9. HYDROLOGY, HYDROGEOLOGY, GEOLOGY, SOILS AND PEAT

Executive Summary

This chapter considers the likely significant effects on hydrology, hydrogeology, soils and peat associated with the construction, operation and decommissioning of the proposed varied development.

There are a number of watercourses and lochans on the site, as illustrated in Figure 9.1: Surface Water Setting. Online Flood Mapping indicates that areas of high and medium flood risk are confined to the areas alongside the lochans and watercourses, as well as some small areas of surface water flood risk. However, no infrastructure would be located within these flood risk areas.

The majority of the site is underlain by bedrock geology of metamorphosed sedimentary rock as illustrated in Figure 9.2: Bedrock Geology. The bedrock is mostly overlain with diamicton till deposits and extensive blanket bog and other peatland habitats (togethering accounting for more than 90% of the total semi-natural habitats) as shown in Figure 9.3: Superficial Geology. Shallow rock head or rock outcrop is found in stream beds and at the summit of ridges and hills. The carbon-rich soils, deep peat and priority peatland habitat mapping (SNH, 2016[1]) identifies the site as predominantly 'class 1' where 'all vegetation cover indicates priority peatland habitat; all soils are carbon-rich soils and deep peat', however it is noted that the extensive surveying carried out to inform the Habitat Management Plan (HMP) potential restoration areas identified that approximately 25% of the peatland habitats on the site have upwards of 20% bare peat and can therefore be considered to be degraded.

The distribution and character of soils across the site varies according to geology, topography and drainage. Site surveys undertaken for the ES confirmed that the dominant soil types were 'deep and eroded blanket peat' and 'deep blanket peat', accounting for 79.5% of the site area. An updated peat and soil characterisation survey was undertaken in 2018, which confirms that:

- peat is widespread across the site, predominately on flat lying ground in the small valleys between hills on site;
- approximately 12% of probe locations identified soil/peaty soils < 0.5 m in depth;
- approximately 42% recorded peat >0.5 m and less than 1.5 m; and
- approximately 43% of probes measuring peat > 1.5 m[2] up to a maximum depth of 5.75 m.

The underlying soil/peat thickness recorded has been used to draw the interpreted peat thickness map and used to inform track layout and turbine layout for the consented Viking Wind Farm. A 'stage 1' peat management plan is provided in Technical Appendix 2.4 of this EIA Report in accordance with good practice guidance[3]. The additional peat probing data collected in 2018 will be used to inform more detailed design of the site infrastructure post-consent/pre-commencement and will be used as the basis of a 'stage 2' peat management plan.

Three Private Water Supplies (PWS) have been identified in the vicinity of the site but these are considered to be hydrogeologically distant (all greater than 1 km from the proposed varied development) and are unlikely to be in hydraulic continuity, see Figure 9.5: Private Water Supplies.

In accordance with the Scottish Environment Protection Agency (SEPA) guidance (SEPA, 2017), the locations of potential sensitive groundwater dependent terrestrial ecosystems (GWDTE) within the

[1] URL: http://map.environment.gov.scot/Soil_maps/?layer=10# (accessed 24/08/2018)
[2] The balance (approximately 3%) of probes recorded no peat or soil.
[3] Development on Peatland, Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste, a Joint Publication by Scottish Renewables and Scottish Environment Protection Agency Version 1, January 2012

site have been identified. Figure 8.4: GWDTE illustrates the locations of the potential GWDTE in relation to the proposed development.

The assessment of the likely significant effects for the consented Viking Wind Farm concludes that following the consideration of proposed mitigation, including measures set out in a Site Environmental Management Plan (Technical Appendix 2.2.), all activities with potential to affect hydrology, hydrogeology, geology, soils and peat would be appropriately managed and there would be **no significant effects**. On the basis that the footprint of the proposed varied development is unchanged from the consented Viking Wind Farm, **no significant effects** are associated with proposed varied development and there is no difference between the likely significant effects reported upon in the ES and Addendum and the proposed varied development.

9.1 Introduction

9.1.1 This chapter reports on the likely significant effects on hydrology, hydrogeology, geology, soils and peat associated with the construction, operation and decommissioning of the proposed development. The specific objectives of the chapter are to:

- describe the geological, hydrogeological and hydrological baseline;
- summarise the assessment methodology and significance criteria used in completing the impact assessment;
- describe the likely significant effects for the consented Viking Wind Farm;
- describe the likely significant effects of the proposed varied development;
- describe the mitigation measures proposed to address likely significant effects; and,
- describe the residual effects of the proposed varied development and describe how these differ from the effects of the consented Viking Wind Farm.

9.1.2 This chapter has been prepared by Ramboll Environment and Health UK Limited (Ramboll).

9.1.3 This chapter refers to the following technical appendices where appropriate:

- Technical Appendix 2.2: Site Environmental Management Plan;
- Technical Appendix 2.3: Peat Stability Assessment;
- Technical Appendix 2.4: Peat Management Plan;
- Technical Appendix 2.5: Borrow Pit Assessment; and
- Technical Appendix 2.7: Watercourse Crossing Details.

9.1.4 Figures 9.1 – 9.5 are referenced in the text where relevant. Further detail on GWDTE is provided in Chapter 8: Ecology.

9.2 Assessment Methodology and Significance Criteria

Scope of the Assessment

9.2.1 The proposed varied development would introduce physical changes which have the potential to alter the hydrological and hydrogeological characteristics of the site. This assessment considers likely significant effects on water quality, flooding and water resources during construction and operation of the consented Viking Wind Farm and any different likely significant effects of the proposed varied development, as described in Chapter 2 (Description of Development). The assessment of residual effects is made based on the assumption that the measures set out in the Site Environmental Management Plan (SEMP) as described in Technical Appendix 2.2 are implemented.

