a smaller relative area of effect.

13.2.4.31 Where and when exposed, export and inter-array cable infrastructure might also induce some local scour, but only of a very small magnitude (order of 10s of centimetres). Scour associated with gravity based OSP foundations is of a similar order to that of the turbine foundations and is considered as a minor increase to the values already presented.

13.2.4.32 The effects of the foundations in causing scour are of a low to medium magnitude relative to the range of naturally occurring variability in seabed level but do not cause the normal range of water depths to be exceeded. The effects of scour are limited to only a small proportion of the area of each of the three proposed wind farms and an even smaller proportion of the area of Smith Bank.

13.2.4.33 A low to medium magnitude of change that does not exceed the range of natural variability is therefore assessed to arise in an area of low sensitivity. The resulting cumulative effect is therefore of minor significance.

Decommissioning

13.2.4.34 It is considered that the methods likely to be employed during decommissioning will be of a similar general nature but overall less energetic and disturbing a smaller volume of sediment than previously assessed in relation to construction. Therefore, the types of effect from decommissioning and their significance can only be considered to be similar to, or less than, that already provided above (either not significant or of minor significance).

13.2.5 Assessment of WDA

13.2.5.1 The effect of locating 500 MW capacity (a maximum of 139 turbines) into the WDA instead of in the three wind farm sites has also been considered. More details of this sensitivity assessment may be found in Technical Appendix 3.4 C (ABPmer, 2012b). The WDA has been assessed on the basis of a 3.6 MW layout (i.e. the largest number and closest spacing of turbine foundations and the largest corresponding potential effect on sedimentary processes). It is noted that there is presently no decision or indication as to which of the three sites might be built with less than the presently planned capacity.

13.2.5.2 The results of the sensitivity assessment in terms of both magnitude and extents of effect, and the resulting levels of significance, are the same as reported previously for developments in the EDA including the three wind farms in Section 3, Chapter 6.2 (Sedimentary and Coastal Processes) and for the OfTI in Section 4, Chapter 9.2 (Sedimentary and Coastal Processes). Other consequential (indirect) effects are also considered, where relevant, in other chapters: Chapter 14.1 (Benthic Ecology); Chapter 14.2 (Fish and Shellfish Ecology); and Chapter 15.5 (Archaeology).

13.2.6 Habitats Regulations Appraisal

13.2.6.1 Likely cumulative effects from the construction, operation and decommissioning of development in the area, and assessed above, on the physical marine environment are of negligible significance and therefore do not give rise to Habitats Regulations Appraisal concerns. The effects on the physical marine environment considered in this section are also considered with respect to the requirements for Habitats Regulation Assessment in other chapters: Chapter 10.1 (Benthic Ecology); Chapter 10.2 (Fish and Shellfish Ecology); Chapter 10.4 (Ornithology); and Chapter 12.2 (Habitat Regulations Appraisal Summary).

13.2.7 References

ABPmer, 2011c. Moray Firth Round 3 Zone: Physical Processes Scheme Impact Assessment. ABPmer Report R1894.

BOWL, 2012. Beatrice Offshore Wind Farm Environmental Statement.

ERM 2011. Cumulative Impacts Assessment Discussion Document. For the Moray Firth Offshore Wind Developers Group, April 2011. 181pp.

Whitehouse, R.J.S.,1998. Scour at marine structures: A manual for practical applications. Thomas Telford, London, 198 pp.

13.3 Hydrology, Geology and Hydrogeology

13.3.1 Summary

13.3.1.1 A summary of the likely significant cumulative effects is provided in Table 13.3-1 below. In general, following mitigation, the cumulative effect on the hydrology, geology and hydrogeology is considered to be **insignificant** or of **minor significance**.

13.3.1.2 A key effect considered as part of all cumulative sites is water pollution due to construction activities. Although this could lead to a cumulative effect, the spatial distribution and the timing of the works makes it highly unlikely that there will be a significant cumulative effect on any surface water or groundwater body.

13.3.1.3 Generally, all sites will be required to minimise the effect on the water environment through effective drainage solutions and pollution prevention measures to acceptable levels within the site boundary. This reinforces the assessment that there will be no significant cumulative effect.

