14. SOIL AND WATER

14.1 INTRODUCTION

This chapter assesses the effects of the proposed Viking Wind Farm on soil and water. The assessment was undertaken by Mouchel's water and environmental consultancy team.

Soil and water are closely linked resources with the possibility of common effects. For the purposes of this assessment, 'soil' is considered to include mineral soil, peat and drift deposits. 'Water' is considered to include surface water and ground water.

Effects on soil and water may result in secondary ecological effects on habitats (e.g. peatland) or species (e.g. fish). Such potential effects are considered fully in the Non-avian Ecology section, Chapter 10.

The assessment is supported by additional information in the following appendices.

- Appendix 14.1 Peat Stability Assessment;
- Appendix 14.2 Borrow Pit Assessment;
- Appendix 14.3 Stream Crossing Guidance;
- Appendix 14.4 Estimated Peat Extraction Volumes and Potential Reuse;
- Appendix 14.5 Hydrochemistry Survey;
- Appendix 14.6 Framework Site Environmental Management Plan / Pollution Prevention Planning;
- Appendix 14.7 Framework Site Waste Management Plan.

Soil and water considerations have influenced the design of the proposed development, and these issues are discussed in the applicable appendices.

14.2 SCOPE OF ASSESSMENT

14.2.1 Project interactions

During construction there will be physical disturbance and removal of soil by mobile plant. The wind farm and related infrastructure will introduce physical changes, which may alter the hydrological characteristics of the site. During the construction phase, and to a lesser extent during operation, potential sources of pollution will be present on the site.

14.2.2 Study area

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

The site location map is shown on Figure 1.1. This map defines four individual quadrants for site reference purposes. This enables specific regions of the area of interest to be identified within this assessment, e.g. eastern boundary of the Delting Quadrant etc.

14.2.3 Scoping and consultation

The scoping and consultation responses relating to soil and water are summarised in Table 14.1.

Table 14.1 Summary of Scoping and Consultation Responses relevant to Soil and Water

Consultee	Key Item of Response	Response Addressed
Scottish Executive	Requested that the impacts of the proposed works on peatland hydrological units within or adjacent to the site be considered carefully and that the layout design and construction techniques used should minimise the impact on peatland habitats and hydrology.	Section 14.6.1 (b); Technical Appendix 14.1
	Indicative peat depth mapping was recommended to aid the design of the wind farm, including access and cabling routes and turbine siting.	Technical Appendix 14.1
	Evaluation of peat stability and the risk of peatslides due to wind farm construction was also recommended. It was noted that geotechnical surveys may be required to facilitate this assessment.	Technical Appendix 14.1
	It was additionally recommended that potential impacts on water courses, water quality and migratory and other fish species be considered. It was noted that the *Water Environment (Controlled Activities) (Scotland) Regulations 2005* introduce specific controls on activities impacting on the water environment, including engineering works (e.g. watercourse crossings).	Technical Appendix 14.3
Scottish Environment Protection Agency	Highlighted areas of concern including the hydrological impact on peat bodies and water courses, particularly from the construction of access tracks and borrow pits.	Section 14.6.1 (b)
(SEPA)	Identification of the private water supplies and measures taken to ensure no pollution or diminution of the water quality during or after construction is required.	Section 14.5.8 (b)
	Site work activities have the potential to cause negative effects on soil and water. Measures should be evaluated to prevent particulate and chemical pollution, to prevent erosion and sedimentation of site features and to ensure suitable design of watercourse crossings (where crossings cannot be avoided).	Section 14.6.1 (b); Technical Appendix 14.3
	Special consideration should be given in relation to concrete production and fuel storage areas. Locations for these activities should be carefully chosen with specific pollution prevention measures in place.	Section 14.6.1 (b)
	Contingency plans should be prepared and be in place to deal with local and large scale oil spills during site work.	Section 14.6.1 (b)