9.2.2 The effects on surface and groundwater may also result in secondary effects on terrestrial ecology such as peat forming habitats and ground water dependent terrestrial ecosystems (GWDTE) and/or

aquatic ecology. Such receptors are considered in this chapter only in terms of the potential for changes to the hydrological and hydrogeological regimes to impact upon them. Effects on peatland habitats and GWDTEs are considered in more detail in Chapter 8: Ecology. Further information on the extent and depth of peat on the site is considered in Technical Appendix 2.3: Peat Stability Assessment and in Technical Appendix 2.4: Peat Management Plan, which provides an updated stage 1 peat management plan.

Study Area

9.2.3 The study area is based on the site boundary, as shown on Figure 1.1, and includes areas downstream of the site which are potentially affected. In the case of watercourses, these are taken to the coast.

9.2.4 All watercourses, peatland and geology associated with the Delting and Collafirth quadrants of the scheme assessed in the ES are not considered in this assessment as those areas were removed in the relevant section 36 consent.

Baseline Conditions

Desk Study

9.2.5 A review of the desk study carried out for the ES has been undertaken, in respect of the reduced study area, in order to:

- identify all catchments, watercourses, springs and boreholes;
- collate data on public and private abstractions;
- collate historic hydrological and flooding information for the immediate area and the main downstream watercourses;
- collate geological and hydrogeological information; and
- collate topographic (digital terrain model) information.

9.2.6 In undertaking the baseline assessment, various data sources and documents were reviewed, including:

- Ordnance Survey 1:25,000 Explorer Maps 467, 468 and 469;
- British Geological Survey 1:50,000 Solid Edition, Scotland Sheet 128, Central Shetland;
- British Geological Survey 1:50,000 Drift Edition, Scotland Sheet 128, Central Shetland;
- Hydrogeological Map of Scotland;
- Groundwater Vulnerability Map of Scotland;
- Soil Survey of Scotland 1:250,000 Sheet 1, Orkney and Shetland;
- Flood Estimation Handbook (version 2.0);
- ISIS Hydrological Software Package; and
- SEPA Interactive Flood Map.

Field Study

9.2.7 Field surveys were undertaken for the ES to evaluate the existing soil and water conditions within the study area, for the purpose of assessing catchment areas, investigating private water supplies, inspecting the main surface waters and completing a morphological inspection of the peatland.

9.2.8 Additional field surveys to collect further data of peat depth and condition were carried out in 2018 and the results inform an updated peat management plan provided in Technical Appendix 2.4. This additional baseline data will be used to inform more detailed design of the site infrastructure post-consent/pre-commencement and will be used as the basis of a 'stage 2' peat management plan. All other baseline information collected to inform the ES are still considered relevant for the purposes of this EIA Report.

Cumulative baseline

9.2.9 In respect of hydrology and hydrogeology, no cumulative developments are located within the same surface water catchment as the proposed varied development; therefore, the potential for cumulative effects are not considered further in this assessment.

Assessment of Effects

Criteria for Assessing Sensitivity of Receptors

9.2.10 Effects on water resources are described as beneficial, neutral or adverse and are considered with reference to the value or sensitivity of the receptor, as described in Table 9.1.

Table 9.1: Sensitivity of Environmental Resource

Sensitivity of Receptor	Definition	Typical Criteria
High	International or national level importance. Receptor with a high quality and rarity, regional or national scale and limited potential for substitution/ replacement.	• High likelihood of fluvial/ tidal flooding in the sub catchment – defined as 1:10 probability in a year. • EC Designated Salmonid / Cyprinid fishery. • Surface water WFD class 'High'. • Scottish Government Drinking Water Protected Areas. • Aquifer providing regionally important resource such as abstraction for public water supply, abstraction for private water supply. • Supporting a site protected under EC or UK habitat legislation / species protected by EC legislation. • Protected Bathing Water Area. • Active floodplain. • Highly Groundwater Dependent Terrestrial Ecosystems. • Qualifying characteristics for class 1 priority peatland habitat – all vegetation cover indicates priority peatland habitat; all soils are carbon rich soils and deep peat.
Medium	Regional, county and district level importance. Receptor with a medium quality and rarity, regional scale and limited potential for substitution/replacement.	• Medium likelihood of fluvial/ tidal flooding in the sub catchment – defined as a 1:200 probability in a year. • Surface water WFD class 'Good' or 'Moderate'. • Aquifer providing water for agricultural or industrial use. • Local or regional ecological status / locally important fishery. • Contains some flood alleviation features. • Qualifying characteristics for class 2 peatland habitat – most vegetation cover indicates priority peatland habitat; all soils are carbon rich soil and deep peat. • Moderately Groundwater Dependent Terrestrial Ecosystems.
Low	Local importance	• Surface water WFD class 'Poor'. • Unproductive strata / no abstractions for water supply.

Table 9.1: Sensitivity of Environmental Resource		
	Receptor is on-site or on a neighbouring site with a low quality and rarity, local scale. Environmental equilibrium is stable and is resilient to changes that are greater than natural fluctuations, without detriment to its present character.	• Sporadic fish present. • No flood alleviation features. • Sewer. • Qualifying characteristics for class 3, 4 or X habitat – vegetation cover does not indicate priority peatland habitat (as defined by SNH[4]).

Criteria for Assessing Magnitude of Change

9.2.11 The size or magnitude of each impact is determined as a predicted deviation from the baseline conditions during construction, operation and decommissioning, as described in Table 9.2.

Table 9.2: Magnitude of Impact on a Receptor	
Magnitude of Impact	**Criteria**
Large	Large alteration / change in the quality or quantity of and / or to the physical or biological characteristics of environmental resource.
Medium	Medium alteration / change in the quality or quantity of and / or to the physical or biological characteristics of environmental resource.
Small	Small alteration / change in the quality or quantity of and / or to the physical or biological characteristics of environmental resource.
None	No alteration / change detectable in the quality or quantity of and / or to the physical or biological characteristics of environmental resource.