Table 13.3-1 Cumulative Impact Summary

Effect	Receptor	Individual Effect	Cumulative Effect	Mitigation Method (if required)
Changes to surface runoff and drainage	Kessock Burn catchment	Insignificant (areas with low gradient topography) Minor significance (areas with moderate or high gradient topography)	None (no cumulative sites in catchments)	N / A
	Water of Philorth Catchment			
	Burn of Savoch catchments (Ellie Burn, Green Burn and Burn of Logie)			
	North Ugie Water catchment		Minor significance	None required
	South Ugie Water catchment			
	Burn of Faichfield catchment			
	Remaining River Ugie catchments			
	Unnamed catchment south of Peterhead		None (no cumulative sites in catchments)	N / A
	Unnamed catchment at Peterhead Power Station			
	Soils	Insignificant	Minor significance	None required
Subsoil compaction and reduced infiltration	Kessock Burn catchment	Insignificant	None (no cumulative sites in catchments)	N / A
	Water of Philorth Catchment			

Effect	Receptor	Individual Effect	Cumulative Effect	Mitigation Method (if required)
Subsoil compaction and reduced infiltration (continued)	Burn of Savoch catchments (Ellie Burn, Green Burn and Burn of Logie)			
	North Ugie Water catchment		Minor significance	None required
	South Ugie Water catchment			
	Burn of Faichfield catchment			
	Remaining River Ugie catchments			
	Unnamed catchment south of Peterhead		None (no cumulative sites in catchments)	N / A
	Unnamed catchment at Peterhead Power Station			
	Soils	Insignificant	Minor significance	None required
Localised overland flooding	All catchments	Minor significance	Effect not assessed / not relevant in other developments	N / A
Excessive erosion and sedimentation	Kessock Burn	Minor significance	None (no cumulative sites in area)	N / A
	Water of Philorth			
	Burn of Savoch tributaries (Ellie Burn, Green Burn and Burn of Logie)			
	North Ugie Water		Minor significance	None required
	South Ugie Water			
	Burn of Faichfield			
	River Ugie			
	Unnamed watercourse south of Peterhead		None (no cumulative sites in area)	N / A
	Unnamed watercourse at Peterhead Power Station			
	Minor watercourses throughout study area		Minor significance	None required
	Loch of Strathbeg	Minor significance	None (no cumulative sites in area)	N / A

Effect	Receptor	Individual Effect	Cumulative Effect	Mitigation Method (if required)
Excessive erosion and sedimentation (continued)	Soils	Minor significance	Minor significance	None required
	(surface) Water Supplies/ abstraction	Minor significance	Minor significance	None required
Alteration of groundwater levels/patterns (groundwater and dependent water supplies)	Groundwater (Class 2)	Minor significance	Minor significance	None required
	Groundwater (Class 3)	Minor significance		
	Groundwater (Class 4b, 4c and 4d)	Minor significance		
	(Ground) water supplies/ abstractions	Minor significance	Minor significance	None required
Water quality deterioration due to construction activities	Kessock Burn	Minor significance	None (no cumulative sites in area)	N / A
	Water of Philorth			
	Burn of Savoch tributaries (Ellie Burn, Green Burn and Burn of Logie)			
	North Ugie Water		Minor significance	None required
	South Ugie Water			
	Burn of Faichfield			
	River Ugie			
	Unnamed watercourse south of Peterhead		None (no cumulative sites in area)	N / A
	Unnamed watercourse at Peterhead Power Station			
	Minor watercourses throughout study area		Minor significance	None required
	Loch of Strathbeg	Minor significance	None (no cumulative sites in area)	N / A
	Water Supplies	Minor significance	Minor significance	None required
	Groundwater (Class 2)	Minor significance	Minor significance	None required
	Groundwater (Class 3)	Minor significance		
	Groundwater (Class 4b, 4c and 4d)	Minor significance		
Loss of agricultural soils and peat	Soils	Insignificant	Minor significance	None required
	Peat	Insignificant	None (no cumulative sites in area)	N / A

Effect	Receptor	Individual Effect	Cumulative Effect	Mitigation Method (if required)
Sterilisation of Mineral Reserves	Mineral Reserves	Insignificant	Effect not assessed / not relevant in other developments	N / A
Disturbances to small watercourses at crossing locations (small rivers)	Kessock Burn	Insignificant to Minor significance	None	N / A
	Burn of Savoch tributaries (Ellie Burn, Green Burn and Burn of Logie)			
	Unnamed watercourse south of Peterhead			
	Unnamed watercourse at Peterhead Power Station			
	Unnamed watercourse at Peterhead Power Station			
	Minor watercourses throughout study area	Insignificant		
Disturbance to medium and large rivers and floodplains (medium to large rivers and floodplains)	Water of Philorth	Minor significance	None	N / A
	North Ugie Water			
	South Ugie Water		Effect not assessed / not relevant in other developments	N / A
	Burn of Faichfield	Insignificant to Minor significance	None	N / A
	River Ugie	Minor significance	Effect not assessed / not relevant in other developments	N / A
Loss of coastal flood protection	Dunes	Insignificant	Effect not assessed / not relevant in other developments	N / A
Damage to geological / geomorphological sites	Kirkhill and Philorth Valley SSSI	Minor significance	Effect not assessed / not relevant in other developments	N / A
	Sinclair Hills SESA	Minor significance		
Disturbance and movement of contaminated materials	Soils	Minor significance	Effect not assessed / not relevant in other developments	N / A
	Peat	Minor significance		
	Superficial Geology	Insignificant		
	Kessock Burn	Minor significance		
	Water of Philorth			

