# 5 Design Evolution & Alternatives

## 5.1 Introduction

5.1.1 Given that the infrastructure of the Consented Development is not changing as part of the S36C variation proposals, there are therefore no changes to the design evolution set out and alternatives previously considered. The discussion of the previous design evolution & alternatives remains valid and the original chapter is presented in full below.

5.1.2 This chapter considers the design principles that have informed the selection of the Site as suitable for a wind farm. It also describes the iterations of the turbine layout and infrastructure requirements that have led to the Consented Development described in Chapter 3: Project description. An outline of the embedded mitigation that has been integral to the EIA process has also been included in this chapter.

5.1.3 The design of the Consented Development reflects a wide range of technical and environmental factors, together with development plan policies, issues raised by consultees in the scoping response and public consultation. This Chapter has been prepared by Wardell Armstrong LLP acting as coordinating consultant for the preparation of the EIA.

## 5.2 Legislative and policy context

5.2.1 Schedule 4 Part II(4) of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended) specify that an outline of '*The main alternatives studied by the applicant and the main reasons for his choice, taking into account the environmental effects'* should be included as part of the information presented in the Environmental Impact Assessment Report (EIAR).

5.2.2 The Scottish Government has prepared a document entitled *'Guidance on the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000'* (hereafter referred to as the Regulations) to assist developers and other stakeholders interpret the requirements of the aforementioned Regulations. As regards the consideration of alternatives as part of the Environmental Impact Assessment (EIA) process, the guidance note confirms in paragraph 4.1.1 that while there is no statutory provision as to the form of an Environmental Impact Assessment Report (EIAR) for applications for power generating stations submitted under Section 36 of the Electricity Act 1989, the EIAR *'must contain, as a minimum, the information specified in Part II of Schedule 4 to the Regulations, and the relevant information in Part 1'.* This matter is again dealt with in paragraph 5.3.1 of the guidance which confirms that in considering the adequacy of an EIAR, the Scottish Ministers must satisfy themselves in every case that the EIAR contains '*at least the information specified in Part II of Schedule 4, as well as all the relevant information that the developer can reasonably be required to compile in Part 1'.*

5.2.3 Paragraph 4.1.3 of the Guidance states that in the context of the Regulations, the requirement to include reference to the main alternatives to the Consented Development in the EIAR is *'likely'* to mean considering alternative sites for generating stations and the '*environmental statement must discuss those alternatives which have been considered*'.

5.2.4 This chapter provides further information on the alternatives to the Consented Development considered by the developer, including commentary on the main reasons for choices made through the EIA process, taking account of identified potential environmental effects.

## 5.3 Site selection and initial feasibility

5.3.1 The first step of identifying a suitable site for a wind farm would be to consider:

- Suitable wind speed;
- Proximity of housing;
- Identification of environmental designations;
- Adequate access;
- Availability of a grid connection; and
- Land ownership.

5.3.2 With regards to the Consented Development, Peel Wind Farms (Yell) Limited (PWFY) acquired the Site directly from the previous developer Enertrag as a result of a tendering process following an assessment of the Site against the aforementioned criteria and other relevant considerations. The previous developer had explored the feasibility of a wind farm development at the Site, including discussions with the Scottish Government and submission of a Scoping Report. PWFY did not consider alternatives sites on Shetland for a power generating station but it did consider a variety of locations within the Site for wind turbines before settling on the layout that now comprises the Consented Development. This chapter of the EIA will therefore focus on the initial assessment work that Peel undertook of the Site and how this influenced the design evolution process.

5.3.3 When a suitable site, such as this one, has been identified by PWFY the initial turbine layout is developed based on the following criteria:

5.3.4 Technical constraints;

- Siting wind turbines to avoid wake effects and turbulence thus optimising turbine performance;
- Suitable ground contours and conditions for wind turbine foundations, access tracks and control building;
- Availability of suitable access for the transportation or turbine components and construction plant;
- Availability and accessibility of connection to the electricity transmission grid;
- Aviation interests; and
- Interference with telecommunication links.

5.3.5 High level environmental constraints derived from desktop study;

- Landscape character and visual impact (e.g. Landscape designations);
- Visual and noise amenity of residential properties (buffer zones around residential properties);
- Existing land uses including forestry;
- Sites of designated ecological importance and protected species;
- Sites, features and buildings of designated archaeological and/or historic interest; and
- Surface and groundwater resources.