9.2.12 In describing a potential effect, consideration has also been given to its geographical scale and duration, which have been defined as follows:

- The geographical scale of an impact refers to the zone of influence, and can be described as: localised, site-wide, a specific distance / range from a source, regional, national, global; and
- The duration of an impact can be described as: short to long term, permanent or temporary for the duration of the construction / operational period.

Significance Criteria

9.2.13 The significance of residual effects is defined as a function of the sensitivity of receptors and the magnitude of change, as presented in Table 9.3, taking account of any mitigation proposed. Differentiations between categories, and thus the final significance ratings, are based upon professional judgement.

Table 9.3: Significance Criteria					
		Magnitude of Impact			
		None	**Small**	**Medium**	**Large**
Sensitivity of Receptor	**High**	None	Minor	Major	Major
	Medium	None	Minor	Moderate	Moderate
	Low	None	Negligible	Minor	Minor

[4] Scottish Natural Heritage (2016) Carbon-rich soils, deep peat and priority peatland habitat mapping, Consultation analysis report. URL: https://www.nature.scot/carbon-and-peatland-map-consultation-analysis-report

9.2.14 Major and moderate impacts (shaded in grey) are deemed significant in the context of the EIA Regulations. Minor and negligible impacts are not considered significant in EIA terms.

9.3 Baseline Conditions

Current Baseline

Surface Hydrology

9.3.1 There are a number of watercourses and lochans on the Kergord and Nesting parts of the site. These are shown on Figure 9.1.

9.3.2 The main catchments are:

- South Burn of Burrafirth catchment, in the western part of the site;
- Burn of Weisdale catchment, in the central western area of the site;
- Stromfirth Burn catchment, in the centre of the site;
- Laxo Burn/Gossawater Burn catchment, in the northern part of the site; and
- Burn of Grunnafirth/Burn of Forse catchment, in the western part of the site.

9.3.3 The remainder of the site contains water features which flow directly into the sea.

Flood Risk

9.3.4 A review of the Scottish Environment Protection Agency's (SEPA) online Flood Mapping[5] indicates that areas of high and medium flood risk are confined to the areas alongside the lochans and watercourses, as well as some small areas of surface water flood risk. However, no infrastructure would be located within these flood risk areas. Therefore, no further assessment of fluvial or tidal flood risk is considered necessary.

Water Quality

9.3.5 South Burn of Burrafirth, Burn of Weisdale, Burn of Pettawater, Gossawater Burn and Burn of Forse, which are fed by tributary watercourses draining the site and which run through the western, central and northern parts of the site, respectively, have been classified under SEPA's River Basin Management Plans (RBMP)[6] as having Good water quality, with a target to keep this status in the forthcoming years. The current status of the water bodies meets the requirements of the Water Framework Directive, thus SEPA intends to ensure that no deterioration from good status occurs, unless caused by a new activity providing significant specified benefits to society or the wider environment. No other watercourses or lochans within the site have been classified under the RBMP.

Geology

9.3.6 The Shetland Isles are elongate and dominated by north to south trending geological units separated by similar trending faults. The bedrock within the site is bounded by the Walls Boundary Fault, located approximately 2 km west of the site boundary, and the Nesting Fault, located in the eastern area of the site. The British Geological Society (BGS) 50K bedrock geology data (Figure 9.2), indicates that the majority of the site is underlain by Dalradian rocks comprising graphitic pelite, calcareous pelite, calcsilicaterock and psammite from the Appin Group and psammite, semipelite and pelite from the Argyll and Appin groups. Metamorphosed plutonic igneous rocks (metalimestone) from the Dalradian Supergroup are also present across the centre of the site.

[5] URL: http://map.sepa.org.uk/floodmap/map.htm
[6] URL: https://www.sepa.org.uk/environment/water/river-basin-management-planning/the-current-plans/ (accessed 15/8/18)

9.3.7 The BGS 50K superficial geology data (Figure 9.3) indicates that diamicton till deposits are present towards the centre of the site. There is also extensive blanket bog formed of peat, while shallow rock head or rock outcrop is found in stream beds and at the summit of ridges and hills.

Soils and Peat

9.3.8 The majority of the site has been mapped as 'class 1' in the SNH Carbon-rich soils, deep peat and priority peatland habitat mapping[7]. This mapping indicates the likely presence of 'nationally important carbon-rich soils, deep peat and priority peatland habitat' likely to be of high conservation value, as referenced in SNH guidance on Spatial Planning for Onshore Wind Turbines (2015)[8]. There are no areas of 'class 2' peat mapped within the site. Peat surveys were undertaken to gather site specific information of the presence and condition of peaty soils and/or peat. Peat is defined as an organic soil in excess of 0.5 m, if the soil is less than 0.5 m, then it is considered to be potential carbon-rich soil. Peat was found to be widespread across the site in terms of thickness and coverage. The ground conditions were assessed by using peat depths recorded during the peat probing surveys.

9.3.9 In summary the peat depth probing has shown that:

- peat is widespread across the site, predominately on flat lying ground in the small valleys between hills on site;
- approximately 12% of probe locations identified soil/peaty soils < 0.5 m in depth;
- approximately 42% recorded peat >0.5 m and less than 1.5 m; and
- approximately 43% of probes measuring peat > 1.5 m up to a maximum depth of 5.75 m.

Groundwater Bodies

9.3.10 Groundwater flooding is most likely to occur in low-lying areas underlain by highly permeable rocks (aquifers). These may be extensive, regional aquifers, comprised of chalk or sandstone, or localised sands or river gravels in valley bottoms underlain by less permeable rocks. Such aquifers are susceptible to flooding as the storage capacity within these deposits is often limited and direct rainfall recharge can be relatively high, subsequently increasing the water levels within the groundwater and providing a good hydraulic connection with adjacent river networks.

9.3.11 The 625K hydrogeological data available from the British Geological Society (BGS), indicates that all of the bedrock formations mentioned in section 9.4.6 comprise low productivity aquifers with small amounts of groundwater in near surface weathered zones and fractures (Figure 9.4).