Effect	Receptor	Individual Effect	Cumulative Effect	Mitigation Method (if required)
Disturbance and movement of contaminated materials	Burn of Savoch tributaries (Ellie Burn, Green Burn and Burn of Logie)	Minor significance	Effect not assessed / not relevant in other developments	N / A
	North Ugie Water			
	South Ugie Water			
	Burn of Faichfield			
	River Ugie			
	Unnamed watercourse south of Peterhead			
	Unnamed watercourse at Peterhead Power Station			
	Minor watercourses throughout study area			
	Water Supplies			
	Groundwater (Class 2)			
	Groundwater (Class 3)			
	Groundwater (Class 4b, 4c and 4d)			
Pollution of water supplies	Water supplies	Minor significance	Minor significance	None required
Human health effects from contaminated materials	Human Health	Minor significance	Effect not assessed / not relevant in other developments	N / A
Damage to construction materials by contaminated ground	Construction materials	Insignificant	Effect not assessed / not relevant in other developments	N / A

13.3.2 Assessment of Cumulative Effects

13.3.2.1 This chapter presents the results of assessment of the likely significant cumulative effects upon the hydrology, geology and hydrogeology arising from the MORL Onshore Transmission Infrastructure (OnTI). The Assessment is undertaken in conjunction with other existing or reasonably foreseeable marine and coastal developments and activities.

13.3.2.2 This chapter contains relevant information on the OnTI to allow Scottish Ministers and Marine Scotland to make decisions on the applications for Section 36 consents and Marine Licences for the three proposed wind farm sites and the OfTI. Discussions are ongoing with landowners to determine the exact location and layout of the substation(s) on their land within the preferred onshore substation area. This will be finalised following production of a masterplan by the owner / operator of the Peterhead Power Station compound which forms part of the preferred area. Once the precise location and layout for the onshore substation(s) and export cable location has been confirmed, an application for planning permission for the OnTI will be submitted to Aberdeenshire Council and will be supported by this ES and such further information as is required to support the planning application.

13.3.2.3 The developments and activities considered within the cumulative impact assessment are listed in Table 13.3-2 below and also shown in Figure 1.3-2, Volume 6 a.

Table 13.3-2 Cumulative Impact Assessment Scope – Developments and Activities

Name	Details	Evidence	Planning status	Construction timescale
Within the study area				
SHETL substation	Erection of electrical equipment and associated infrastructure	Consultation document, Jan 2012 (Scottish Hydro-Electric Transmission Ltd, 2012)	Information Awaited	Information Awaited
Peterhead Power Station	Erection of 550 MW gas turbine power station, associated buildings, plant and 2 x 90m high gas turbine stacks.	ES, published Aug 2006 (ERM, 2006)	Approved Jun 2007	Not known
Within 5 km of the study area				
Overside and Greenwellheads Farms (wind farm)	Erection of 4 x 99.5 m high (to blade tip) 2.3 MW wind turbines.	ES, published Mar 2011 (Green Cat Renewables, 2011a)	In planning	Not known
St Fergus Moss (wind farm)	Three wind turbines, < 100 m to blade tip with associated infrastructure, proposed by The Greenspan Agency	ES, published Jun 2010 (The Greenspan Agency, 2010a)	Approved, Feb 2012	Not known
Ednie Farms (Bruxiehill Wind Farm Extension)	Erection of 2 x 79.6 m high (to blade tip) 800 KW wind turbines and associated infrastructure.	Environmental report, published Nov 2009 (Green Cat Renewables, 2009)	Approved Sep 2010	Not known