5.3.6 Having established against these criteria that the Site offers an excellent opportunity to develop a wind farm, a range of studies are then undertaken to develop and subsequently refine the Consented Development through the EIA process and consultation.

## 5.4 Design principles for the Consented Development

5.4.1 The key design principles that were considered during the design evolution are outlined in Table 5.1:

**Table 5.1: Design principles**

| *Receptor* | *Design principles* |
|---|---|
| Ornithology, ecology & biodiversity | To maintain the management objectives of Natura 2000 sites, identified for ecological, ornithological and marine interests;<br>To limit the potential impact of the Consented Development on features of biodiversity interest at a regional and local level;<br>To ensure the layout of turbines and other infrastructure takes account of, and limits the potential impact on, peatland habitats; in particular blanket bog and ground water dependent terrestrial ecosystems (GWDTEs);<br>To ensure that there are no cumulative adverse effects taking account of other planned developments;<br>To introduce habitat management planning, for the land that is included in the wind farm development; and<br>That all national guidance and policies can be adhered to, together with good practice for construction of wind farms within areas of peat (NatureScot, SEPA and others). |
| Landscape & visual impact | To limit the zone of theoretical visibility (ZTV) and areas of potentially significant landscape and visual effects, associated with turbine structures. The design has taken account of landscape sensitive receptors such as coastlines, important landscape and recreational areas, residential areas, public highway and rights of way;<br>To ensure that the Consented Development is compatible with other planned and consented wind farms within viewshed on the Shetland Islands;<br>To ensure that the design and appearance of turbines does not give rise to unacceptable landscape and visual impacts; and<br>To limit the landscape effects on neighbouring landscape character areas which may be considered as being of high visual sensitivity, including wild land and scenic areas such as the coastline. |
| Cultural heritage | To limit the potential impact during construction of the Consented Development on features of cultural and archaeological interest;<br>To map all features of cultural and archaeological interest within the Site to avoid potential impacts on known features during the construction stage;<br>To minimise the potential impact associated with the Consented Development on the setting of features of cultural importance and interest in the locality of the Site; and<br>To develop design measures that conform to planning policy advice at a national level, as well as the advice and good practice set out by Historic Environment Scotland and Shetland Amenity Trust for protection of cultural and archaeological resources during the construction and operational phases of the Consented Development. |

**Table 5.1: Design principles**

| *Receptor* | *Design principles* |
|---|---|
| Hydrology & hydrogeology | To limit the potential impact during construction of the Consented Development on surface and groundwater resources within the Site;<br>To map all watercourses and waterbodies and apply a 50m exclusion buffer to minimise potential impacts such as pollution and interference with fluvial flood plains;<br>To define the areas of known GWDTEs, to reduce the risk to these habitats and thus limit potential impacts associated with wind farm construction;<br>To identify and map all watercourse crossings and define design requirements for passage of otters and fish whilst maintaining the capacity for a 1 in 200 year flood event at the crossing point(s); and<br>To develop design measures that conform to planning policy advice at a national level, as well as the advice and good practice set out by SEPA for protection of water resources with particular focus on the construction phase. |
| Peat & carbon balance | To limit the potential impact during construction of the wind farm on peat resources within the Site;<br>To define the areas of known active (peat forming) blanket bog habitat (a priority habitat defined in the Habitats Directive) and limit potential impacts associated with construction activities;<br>To identify and map areas within the Site at risk of peat instability that have the potential cause peat slide during construction; and<br>To develop design measures that conform to planning policy advice at a national level, as well as the advice and good practice set out by NatureScot (previously SNH) and SEPA for protection of peat during construction of wind farms. |

## 5.5 Turbine layout design evolution

5.5.1 A summary of the steps and embedded mitigation measures that have led to the current turbine layout are outlined below. Further detail on all of the designed mitigation measures outlined below is available in the relevant technical chapters.

5.5.2 As stated earlier, PWFY acquired the Beaw Field Wind Farm project from Enertrag Limited in October, 2014. The Study Area has been the subject of a previous scoping request submitted by Enertrag Limited. The Enertrag Limited scheme proposed a 17 turbine layout with a maximum generating capacity of 102 MW. This was based on 6MW turbines with a maximum tip height of 165m.