9.3.12 Much of the crystalline metasedimentary bedrock does not have a significant weathered horizon and groundwater will be restricted to fractures and joints only to a depth of a few metres below surface. However, the calc-silicate or crystalline limestone may be deeply weathered and contain cavities with significant groundwater potential.

9.3.13 Groundwater may also be found associated with the Walls Boundary Fault, the Nesting Fault and other, minor, faults in the area.

9.3.14 Groundwater within peat is generally perched on the less permeable basement or drift it overlies. Where the peat is thick and located in areas of low relief, as observed on valley floors and saddles in elevated areas, it provides baseflow to local streams. While peat aquifers in some areas have sufficient storage to ensure perennial flow, flow in the majority of peat aquifer-fed watercourses is intermittent and restricted to periods during, and immediately following, prolonged wet weather. In lower-lying areas of lesser relief and where peat is relatively thin, the groundwater generally occurs at shallow depth. Groundwater may rise above the surface for short periods following

[7] SNH and JHI (2016) Carbon and Peatland 2016 map, URL: http://soils.environment.gov.scot/maps/carbon-and-peatland-2016-map/#technicalAndReferenceMaterial (accessed 15/8/18)
[8] Scottish Natural Heritage (2015) Spatial Planning for Onshore Wind Turbines – natural heritage considerations; URL: https://www.nature.scot/sites/default/files/2017-06/A1663759.pdf (accessed 20/8/18)

extended rainfall. These areas are often defined by the presence of sphagnum species on the site surface.

9.3.15 The Shetland groundwater body, which underlies the entire site, is classified by SEPA under the RBMP system as having an overall status of Good[9].

Private Water Supplies

9.3.16 The ES identified three private water supply locations with the potential to have hydraulic connectivity with the site of the proposed varied development via downstream geology or watercourses, as shown on Figure 9.5. Details of these private water supplies are provided in Table 9.4 below.

Table 9.4: PWS with Potential Hydraulic Connectivity

Ref	Property	Location	Source
1	Easthouse	Grobsness NGR HU370633	Hillside spring source located approximately 2.7 km north west of the site.
2	Lea of Burrafirth	East Burrafirth NGR HU352586	Supplied by a spring source located downslope and approximately 2 km west of the site.
3	'Abandoned property'	South of Selie Ness NGR HU351596	Located approximately 2.5 km west of the site. This property appeared abandoned and in a derelict state during the site visit conducted in April 2006. There was evidence of water supply infrastructure at the location, but this did not appear to be fit for operation.

9.3.17 SEPA has stated that all groundwater abstractions within the following distances of development need to be identified, in order to assess potential risk:

- within 100 m radius of all excavations shallower than 1 m; and
- within 250 m of all excavations deeper than 1 m.

9.3.18 None of the identified PWS locations fall within these radii; therefore, no further assessment is required.

Groundwater Dependant Terrestrial Ecosystems

9.3.19 A number of potential Highly and Moderately GWDTE were identified on the basis of the Phase 1 habitat survey information, gathered by Highland Ecology in 2005 and 2008. The ecological assessment presented in Chapter 8: Ecology describes the different mosaic habitats represented on the site and notes that the potential GWDTE are of varying condition and subject to modification due to their location within the blanket bog habitats. The GWDTE areas do include areas of increased diversity and naturalness and as a result, the GWDTE is considered to be of regional ecological importance.

9.3.20 The SNIFFER (2007) guidance[10] states that the dependence of wetlands on groundwater bodies is a result of the hydrological connectivity. The degree of dependency will vary depending upon whether the wetland is underlain by a low productivity or high productivity aquifer and whether there is a hydrological linkage mechanism between groundwater and the surface wetland. Likelihood of dependency is based upon the following:

[9] https://www.sepa.org.uk/data-visualisation/water-classification-hub/?display=information_sheet&waterbodyid=150687 (accessed 20/8/18)
[10] Scotland & Northern Ireland Forum for Environmental Research, Wetland Hydrogeomorphic Classification for Scotland [available at: http://www.envirobase.info/PDF/SNIFFER_WFD66_Final_Report.pdf]

- High Likelihood: Characterised by intergranular, high productivity drift aquifer and dominantly intergranular, highly productive aquifer;
- Moderate Likelihood: Characterised by intergranular, moderate productivity drift aquifer and fractured, very low productivity aquifer; and
- Low Likelihood: Characterised by intergranular, low productivity drift aquifer and fractured, very low productivity aquifer.

9.3.21 The site is underlain by bedrock aquifers with low productivity where the flow is virtually all through fractures and other discontinuities. Where drift deposits are present within the site, these would also be of low productivity. Figure 8.4 presents the location of the potential GWDTEs relative to the proposed site infrastructure. However, it is noted that there is low likelihood of groundwater dependency for all the potential GWDTEs within the site.

Future Baseline

9.3.22 There is potential for climate change to impact on future baseline conditions. Climate change studies predict a decrease in summer precipitation and an increase in winter precipitation alongside slightly higher average temperatures. Summer storms are predicted to be of greater intensity. Peak fluvial flows associated with extreme storm events may increase in volume and velocity. The predominant habitat on the site (peat bog) is highly dependent on the frequency and amount of precipitation. While 'active' peat bog is likely to have a high resilience to potential future climate change, areas which are damaged and degraded (haplotelmic) e.g. by overgrazing are likely to be more vulnerable to climate change effects (e.g. increased erosion) as a result of lacking an active vegetation layer. These climate change factors have been taken into account when considering the potential for likely significant effects.

Identified Sensitive Receptors

9.3.23 A summary of the receptors identified as being sensitive to the proposed varied development and which have been 'scoped-in' to the assessment are as follows:

- Soils and peat;
- GWDTE; and
- Surface water run-off / site drainage and water quality.