Name	Details	Evidence	Planning status	Construction timescale
Redbog Extension (wind farm)	Two wind turbines, < 80 m to blade tip with associated infrastructure, proposed by Peter Chapman	ES, published Nov 2010 (Green Cat Renewables, 2010)	In planning	Not known
Middleton of Rora (wind farm)	Erection of 81m high (to blade tip) 850 KW wind turbine, also construction of substation, hardstanding, foundation and access track.	Environmental report, published Aug 2010 (The Greenspan Agency, 2010b)	Approved Sep 2011	Not known
Mains of Inverugie (wind farm)	Erection of 79.6 m high (to blade tip) wind turbine and associated infrastructure.	Environmental report, published Nov 2011 (Green Cat Renewables, 2011b)	In planning	Not known
Keith Inch and Green Hill (wind farm)	Erection of 2 x 99.5 m high (to blade tip) 2.3 MW wind turbines and associated infrastructure.	Environmental Statement, published Mar 2011 (Green Cat Renewables, 2011c)	In planning	Not known
Toux Farm (wind farm)	Erection of 74 m high (to blade tip) wind turbine and transformer housing unit.	No hydrological, geological or hydrogeological assessment available	In planning	Not known
Gallows Hill, Inverquhomery Wind Turbine	Erection of 79.6 m high (to blade tip) wind turbine and associated infrastructure.	Environmental Statement, published Aug 2011 (Fowlie et al., 2011)	Approved Mar 2012	Not known
Aldie Wind Farm	Erection of 2 x 87 m high (to blade tip) wind turbines and associated infrastructure.	Supporting Statement (TNEI, 2011)	In planning	Not known
3 meteorological masts	Temporary erection of met masts at West Knock, Baluss and Nether Aden Farm	Not assessed in detail	N / A	N / A
Further than 5 km away, within study area catchments				
7 wind farms	Erection of between 1 and 3 wind turbines at each site with blade tip heights up to 99.5 m	Not assessed in detail	N / A	N / A
2 meteorological masts	Temporary erection of met masts	Not assessed in detail	N / A	N / A

13.3.3 Methodology

13.3.3.1 MORLs approach to the assessment of cumulative effects is described in Chapter 1.3 (Environmental Impact Assessment).

13.3.3.2 All planned developments within 5 km of the onshore cable route or substation or within the study area's hydrological catchments and for which environmental statements (ESs) were available have been researched and considered (see Table 13.3-1 above and Figure 1.3-2, Volume 6 a).

13.3.3.3 Within the study area itself, two proposed developments have been identified: the Scottish Hydro Electric Transmission Ltd (SHETL) substation and the Peterhead Power Station.

13.3.3.4 All developments are assessed for likely significant cumulative hydrology, geology and hydrogeology effects with those effects identified by the Hydrology, Geology and Hydrogeology impact assessment in Chapter 9.3. Information on each development's effect has been taken from the relevant Environmental Statements where available.

13.3.4 Impact Assessment

13.3.4.1 The likely significant effects that are reviewed in this cumulative impact assessment are:

- Changes to surface runoff and drainage;
- Subsoil compaction and reduced infiltration;
- Localised overland flooding;
- Excessive erosion and sedimentation;
- Alteration of groundwater levels/patterns;
- Water quality deterioration due to construction activities;
- Loss of agricultural soils and peat;
- Sterilisation of sand and gravel/granite reserves;
- Disturbances to small watercourses at crossing locations;
- Disturbance to floodplains;
- Loss of coastal flood protection;
- Damage to geological/geomorphological sites;
- Disturbance and movement of contaminated materials;
- Pollution of water supplies;
- Human health effects from contaminated materials; and
- Damage to construction materials by contaminated ground.

Changes to Surface Runoff and Drainage

13.3.4.2 Environmental impact assessments for most proposed developments considered in the cumulative assessment include an evaluation of the effect on runoff and drainage. This effect is associated with the construction of road, tracks, buildings and impermeable surfaces in general.

13.3.4.3 The relevant receptor catchments potentially affected are shown in Table 13.3-3 below.

Table 13.3-3 Receptors Cumulative Effect Changes to Surface Runoff and Drainage

Receptor	Cumulative Site Name	Cumulative Development Description
North Ugie Water catchment	Toux Farm	Wind turbines
	Red Bog extension	Wind turbines
South Ugie Water catchment	Upper Kinknockie	Wind turbines
	Newton of Kinmundy	Wind turbines
	West Crichie	Wind turbines
	West Knock Farm	Wind turbines
	West Knock	Meteorological mast
	Gallows Hill, Inverquhomery	Wind turbine
	North Windhill	Wind turbines
	Nether Aden Farm	Meteorological mast
	Baluss	Meteorological mast
	Bogenjohn Farm	Wind turbines
Burn of Faichfield catchment	Aldie Wind Farm	Wind turbines
Remaining River Ugie catchments	St. Fergus Moss	Wind turbines
	St. Fergus Moss	Meteorological mast
	Middleton of Rora	Wind turbine
	Main of Inverugie	Wind turbine
Other catchments	None	

13.3.4.4 Where considered, this effect for the cumulative sites on the relevant catchments has been reported as low to negligible significance.