5.5.3 Having acquired the site PWFY Limited re-considered the proposed layout with a reduced tip height of 145m. This decision was made after consultation with the project Landscape Architect in order to reduce effects on amenity and also to bring the Consented Development in line with the scale of turbines adopted by Viking Wind Farm on Mainland. This scheme represented a comparable development and allowed a total of 65 turbines to be accommodated by the Site, considered from a solely technical position without consideration of the technical and ecological constraints associated with the Site (see Figure 5.1).

5.5.4 The 65 turbine layout was, in the first instance, assessed against known ecological designations and the results of baseline ecological surveys that had been obtained thus far. Although ecological surveys remained ongoing at this stage, there was sufficient data available to identify that turbines should be excluded from the north western area of the Site. This was to protect the Otterswick and Graveland

SPA and SSSI and more specifically to remain clear of the flight lines used by red-throated diver (a qualifying species of the SPA). This process was carried out in two stages, first reducing the number of turbines down to 52 turbines (Figure 5.2) and then reducing further to 47 turbines when new flight line data became available (Figure 5.3).

5.5.5 Baseline data relating to peat depth, hydrology and ground water dependent ecosystems (GWDTE's), obtained later during 2015, identified areas of unmodified blanket bog and potentially ground water dependent ecosystems. These habitats were largely within areas already excluded for ornithological reasons (Figures 5.2 & 5.3). However, the baseline data resulted in further optimisation of the turbine layout to avoid additional areas of valued habitat and led to a further reduction in the number of turbines that could be accommodated within the Site to 43 (see Figure 5.4).

5.5.6 Following detailed assessments and direct consultation on the potential effects of the Consented Development on operations at Scatsta Airport it became apparent that a large portion of the available land area within the Site lay beneath the Obstacle Limitation Surface (OLS). The OLS places restrictions on the building of tall structures that have the potential to adversely impact on the operation of the airport. This led to a significant re-design of the turbine layout, with multiple iterations ranging from 28 to 20 turbines of varying scales (i.e. 28 smaller turbines or 20 larger turbines) being considered. An example of one of the design iterations is shown in Figure 5.5 and illustrates a 24 turbine layout. A 20 turbine layout was used for the Scoping Opinion request as this deemed to represent the worst case scenario from a visual perspective as it involved the tallest turbines. During the scoping period both designs were presented for public consultation which concluded that fewer larger turbines were preferred (see PAC report). This 20 turbine layout is shown on Figure 5.6.

5.5.7 Figure 5.7 illustrates a further revision of the layout, required as a consequence of the archaeology baseline studies to include a 1,500m buffer from Gossabrough Broch, a Scheduled Ancient Monument. The buffer was to ensure that the turbine layout did not cause an unacceptable impact upon the asset's setting. There were also defined offsets applied from residential dwellings based upon feedback from the public consultation exercise (undertaken at scoping stage). This revision to the layout also had input from the landscape advisors to ensure that the turbines were as visually cohesive and well-spaced as possible.

5.5.8 Further ecological survey in summer 2015 confirmed a successful nest site for red-throated diver on Litla Water that had previously been identified in 2011. This led to an exclusion zone, which was based upon the known flight lines of the breeding pair, during nesting and feeding. These modifications to the layout reduced the wind farm to 17 turbines (see Figure 5.8).

5.5.9 Following consultation with OFCOM and various network operators it was discovered that several links crossed the Site (Figure 3.11). One link carrying signals for Vodafone and Shetland Islands Council passes through the centre of the Site from the southwest to the northeast without being affected by the turbines. A second link operated by BT crosses the Site from south to north. Discussions with BT revealed that it would not be possible to reroute this link. In order to ensure that the turbine development has no detrimental effect on the transmission of the signal BT requested a buffer of 25m on top of the second Fresnel zone around the link centreline. To accommodate this standoff it was necessary to relocate turbine T13 approximately 123m to the north east and, as a consequence, to maintain spacing T12 was also moved 74m to the north. A third link was also identified crossing the Site from north to south but turbines T3 and T8 both lay directly in the centreline of this link. Due to the existing constraints on Site there was no option to revise the layout to ensure that the link avoided the turbines. A

telecommunications tower has been proposed in the south-eastern corner of the Site to facilitate this. This 17 turbine layout is the layout submitted for approval and is shown in Figure 3.1.

## 5.6 Design of access tracks and other infrastructure

5.6.1 In general, the location of access tracks, crane pads and other associated infrastructure has by necessity followed the evolution of the wind turbine layout and been subject to very similar constraints and design criteria. However, there are a number of embedded mitigation measures that relate to the ancillary infrastructure that have not been considered above and are considered in the following sections. Each design option is shown of Figure 5.9.