9.4 Assessment of Effects

Effects on Soils and Peat

Construction effects (pre-mitigation) – consented Viking Wind Farm

9.4.1 The nature of the site is such that it is impossible to avoid priority peatland habitat. Almost the entire site is considered to have either medium or high sensitivity to impacts on peatland habitat. As such the focus of the design (for the consented Viking Wind Farm) was to, as far as possible, avoid identified areas of higher sensitivity peat. This was completed in three phases as follows:

- a preliminary layout was defined on the basis of an initial peat depth survey during which peat depths were sampled at 50 m intervals along a selected number of transects, chosen to traverse different terrain types found across the site. The preliminary layout located the various elements of the development away from identified areas of deep peat;
- more detailed peat probing was carried out along the route of the proposed site tracks and at the centre point of the preliminary turbine locations, following which some turbine locations and various sections of track were repositioned away from identified areas of peat greater than 2.5 m depth; and

- ground condition surveys were completed in order to investigate items such as final design stream crossing locations and peat depths on finalised sections of tracks, turbine locations and construction compounds and in order to feed into the peat stability assessment process.

9.4.2 Without further mitigation, it is assessed that there would be potential for significant direct effects on the soil/peat resource as a result of pollution, erosion and peat landslide associated with the consented Viking Wind Farm. In addition, there would be the potential for significant indirect effects as a result of peat landslide or erosion through pollution to surface watercourses.

9.4.3 The overall sensitivity of the soil and peat resource is considered to range from medium in areas of highly eroded peat, to high where unmodified active peat forming habitats are present. When assessed assuming no further mitigation is implemented (i.e. in addition to the design approach of avoiding deep areas of peat and priority peatland), the magnitude of potential impacts on the soil and peat resource during construction is considered to be locally medium. This could lead cumulatively across the site to a potential moderate adverse and significant effect.

Summary of Effects of Soils and Peat (pre-mitigation) – proposed varied development

9.4.4 An additional peat probing exercise has been undertaken in 2018 in accordance with the relevant guidelines[11] to determine the thickness of peat associated with turbines and infrastructure. 11,754 peat probes have now been collected. Based on the findings of the 2018 survey, it was confirmed that where practicable, the locations of proposed turbines and infrastructure have been sited such that the majority of identified areas of deep peat (greater than 1.5 m in depth) are avoided. Micro-siting will be used as far as possible to further reduce effects on peat associated with the turbines and supporting infrastructure (e.g. tracks, hardstanding, cable routes).

9.4.5 Given that the proposed varied development does not change the footprint of the consented Viking Wind Farm, it follows that without further mitigation, there would be potential for significant direct effects on the soil/peat resource as a result of pollution, erosion and peat landslide. In addition, there would be the potential for significant indirect effects as a result of peat landslide or erosion through pollution to surface water courses.

9.4.6 The overall sensitivity of the soil and peat resource to change as a result of the proposed varied development remains unchanged and is considered to range from medium in areas of highly eroded peat, to high where unmodified active peat forming habitats are present. When assessed assuming no further mitigation is implemented, the magnitude of potential impacts on the soil and peat resource during construction is considered to be locally medium, leading cumulatively across the site to a potential moderate adverse and significant effect.

9.4.7 As a result of this assessment, specific mitigation measures are proposed in section 9.5.

Operational Effects – consented Viking Wind Farm and proposed varied development

9.4.8 There are not anticipated to be any impacts on soils and peat further to those identified during the construction phase for the consented Viking Wind Farm, or for the proposed varied development.

Effects on GWDTE

Construction Effects (pre-mitigation) – consented Viking Wind Farm

9.4.9 Chapter 8: Ecology identifies areas of the site, which based on their National Vegetation Classification (NVC), are potential GWDTE. Excavation into the bedrock during the construction phase may cause localised disruption and interruption to groundwater flow. However, it is noted that the underlying geology is likely to be low productivity and unlikely to support groundwater dependent habitats. The habitats are considered to be likely to be rainwater fed. The consented Viking Wind Farm includes provision for floated tracks in all areas where peat is greater than 1 m in

[11] Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey. Guidance on Developments on Peatland, on-line version only.

depth, where this is achievable taking account of other engineering led considerations, for example, the potential for peat instability. By using a floated construction, the hydraulic continuity across habitat areas would be maintained.

9.4.10 The overall sensitivity of the potential GWDTE mapped in Chapter 8: Ecology to changes in the groundwater resource is considered to be low on the basis that the hydrogeology of the underlying bedrock is highly unlikely to support a productive aquifer. The habitats on the site are considered to be highly dependent on rainwater. The description of the development in Chapter 2 of this EIA Report confirms that all tracks on peat greater than 1 m in depth would be floated, where practicable.

9.4.11 The assessment in Chapter 8: Ecology identifies a direct impact (habitat loss) on 30 ha of GWDTE habitat, and an indirect (modification) effect on 54.5 ha. Both these effects are classified as of low magnitude based on this type of habitat being ubiquitous within the study area. In addition, the vast majority of the site is considered to be rainwater -fed (ombrotrophic) peatland habitat. The proposed construction of site infrastructure would take account of the need to maintain hydraulic continuity across, e.g., track features by using floating track construction. On this basis, the impact on GWDTE is considered to be small magnitude change, amounting to no greater than a minor and not significant effect.

Summary of Effects (pre-mitigation) – proposed varied development

9.4.12 Overall, when assessing the proposed varied development, assuming no further mitigation is implemented, the magnitude of potential impacts on the potential GWDTE remain the same as for the consented Viking Wind Farm i.e. minor and not significant.

Operational Effects - consented Viking Wind Farm and proposed varied development

9.4.13 There are not anticipated to be any impacts on GWDTE further to those identified during the construction phase for the consented Viking Wind Farm, or for the proposed varied development.

Effects on Surface Water Runoff and Water Quality

Construction Effects (pre-mitigation) – consented Viking Wind Farm

9.4.14 There is the potential to alter in-channel or overland flow regimes in terms of runoff volume, rate and quality through excavations, disruption to existing drainage patterns, exposure of bare earth or rock and the construction of 55 new watercourse crossings (see Technical Appendix 2.7, which identifies 55 watercourse crossings within the Kergord and Nesting areas).