13.3.4.5 The cumulative effect with the proposed onshore cable route is considered insignificant. This is because the effect is highly localised. All developments include very small proportions of the relevant catchment areas being developed. Additionally, all developments include mitigation measures, for example, sustainable drainage systems (SUDS), which ensure there is no significant effect on runoff and drainage processes.

13.3.4.6 The proposed SHETL substation and the proposed Peterhead Power Station (gas turbine) are located in the same area as the proposed substation for the Telford, Stevenson and MacColl wind farms near the existing Peterhead Power Station. If all developments take place, a larger proportion of the catchment area (currently greenfield) may be developed. Here, all developments would be required to implement effective drainage systems in line with Aberdeenshire Council and Scottish Environmental Protection Agency (SEPA) guidance. The cumulative effect of these developments on runoff and drainage on relevant catchments is therefore considered insignificant or of **minor** significance.

Subsoil Compaction and Reduced Infiltration

13.3.4.7 Although soil compaction and the effect on infiltration is not explicitly discussed in the assessments of the cumulative sites, this effect is related to changes to runoff and drainage and is due to groundworks, construction of hardstanding areas etc. This effect therefore relates to the same receptors as shown in Table 13.3-3 above.

13.3.4.8 The cumulative effect on relevant catchments is therefore considered of **minor** significance.

Localised Overland Flooding

13.3.4.9 The ESs for the cumulative sites do not include consideration of effects from localised overland flooding. It is therefore assumed that this effect is not relevant to the proposed developments for the cumulative sites and hence does not require to be considered cumulatively with the proposed OnTI.

Excessive Erosion and Sedimentation

13.3.4.10 Likely significant erosion and sedimentation effects have been considered for a number of the cumulative sites.

13.3.4.11 The relevant receptors are the rivers within the catchments listed in Table 13.3-3 above. Additional receptors are the Loch of Strathbeg, surface water supplies and abstractions and soils.

13.3.4.12 The direct effect on soils is localised and is not expected to have a cumulative effect.

13.3.4.13 In relation to surface waters, the cumulative effect on downstream water quality due to sediment laden runoff could potentially be significant. Here the cumulative sites are located at sufficient distance from the onshore cable route such that there is not likely to be a significant effect on any given watercourse. Additionally, all sites are likely to be required to use adequate control measures including settlement lagoons to ensure there is **no significant effect** on water quality.

Alteration of Groundwater Levels/Patterns

13.3.4.14 The likely significant effects on groundwater levels and patterns have been considered for a number of the cumulative sites. Cumulative sites are situated above groundwater bodies with vulnerability classes 2, 3, 4a, 4b, 4c and 5. The proposed OnTI extends across groundwater vulnerability classes 2, 3, 4b, 4c and 4d.

13.3.4.15 This effect is highly localised due to small scale dewatering activities, if required. The cumulative effect is therefore considered to be of **minor** significance.

Water Quality Deterioration Due to Construction Activities

13.3.4.16 All cumulative sites include an assessment of the likely significant effect on water quality as a result of construction activities.

13.3.4.17 The relevant receptors are the rivers within the catchments listed in Table 13.3-3 above. Additional receptors are the Loch of Strathbeg, groundwater bodies and water supplies.

13.3.4.18 These effects are potentially cumulative from upstream to downstream along a river or within a single groundwater body. Again, due to the spatial distribution of the sites the cumulative effect is considered to be of **minor** significance.

13.3.4.19 All sites will be required to implement pollution prevention measures to ensure environmental risks are reduced to an acceptable level. Additionally, if a spillage were to occur, it is highly unlikely that such an incident would occur at multiple sites simultaneously along the same river or within the same groundwater body.

Loss of Agricultural Soils and Peat

13.3.4.20 Consideration of loss of peat has not been included in the ESs for the cumulative sites with the exception of St Fergus Moss Wind Farm. The St Fergus Moss ES considers the effects of peat disturbance and carbon loss / payback due to construction activities in the peat bog. Based on the distribution of this peat body as shown on geological plans (Figure 6 in Technical Appendix 3.7 A) and that it does not extend into the MORL study area, then cumulative effects do not require consideration.