### Access roads

5.6.2 The first access track design was based on use of B9081 to gain access into the Site to the north of Burravoe. This decision was informed by advice given by local landowners and the Highways Department as it would reduce the visual and environmental effects. Despite this the option was discounted because of the potential unacceptable impact of large construction vehicles, including haulage vehicles travelling through Hamnavoe, Houlland and Burravoe.

5.6.3 The second option for the access track was the shortest route from the proposed access from the B9081 north west of Hamnavoe to the location of Turbine 8 on an alignment to the west of Beaw Field. Subsequent peat depth surveys showed that the access track would have been constructed through areas of deep peat and the floating road option would not have been practical due to the gradient and steep topography.

5.6.4 The third option was following the route of an existing track from a point south of Turbine 11 to the B9081, to the north west of Hamnavoe. The alignment of the access track followed an existing Scottish Water supply pipeline and was within the 10m buffer restriction; as a result this route was discounted.

5.6.5 The final route to the Site for which consent is sought meets the technical constraints regarding gradients between water crossing points and bend radii and also results in reduced environmental effects. The route provides construction access to the Site compound and long term operational access to the substation and wind turbines. The proposed access track route follows wherever possible areas of low to moderate peat depth. Floating roads would be used in areas where the longitudinal and cross gradient of the land is 1 in 20 or less to minimise the impact on peat and its natural drainage.

### Turbine foundations and hardstanding

5.6.6 The construction requirements for the candidate Senvion 3.4 MW turbine have been used to define potential impacts on peat. They have also been used to prepare outline designs of cut-and -fill for the platforms required to construct and erect the turbines. Where possible these platforms have been oriented to minimise cut and fill and to avoid environmentally sensitive areas.

### Borrow pits

5.6.7 Aggregate for the access tracks, crane pads, hardstandings and foundations will be obtained from up to four potential borrow pits, which would be quarried within the Site. An initial desk-based study identified several candidate areas that were potentially suitable borrow pit locations. These options were assessed further following engineering site walkover studies, together with information obtained from Shetland Islands Council (SIC) on previous land use, including landfill. Two potential borrow pits shown

in Figure 5.4 as identified borrow pits F and B, were subsequently discounted due the presence of adjacent old landfill sites that are now restored (see Figure 3.11 Technical Constraints for location of former landfill sites).

5.6.8 In addition to the initial borrow pit identification exercise, the potential to reopen Houlland Quarry (identified borrow pits A and I), to the south of the Site was initially considered as this provided a source of known good quality aggregate and retained a working face that could be reopened. However, the presence of archaeological features to the north of the quarry and in the direction of the working face meant that the only feasible option for extraction of this aggregate would be via the public road. The resultant increase in the number of HGVs, through Hamnavoe, Houlland and Burravoe was felt to be unacceptable and so this option was dismissed. Identified borrow pit G was discounted after the engineering site walkover due the topography of the area and potential landscape issues. Identified borrow pit location E was assessed to being too far away from the Consented Development to be practical for use.

5.6.9 The four proposed borrow pits, taking account of their predicted capacities (Figure 3.1), will meet the requirement for aggregate to construct the access road from the B9081 to the site compound (Figures 3.15 & 3.16) and will supply aggregate required for foundations and hardstanding for those turbines to the west of the B9081 (Figure 3.17) and to the east of the B9081 (Figure 3.18).

5.6.10 Sand and cement for concrete production will be sourced offsite and a concrete batching plant to be located in the site compound is the most likely option to produce the volume of concrete required for turbine foundations.

## Site compound and substation

5.6.11 The Site compound will be located in area of flat land to the west of the B9081, which has thin or no peat cover as a consequence of peat cutting and over grazing (Figure 3.1). This area is also relatively central and allows people and materials to be moved around the Site efficiently.

5.6.12 The substation will be located along the access track to the west of the Site, again using areas of ground that were previously disturbed as a result of the construction of a water pipeline construction. This location will minimise environmental effects by reducing the length of the grid connection required and the resultant ground disturbance.

## Summary

5.6.13 Table 5.2 provides a summary of the embedded mitigation that has been included in the final design of the Consented Development.