9.4.15 All of the watercourse crossings identified for the proposed development would be designed in compliance with requirements of The Water Environment (Controlled Activities) (Scotland) Regulations 2011 as amended. The design of watercourse crossings would also take account of the future 'with climate change' baseline, and to avoid altering the flow regime would be sized for a 1:200 year plus climate change flood event. In addition, the construction work would be required to operate in accordance with a Construction Site Licence, issued under the Water Environment (Controlled Activities) (Scotland) Regulations 2011, as amended by SEPA, which requires adherence to a pollution prevention plan.

9.4.16 The overall sensitivity of the surface water environment is considered to range from medium to high.

9.4.17 In the absence of mitigation, the magnitude of potential impacts relating to disruption of flow or increased runoff during construction is assessed as none to small, with the potential for local sub-catchment scale small beneficial effects associated with increasing the natural attenuation capacity of the site, which may include stabilisation and restoration of eroded peatland. Therefore, overall effects for the consented Viking Wind Farm were anticipated to be minor adverse or negligible and not significant.

9.4.18 Without further mitigation, there would be potential for significant erosion associated with the construction work. Potential effects include indirect effects on aquatic ecology and fluvial morphology downstream of the site. The magnitude of potential impacts is considered to be medium, leading cumulatively across the site to a potential moderate adverse and significant effect.

9.4.19 There is the potential to impact on receiving soils, groundwater and watercourse quality through the release of contaminated water and stored chemicals used on-site during construction works. Potential effects include degradation of water quality and indirect effects on aquatic ecology. Due to the low infiltration potential of peat, contaminants are considered unlikely to penetrate into the peat or groundwater. The high surface runoff coefficient means that in the event of a pollution event, when assessed assuming no further mitigation is implemented, a large area could be affected resulting in a large magnitude effect. This could potentially result in a major adverse and significant effect.

Summary of Effects (pre-mitigation) – proposed varied development

9.4.20 Overall, when assessing the proposed varied development, assuming no further mitigation is implemented, the magnitude of potential impacts on the surface water runoff are not expected to change from the consented Viking Wind Farm. As such the effects of the water environment associated with proposed varied development are assessed as:

- negligible to minor and not significant effect as a result of disruption of flow or increased runoff;
- moderate to major adverse and significant effect as a result of erosion; and
- Major adverse and significant effects as a result of chemical pollution.

Operational Effects -- consented Viking Wind Farm and Proposed Varied Development

9.4.21 On the basis that all watercourse crossings will be designed following good practice, and the detailed drainage design will ensure pre-construction run-off rates are maintained there are not considered to be any significant impacts the water environment further to those identified during the construction phase for the consented Viking Wind Farm, or for the proposed varied development.

9.4.22 The potential risk of pollution during the operational phase is substantially lower than during construction because of the decreased levels of activity. The majority of potential pollutants will have been removed upon completion of construction although the possibility will remain of leaks of turbine gearbox lubricants, transformer oils and fuel from maintenance vehicles.

9.4.23 Despite the reduction in the number of potential pollutants the magnitude of a pollution incident, without mitigation in place, is medium, leading to moderate adverse and significant effect.

9.5 Mitigation

9.5.1 The assessment of effects identified the potential for direct significant effects on the peatland habitat resource, along with indirect significant effects as a result of erosion and pollution to the water environment. As a result, the Site Environmental Management Plan (SEMP), as described in outline in Technical Appendix 2.2 to this EIA Report[12], will be developed to include comprehensive mitigation measures written in accordance with the relevant best practice guidance on pollution prevention and mitigation, namely the SEPA Guidance for Pollution Prevention[13]. The SEMP will include the following controls:

[12] As required by Condition 22 (Annex 2, part 2) of the relevant section 36 consent.

[13] Guidance for Pollution Prevention (January 2017) Works and Maintenance In or Near Water. GPP5, Version 1.2, February 2018, published by NetRegs –URL: http://www.netregs.org.uk/environmental-topics/pollution-prevention-guidelines-ppgs-and-replacement-series/guidance-for-pollution-prevention-gpps-full-list/ (accessed 21/8/18)

- All equipment, materials and chemicals will be stored well away from any watercourses. Chemical, fuel and oil stores will be sited on impervious bases within a secured bund.
- Standing machinery will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable refuelling of vehicles and machinery will be carried out in one designated area, on an impermeable surface, and well away from any watercourse.
- Construction traffic access would be restricted wherever possible, and the number of vehicle movements limited as much as possible. Land surrounding the immediate construction area would be fenced off or otherwise demarcated to prevent inadvertent intrusion from construction plant. This would help to limit soil disturbance and consequently reduce the potential for erosion.
- Only emergency maintenance to construction plant will be carried out on site, in one designated area, on an impermeable surface well away from any watercourse or drainage, unless vehicles have broken down necessitating maintenance at the point of breakdown, where special precautions will be taken.
- Silt traps and sediment attenuation ponds will be inspected and cleared regularly to ensure they remain fully operational and effective. Silt fences and mats shall be utilised to ensure minimum sediment runoff from stockpiles.
- To prevent any downgrading of water quality status from excellent/good status post-development, runoff flow and loading should be kept to pre-development levels.
- Watercourses, culverts and drainage ditches will be inspected and cleared regularly to prevent blockages and remove the risk of flooding.
- On-site welfare facilities will be adequately designed and maintained to ensure all sewage is disposed of appropriately. This may take the form of an onsite septic tank with soakaway, or tankering and offsite disposal depending on the suitability of the site for a soakaway and agreement with SEPA.
- Fresh concrete and cement is very alkaline and corrosive and can be lethal to aquatic life. The use of wet concrete in and around watercourses will be minimised and carefully controlled.
- Development of contingency plans will ensure that emergency equipment (e.g. spill kits and absorbent materials) is available at appropriate locations on site and that advice is available on action to be taken and who should be informed in the event of a pollution incident.