13.3.4.21 Based on the location of the remaining cumulative sites which are situated away from areas of peat based on the geological mapping, this effect is not considered relevant to the cumulative sites. Therefore, this effect does not require to be considered cumulatively.

Sterilisation of Sand and Gravel/Granite Reserves

13.3.4.22 The ESs for the cumulative sites do not include consideration of sterilisation of sand and gravel / granite reserves. It is therefore assumed that this effect is not relevant to the proposed developments for the cumulative sites and hence does not require to be considered cumulatively with the proposed OnTI.

Disturbances to Small Watercourses at Crossing Locations

13.3.4.23 Watercourse crossings are required for some of the cumulative development sites. However, these are all over minor streams and ditches. Any disturbance would be limited to the construction phase only and therefore of temporary nature. There are no cumulative sites within or outside the study area that require crossings over the same minor watercourses as required for the proposed OnTI. The cumulative effect is considered of **minor** significance due to the different timings of the construction activities and the spatial distribution of the sites.

Disturbance to Medium and Large Rivers and Floodplains

13.3.4.24 This effect has not been included in the available ESs for the cumulative sites. A review of the locations of the cumulative sites indicates that for the most they are not located within areas at risk of flooding, as shown on SEPAs Indicative River & Coastal Flood Map. The exception to this is the temporary met masts at St Fergus Moss and Baluss which are potentially located in the flood plain associated with the South Ugie Water and Latch Burn which is a tributary of the River Ugie. These developments have not had environmental reports prepared for them and have not been considered under the EIA regulations which indicates that they are not considered significant by default. It is therefore not necessary to consider them cumulatively with the proposed OnTI.

Loss of Coastal Flood Protection

13.3.4.25 This effect has not been included in the ESs for the cumulative sites. Based on the location of the cumulative sites which are not situated on the coast, loss of coastal flood protection (as a result of the damage / loss of sand dunes for example) is not relevant. Therefore, this effect does not require to be considered cumulatively.

Damage to Geological/Geomorphological Designated Sites

13.3.4.26 This effect has not been included in the ESs for the cumulative sites. Based on the location of the cumulative sites which are situated away from known geological / geomorphological designated sites, this effect is not considered relevant to the cumulative sites. Therefore, this effect does not require to be considered cumulatively.

Disturbance and Movement of Contaminated Materials

13.3.4.27 The ESs for the cumulative sites do not include consideration of effects from disturbance and movement of existing contaminated soils. It is therefore assumed that this effect is not relevant to the proposed developments for the cumulative sites and hence does not require to be considered cumulatively with the proposed OnTI.

Pollution of Water Supplies

13.3.4.28 Private water supplies have been considered for some of the cumulative sites. This effect is highly localised in nature and the cumulative effect is therefore considered of **minor** significance.

Human Health Effects from Contaminated Materials

13.3.4.29 The ESs for the cumulative sites do not include consideration of effects on human health from existing contaminated ground during construction / operation of the developments. It is therefore assumed that this effect is not relevant to the proposed developments for the cumulative sites and hence does not require to be considered cumulatively with the proposed OnTI.

Damage to Construction Materials by Contaminated Ground

13.3.4.30 This effect relates to the effect of construction materials specific to the development (e.g. cable materials, concrete) and therefore is restricted to the individual development. Therefore it does not require to be considered cumulatively.

13.3.5 References

ERM (2006). Project DF1: Environmental Statement.

Fowlie, A., Elder, A., Oldroyd, F.(2011). Gallows Hill Wind Turbine: Environmental Statement.

Green Cat Renewables (2009). Bruxiehill Extension: Environmental Report.

Green Cat Renewables (2010). Redbog Extension Environmental Statement.

Green Cat Renewables (2011a). Greenside Wind Cluster: Environmental Statement.

Green Cat Renewables (2011b). Mains of Inverugie: Environmental Report.

Green Cat Renewables (2011c). Peterhead Harbour Wind Turbine Project: Environmental Statement.

Scottish Hydro-Electric Transmission Ltd (2012). Eastern HVDC Link and Associated Infrastructure Scotland Onshore Works; Consultation Document.

The Greenspan Agency (2010a). St Fergus Moss Renewables Project: Environmental Impact Assessment.

The Greenspan Agency (2010b). Middleton Renewables Project: Environmental Report.

TNEI (2011). Aldie Wind Farm: Supporting Statement.