**Table 5.2*:* Summary of mitigation by design**

| ***Environmental aspect*** | ***Potential impact*** | ***Mitigation by design*** |
|---|---|---|
| Ornithology<br>Otterswick and Graveland SPA | Potential impact upon the Otterswick and Graveland SPA and their qualifying interests in the context of the conservation objectives and management statements.<br>Impact on the qualifying species of the SPA, the red-throated diver population, in particular the barrier effect of the wind turbines and the collision risk associated with SPA breeding pairs. | Ornithological surveys between 2011 and 2015 have defined a protection zone extending to the south and east of the SPA boundary. The constraints associated with the SPA and flight lines used by red-throated diver have influenced the location of turbines within the array.<br>An analysis of vantage point surveys from 2015 identified a further area of ornithological interest for non-SPA breeding red-throated divers on Litla Water to the east of the Site and a separate constraint buffer was defined. |
| Landscape | Minimise potential impact of the Consented Development upon sensitive receptors | The layout was revised to reduce the number of turbines, with the final design achieving a near even spacing, thus reducing the footprint of the wind farm. The eastern turbines have been removed thereby increasing the distance from the nearest turbine to the coast line. In addition, there are no turbines located on the higher ground to the west of the Site |
| Aviation | Due to the proximity to Scatsta Airport, potential for interference with navigational surveillance instruments and conformance with flight procedures during landing and take-off. | An Aviation Obstacle Limitation Surface excluded 540ha of the total area from wind turbine allocation. This constraint was used to define the turbine layout shown in Figure 5.5. |
| Hydrology | Potential to impact water quality, drainage pattern and flood plain. | The location of wind farm infrastructure has taken account of minimum offset distance of 50m from water courses and water bodies. The access track has made use of existing routes where practical and watercourse crossings have been limited to five crossings of major watercourses and one crossing of a minor watercourse. The design of the watercourse crossings would maintain passage of fish and otters and the crossings have been designed to have capacity for a 1 in 200 year flood event without causing constriction of flow or increasing the potential for flood risk downstream. |
| Cultural Heritage | Potential to impact archaeological features | The baseline survey based on 20m transects identified cultural heritage remains that would be affected by route of the access tracks. Access track alignment avoids potential impact on these finds. The location of borrow pits does not conflict with the findings of the baseline survey. |

**Table 5.2*:* Summary of mitigation by design**

| ***Environmental aspect*** | ***Potential impact*** | ***Mitigation by design*** |
|---|---|---|
| Peat and carbon balance | Much of the Site is covered by deep peat >0.5m which would be disturbed within the construction footprint of the wind farm. | A peat depth survey across the Site identified areas where continuous deposits of deep peat were present. These were excluded from the Consented Development, as the deep peat also coincided with the ornithological constraint buffer to the west of the Site. A second peat depth survey has provided data at a 50m grid around turbine locations and on access routes and has been used to inform the design of infrastructure required for construction of the wind farm. |
| Residential amenity, noise and shadow flicker | Baseline data confirmed that the settlements of Burravoe, Gossabrough and Hamnavoe are quiet with few sources of noise. The properties generally face out to sea and therefore away from the turbines within the wind farm. | During the design evolution, turbines were relocated to increase the separation distance between the nearest properties and the outer edge of the wind farm, in particular a turbine to the south east of the array has been removed in the final Consented Development layout. |
| Telecommunications | Electromagnetic interference on those telecommunications networks with transmissions over or near the Site. | Turbine layout has been modified to ensure that requested separation is maintained from link centreline. Emergency services link operated by Airwave Solutions Ltd is directly impacted by two of the turbines and there is insufficient space to avoid them. Mitigation in this instance entails rerouting the link to avoid the area of the Site where turbines are being deployed. |
| Transport | Increased traffic on public highways | Onsite borrow pits are to be used for stone to be utilised in the construction of the site tracks, crane pads and as concrete aggregates. |

## Conclusions

5.6.14 This chapter of the EIAR demonstrates how PWFY has arrived at its final layout for the Consented Development, though the consideration of alternative layouts and design iterations. The key driver for each of the alternatives considered was to seek to avoid environmental impacts where possible and then to consider technical constraints, including optimising energy generation from the Consented Development.

5.6.15 The design evolution described in this chapter alongside the accompanying figures clearly demonstrates how the baseline environment and potential environmental effects of each design iteration have been considered at each step of the design evolution. The final layout presented for approval is considered to be one that has taken account of and sought to minimise the potential environmental effects associated with the Consented Development, while also seeking to maximise the amount of renewable energy that can be generated.