9.5.2 All relevant staff personnel will be trained in both normal operating and emergency procedures, and, be made aware of highly sensitive areas on site. The staff training, and implementation of site procedures will be overseen by an Environmental Manager or Environmental Clerk of Works to ensure that these measures are carried out effectively to minimise the risk of a pollution incident.

9.5.3 A Peat Management Plan (PMP) is provided (see Technical Appendix 2.4) to outline the approach to managing peat during the construction in accordance with guidance from SEPA[14],[15]. This EIA Report is supported by a 'Stage 1: PMP' which would be the same for both the consented Viking Wind Farm and the proposed development. A Stage 2: PMP would be developed post-consent to establish clear protocols for peat excavation, storage, handling and transport based on a more detailed design.

9.5.4 Mitigation measures that seek to avoid and/or reduce the potential for peat landslide include:

- Micrositing will be used during the detailed design and construction phases to further avoid areas identified as of high risk of instability. This would be undertaken under the direction of an environmental advisor and geotechnical engineer (as necessary).

[14] Scottish Environment Protection Agency. 2010. Regulatory Position Statement – Developments on Peat.

[15] Scottish Renewables, Scottish Environment Protection Agency. 2012. Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste – Version 1

- Tracks will be microsited to avoid the need for localised cut and fill, particularly on convex slopes.
- Geotechnical supervision will be provided throughout construction.
- A Geotechnical Risk Register will be completed as part of the design phase.
- Concentrated loads, such as excavated material placed on the slope, create the single most adverse negative short-term effect on the stability of a slope. The significance of this can be moderate. Accordingly, during the construction phase, all excavated materials would be removed to temporary storage mounds positioned at safe slope gradients and certified by a geotechnical engineer.
- Loading associated with the construction of floating tracks may lead to unstable ground conditions. Accordingly, all tracks will be, as far as possible, constructed under geotechnical supervision and monitored during and after construction.
- Excavation of the slope for foundations or for excavated tracks may remove toe support and increase potential for ground movements. The earthworks and any excavation would be designed and undertaken in such a way as to avoid any excavation of toe support material. The excavation of any temporary slopes would be fully designed.
- Disturbance to the natural drainage system may increase potential for peat instability. Therefore, the design of any new drainage would be undertaken to ensure no adverse loading is placed on areas of marginal peat stability.
- Since peat sliding almost invariably involves increased pore water pressures, it follows that robust drainage plans and engineering control of water during the development should result in a significant overall reduction in the risk of peat instability.

9.6 Good Practice Measures

9.6.1 The principal mitigation measures to address the potential impacts on peat and peat soils, groundwater, runoff volumes and rates, fluvial morphology, water quality in watercourses and water bodies (ponds) and pollution associated with chemical contaminated runoff / pollution are embedded within the proposed design and incorporated into the standard construction environmental management measures, embedded in the design described in Chapter 2: Description of Development (of this EIA Report).

9.6.2 It should be noted that the layout of the turbines, and hence tracks and cables, would be subject to 50 m micrositing. Any micrositing changes would be based on further detailed site investigation to both consider peat depth and respect the hydrology buffer exclusion zones defined within this chapter.

9.6.3 Water emissions resulting from the operational development are anticipated to be limited to surface water, and very small quantities of waste water from the site welfare facilities. The site would be designed to ensure that surface water runoff does not exceed the pre-development volume or rate of run-off. Access tracks would be designed to be semi-permeable and to act in a similar manner to a Sustainable Drainage System (SuDS), allowing some infiltration of surface water through the track surface. In addition, there would be a trackside drainage system installed during construction, where appropriate, incorporating measures to attenuate the flow and provide for physical filtration and infiltration of surface water. It is noted that given the widespread presence of peat and high-water table, infiltration is likely to be limited for the majority of the site. Runoff from areas of hardstanding such as crane pads and foundations is expected to infiltrate locally on unsurfaced areas.

9.6.4 Compensatory restoration for the predicted 85.1 ha of blanket bog permanently lost as a consequence of construction would be undertaken, as detailed in Technical Appendix 8.9: Habitat Management Plan and Technical Appendix 8.10: Habitat Management Plan Figures. The Habitat Management Plan (HMP) proposes to restore 260 ha of blanket bog. This would provide an

additional degree of enhancement with the restoration of greater than three times the area lost. Additional blanket bog restoration would also occur as part of proposed measures for whimbrel *Numenius phaeopus* and diver *Gavia sp.*, as detailed in Technical Appendix 8.9: Habitat Management Plan.

9.7 Residual Effects

9.7.1 With the proposed mitigation in place the impacts on the soil and water environment would not be significant for both the consented Viking Wind Farm and the proposed varied development.

9.7.2 The ES identified potential significant effects related to:

- Peat erosion and instability associated with construction activities; and
- Effects on the local water table around cut tracks and other excavated areas during construction and operation.

9.7.3 Although peat erosion and instability processes were assessed as having potentially significant effects, neither was assessed as being likely to occur as a direct result of the consented Viking Wind Farm. It is noted that these two processes would continue to occur at this site without development of either the consented Viking Wind Farm or the proposed varied development proceeding. Furthermore, it is considered that these processes would potentially be exacerbated by climate change effects in the future, as peatland habitats will have a reduced capacity to adapt to climate change where the vegetative layer is already absent (the HMP identifies 1,500 ha within the site with upwards of 20% bare peat).

9.7.4 This assessment considers that the potential significant effects on peat can be substantially overcome through following the good practice protocols outlined in draft in Technical Appendix 2.2: Site Environmental Management Plan and based on the Habitat Management Plan (HMP) proposal to restore 260 ha of degraded blanket bog, providing compensation for the 85 ha lost directly as a result of either the consented Viking Wind Farm or the proposed varied development, and an additional degree of enhancement (with the restoration of greater than three times the area lost). As such the effects on peat, associated with erosion, instability and impacts on the water table are considered to be minor adverse and not significant. These residual effects are considered to apply to both the consented Viking Wind Farm and the proposed varied development.