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13.4 Noise (Onshore)

13.4.1 Summary

13.4.1.1 This chapter contains relevant information on the Onshore Transmission Infrastructure (OnTI) to allow Scottish Ministers and Marine Scotland to make decisions on the applications for section 36 consents and marine licences for the three wind farm sites and the OfTI. Discussions are ongoing with landowners to determine the exact location and layout of the substation(s) on their land within the preferred onshore substation area. This will be finalised following production of a masterplan by the owner / operator of the Peterhead Power Station compound which forms part of the preferred area. Once the precise location and layout for the onshore substation(s) and export cable location has been confirmed, an application for planning permission for the OnTI will be submitted to Aberdeenshire Council and will be supported by this ES and such further information as is required to support the planning application.

13.4.1.2 A summary of the likely significant cumulative effects is provided below. In general, following mitigation, the cumulative effect with respect to noise and vibration is considered to be **insignificant**.

13.4.1.3 Although a certain degree of cumulative effect may be experienced with other development, the spatial distribution and the relative timing of the works makes it highly unlikely that there will be a significant cumulative effect on any noise sensitive receptors.

13.4.1.4 It is also worth noting that, generally, all developments will be required to minimise the effects of noise to acceptable levels during construction activities. This reinforces the assessment that there will be no significant cumulative effect.

13.4.2 Assessment of Cumulative Impacts

13.4.2.1 This chapter presents the results of assessment of the likely significant noise cumulative effects arising from the OnTI. It should be noted that this assessment is based solely upon the cumulative effects of the construction phase of both the cable and substation. A separate technical report will be prepared in support of a separate planning application for the substation(s) which will address the likely operational effects of this element of the proposals and thus potential cumulative effects.

13.4.2.2 The cumulative assessment herein is undertaken in conjunction with other existing or reasonably foreseeable marine and coastal developments and activities.

13.4.2.3 The developments and activities considered within the cumulative impact assessment are listed in Table 13.4-1 below.

Table 13.4-1 Cumulative Impact Assessment Scope – Developments and Activities

Name	Details	Evidence	Planning status	Construction timescale
Within the study area				
SHETL substation	Erection of electrical equipment and associated infrastructure	Consultation document, Jan 2012 (Scottish Hydro-Electric Transmission Ltd, 2012)	Information Awaited	Information Awaited
Peterhead Power Station	Erection of 550 MW gas turbine power station, associated buildings, plant and 2 x 90 m high gas turbine stacks.	ES, published Aug 2006 (ERM, 2006)	Approved Jun 2007	Not known
Within 5 km of the study area				
Overside and Greenwellheads Farms (wind farm)	Erection of 4 x 99.5 m high (to blade tip) 2.3 MW wind turbines.	ES, published Mar 2011 (Green Cat Renewables, 2011a)	In planning	Not known
St Fergus Moss (wind farm)	Three wind turbines, < 100 m to blade tip with associated infrastructure, proposed by The Greenspan Agency	ES, published Jun 2010 (The Greenspan Agency, 2010a)	Approved, Feb 2012	Not known
Ednie Farms (Bruxiehill Wind Farm Extension)	Erection of 2 x 79.6 m high (to blade tip) 800 KW wind turbines and associated infrastructure.	Environmental report, published Nov 2009 (Green Cat Renewables, 2009)	Approved Sep 2010	Not known
Redbog Extension (wind farm)	Two wind turbines, < 80 m to blade tip with associated infrastructure, proposed by Peter Chapman	ES, published Nov 2010 (Green Cat Renewables, 2010)	In planning	Not known
Middleton of Rora (wind farm)	Erection of 81m high (to blade tip) 850 KW wind turbine, also construction of substation, hardstanding, foundation and access track.	Environmental report, published Aug 2010 (The Greenspan Agency, 2010b)	Approved Sep 2011	Not known
Mains of Inverugie (wind farm)	Erection of 79.6 m high (to blade tip) wind turbine and associated infrastructure.	Environmental report, published Nov 2011 (Green Cat Renewables, 2011b)	In planning	Not known

Name	Details	Evidence	Planning status	Construction timescale
Keith Inch and Green Hill (wind farm)	Erection of 2 x 99.5 m high (to blade tip) 2.3 MW wind turbines and associated infrastructure.	Environmental Statement, published Mar 2011 (Green Cat Renewables, 2011c)	In planning	Not known
Toux Farm (wind farm)	Erection of 74 m high (to blade tip) wind turbine and transformer housing unit.	No hydrological, geological or hydrogeological assessment available	In planning	Not known
Gallows Hill, Inverquhomery Wind Turbine	Erection of 79.6 m high (to blade tip) wind turbine and associated infrastructure.	Environmental Statement, published Aug 2011 (Fowlie et al., 2011)	Approved Mar 2012	Not known
Aldie Wind Farm	Erection of 2 x 87 m high (to blade tip) wind turbines and associated infrastructure.	Supporting Statement (TNEI, 2011)	In planning	Not known
Three meteorological masts	Temporary erection of met masts at West Knock, Baluss and Nether Aden Farm	Not assessed in detail	N / A	N / A

13.4.3 Methodology

13.4.3.1 MORLs approach to the assessment of cumulative effects is described in Chapter 1.3 (Environmental Impact Assessment).