9.7.5 The conclusion of the assessment is that there is no difference in the likely significant effects for the proposed varied development when compared the effects identified for the consented Viking Wind Farm.

9.8 Summary and Conclusions

9.8.1 A summary of the potential effects on hydrology, hydrogeology and geology is provided in Table 9.5, which also provides a comparison of the potential effects identified for consented Viking Wind Farm with the effects identified for the proposed varied development.

9.8.2 Following consideration of proposed mitigation, including measures set out in the SEMP (Technical Appendix 2.2) and the HMP (Technical Appendix 8.9), it is considered that the activities with potential to affect the soil and water environment would be appropriately managed with no significant effects identified.

Table 9.5: Summary of Effects					
Receptor	**Potential Effect Identified for Consented Viking Wind Farm**	**Potential Significant Effect Identified – Proposed Development (2018)**	**Mitigation / Good Practice Controls**	**Means of Implementation**	**Residual Effect / Difference**
Construction					
Soils and peat	Erosion of peat; peat landslide risk.	Erosion of peat; peat landslide risk.	Soil handling and storage will be in accordance with good practice during construction and reinstatement as set out in PMP.	SEMP to be submitted to and approved by the LPA / SEPA to be secured by an appropriately worded planning condition.	MInor –not significant / No change from consented
Soils and peat	Modification of water table around cut tracks and excavations.	Modification of water table around cut tracks and excavations.	Drainage management proposals to ensure groundwater flow and hydraulic continuity is maintained.	SEMP to be submitted to and approved by the LPA / SEPA to be secured by an appropriately worded planning condition.	Minor not – significant / No change from consented
GWDTE	Not assessed	Disruption and interruption to groundwater flow, causing alteration/change in the quality or quantity of and/or the physical or biological characteristics of GWDTE. Majority of habitat areas noted to be rainwater dependent.	Drainage management proposals to ensure groundwater flow and hydraulic continuity is maintained.	SEMP to be submitted to and approved by the LPA / SEPA to be secured by an appropriately worded planning condition.	Minor – not significant / No change from consented
Surface water run-off volume	Modification to surface water run-off and impediment to flows.	Impact on runoff volumes and rates and fluvial morphology through the alteration of drainage patterns.	Drainage management proposals to ensure pre-construction rates / volumes of run-off maintained. The drainage management works would be supervised by the Ecological Clerk of Works (ECoW).	SEMP, including detailed watercourse crossing proposals, to be submitted to and approved by the LPA / SEPA to be secured by an appropriately worded planning condition.	Minor – not significant/ No change from consented
Water quality	Erosion and sedimentation of watercourses.	Impact on water quality and fluvial morphology associated	Drainage management proposals to ensure water quality is maintained	SEMP, including detailed watercourse crossing	Minor – not significant/

Table 9.5: Summary of Effects					
		with sediment-laden runoff or impacts on bank integrity.	through use of good practice silt mitigation. The drainage management works would be supervised by the Ecological Clerk of Works (ECoW).	proposals, to be submitted to and approved by the LPA / SEPA to be secured by an appropriately worded planning condition.	No change from consented
Water quality	Pollution	Effects on water quality from pollution associated with chemical contaminated runoff / pollution.	The baseline review of PWS identified limited potential for effects on PWS. All runoff to be treated in accordance with SuDS principles. Where watercourse crossings are being installed, best practice construction measures will be adopted to prevent contamination through the use of coffer dams and sediment isolation techniques. Petrol interceptors and spill kits will be utilised where chemical spillage is a possibility. In order to address any minor residual risk, a rapid response plan would be developed, which will ensure the rapid delivery of tankered water to those users affected and maintain this supply until problems are remedied.	SEMP to be submitted to and approved by the LPA / SEPA to be secured by an appropriately worded planning condition.	Minor – not significant/ No change from consented
Operation					
Soils and peat	Modification of surface and groundwater flows.	-	On-going maintenance for all proposed drainage measures on the site, particularly including water crossings and sustainable drainage features designed to manage water quality and runoff rate.	SEMP	Minor – not significant/ No change from consented
GWDTE	Not assessed	Disruption and interruption to groundwater flow, causing alteration/change in the quality	None necessary	SEMP	Minor – not significant/

Table 9.5: Summary of Effects					
		or quantity of and/or the physical or biological characteristics of GWDTE.			No change from consented
Surface water run-off / site drainage	Modification to surface water run-off and impediment to flows.	Impact on runoff volumes and rates and fluvial morphology through the alteration of drainage patterns.	On-going maintenance for all proposed drainage measures on the site, particularly including water crossings and sustainable drainage features designed to manage water quality and runoff rate.	SEMP	Minor – not significant/ No change from consented
Water quality	Erosion and sedimentation of watercourses.	Impact on water quality and fluvial morphology associated with sediment-laden runoff or impacts on bank integrity.	On-going maintenance for all proposed drainage measures on the site, particularly including water crossings and sustainable drainage features designed to manage water quality and runoff rate.	SEMP	Minor – not significant/ No change from consented
Water quality	Pollution	Effects on water quality from pollution associated with chemical contaminated runoff / pollution.	On-going maintenance for all proposed drainage measures on the site.	SEMP	Minor – not significant/ No change from consented

References

SEPA (2017) Land Use Planning System SEPA Guidance Note 31, Version 3, Issue date: 11/09/2017 Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems.

Glossary and Abbreviations

Abbreviation	**Expanded Term / Definition**
SNH	Scottish Natural Heritage
PWS	Private Water Supply
SEPA	Scottish Environmental Protection Agency
GWTDE	groundwater dependent terrestrial ecosystems
SEMP	Site Environmental Management Plan
RBMP	River Basin Management Plans
BGS	British Geological Society
NVC	National Vegetation Classification
SuDS	Sustainable Drainage System
ECoW	Ecological Clerk of Works