13.4.3.2 All planned developments within 5 km of the onshore cable route or substation and for which Environmental Statements (ESs) were available have been researched and considered (see Table 13.4-1 above).

13.4.3.3 Within the study area itself, two proposed developments have been identified: the Scottish Hydro Electric Transmission Ltd (SHETL) substation and the Peterhead Power Station.

13.4.3.4 Where relevant, developments are assessed for likely significant cumulative noise effects with those effects identified by the noise impact assessment in Chapter 9.4. Information on each development's impact has been taken from the relevant Environmental Statements where available.

13.4.4 Impact Assessment

Approach

13.4.4.1 In considering the potential for cumulative noise effects, a two stage appraisal has been completed in order to identify those developments that have the potential for significant cumulative effect with the OnTI works.

13.4.4.2 The first stage of the appraisal focussed on the distance between the respective other developments and the study area, discounting any developments that

were considered unlikely to contribute to significant cumulative effects. All remaining sites were then taken through to the second stage which assesses the likely significant cumulative effects based upon the reported effect, reported within this ES, and the reported effects within the relevant ES documentation associated with the relevant other developments.

13.4.4.3 The outcome of the two stages are described below.

Stage 1 – Development Proximity

13.4.4.4 Paragraph 9.4.5.10 in Chapter 9.4 (Noise: Onshore) reports the worst case unmitigated effects as:

"At night, unmitigated noise from construction and asphalting / road surfacing activities at locations less than 500 m away from dwellings are considered to be significant."

13.4.4.5 This also applies to cable installation at night. The distances at which unmitigated effects may be significant during the daytime (when most activity will take place) are an order of magnitude less (50 m) in comparison.

13.4.4.6 Taking account of these worst case predictions, and the reported assessments of the other developments where available, it is considered reasonable to assume that any development more than 1 km from the OnTI is highly unlikely to have significant cumulative effects.

13.4.4.7 Applying this rationale the following developments have been considered in terms of cumulative impacts with the OnTI:

- Peterhead Power Station;
- SHETL substation;
- Middleton of Rora; and
- Red Bog extension.

Stage 2 – Cumulative Assessment

13.4.4.8 From the information available it is clear that the key noise effects considered with respect to Peterhead Power Station related to the construction and operational noise of the new development proposed. It was considered that noise emissions would occur related to construction works and plant, and also construction transportation. However, it was considered that, with the application of standard noise controls, codes of practice, and mitigation (enforced through the employment of a site HSSE Plan), no significant residual effects would occur. With both the OnTI and Peterhead Power Station reporting no significant residual effects, it is considered that no significant cumulative effects will result.

13.4.4.9 SHETL substation is currently going through an appraisal process within SHETL, including final site and route selection for the cable and substation, with an application for construction and operation yet to be submitted. For this reason, the predicted effects for the construction of the HVDC cable and substation are not known and cannot readily be assessed in combination with the effects of the OnTI works.

13.4.4.10 Middleton of Rora wind turbine received a screening opinion from Aberdeenshire Council that a formal EIA was not required for the development. EIAs are required where it is felt that a development is likely to have a significant environmental effect and it is thus considered that this development would be unlikely to result in significant cumulative effects in combination with the OnTI. Moreover, the environmental report which supports the Rora Wind Turbine application only considers operational effects of the turbine.

13.4.4.11 The Red Bog extension was subject to a formal EIA, however, reported effects were not significant for this development with the key focus on the likely operational effects of the wind turbines. It is not considered that there is potential for cumulative effect between the construction of the onshore export cable and Red Bog extension.

13.4.5 References

ERM (2006). *Project DF1: Environmental Statement.*

Green Cat Renewables (2010). *Redbog Extension Environmental Statement.*

Scottish Hydro-Electric Transmission Ltd (2012). *Eastern HVDC Link and Associated Infrastructure Scotland Onshore Works; Consultation Document*.

The Greenspan Agency (2010b). *Middleton Renewables Project: Environmental Report*.

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