Consultee	Key Item of Response	Response Addressed
	SEPA has produced a series of Pollution Prevention Guidelines (PPGs) and advise that the principles contained within the guidelines should be incorporated within the proposed development.	Section 14.3
Shetland Islands Council (SIC)	Commented that the effects of changes to the hydrological regime could be significant when the ongoing effects are looked at in combination.	
	Requested that site drainage, the possibilities of landslides and erosion should be assessed in detail. Advise that peatslides have occurred historically on Shetland and this should be taken into account during the assessment.	Section 14.6.1 (b); Technical Appendix 14.1
	The Shetland Islands Council recognises that large volumes of minerals will be required for the construction of hardstanding, access routes and foundations. The council has a mineral extraction policy which limits the volume of material extracted from borrow pits. Beyond this volume it is preferred that rock is extracted from existing established quarries.	Section 14.6.1 (b); Technical Appendix 14.2
	SIC also comment that quarrying operations are likely to have a significant effect upon soil and water.	Section 14.6.1 (b)
Shetland Anglers Association (SAA)	There are several lochs in the proposed development site that are regularly fished, of which some are owned and some are leased by Shetland Anglers Association. A number of burns are used by SAA members. In addition to this they have identified several important trout and sea trout spawning burns in this area. SAA note that it is an offence to block spawning routes for migratory fish.	Section 14.5.8 (b); Table 14.14
	SAA identified that the development will require the construction of roads, drainage channels, borrow pits and concrete batching sites. There is also likely to be peat removal associated with these activities. Each of the above activities has the potential to cause disruption or pollution to natural watercourses. SAA therefore request strong planning conditions to ensure that there is no detrimental effect on natural water channels from runoff of silt etc. Note that there have been historical peat slippage events in Shetland (e.g. Firth Camp) and that suitable measures should be employed to protect natural water channels. Following a general decline in sea trout population SAA have noted an apparent increase in recent years. SAA would not wish to see this situation reversed due to construction activities. Should development proceed, SAA would not wish members to have access to burns and lochs restricted during the construction period.	Section 14.6.1 (b)
Scottish Water	Confirmed that there are no current water supply sources within the proposed development area. Scottish Water have no plans to develop new abstractions in this area or return	Section 14.5.8 (b)

Consultee	Key Item of Response	Response Addressed
	historic sources to operation. All construction activities should avoid Scottish Water infrastructure.	
Royal Society for the Protection of Birds (RSPB)	Request that the potential hydrological effects of construction of tracks, borrow pits and cables should be carefully considered and appropriate mitigation measures employed. The disposal of waste peat should avoid damage to hydrology and habitats.	Section 14.6.1 (b) Technical Appendices 14.4, 14.6, 14.7

14.2.4 Effects to be assessed

Table 14.2 and Table 14.3 present the summary of potential significant effects identified in scoping, and forms the basis of the effects to be assessed in this chapter.

Table 14.2 Potential Construction Impacts

Construction Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping
General	Suspended solids discharge from stockpiles	Effects on water quality of closest watercourses and waterbodies.	Watercourses, waterbodies and peatland
		Impact on salmon spawning beds and gravels	
Mobile plant operations	Soil disturbance and potential erosion	Soil loss or disturbance	
	Suspended solids discharge	Effects on water quality of closest watercourses and waterbodies.	
	Potential fuel or hydraulic oil spillage	Soil contamination and water pollution	
	Construction activities triggering peatslide events	Soil loss, damage to plant and infrastructure	
Borrow pit operations	Increased surface run off	Change to hydrological regime	
	Suspended solid discharge	Effects on water quality of closest watercourses and waterbodies.	
Access track construction	Construction works altering hydrological pathways within peat deposits	Change to hydrological regime	
	Culverting of	Change to hydrological	

Construction Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping
	watercourses.	regime and to the hydrological continuity of the watercourse	
Cable laying	Creation of temporary drainage route	Change to hydrological regime	

Table 14.3 Potential Ongoing Impacts

Ongoing Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping
Tracks	Increased surface run off	Change to hydrological regime	Watercourses, waterbodies and peatland
	Land drainage adjacent to drainage ditches	Change to hydrological regime	
Sub-station / control building	Increased surface run off	Change to hydrological regime	
Crane pads	Increased surface run off	Change to hydrological regime	
Borrow pits	Increased surface run off	Change to hydrological regime	

14.2.5 Effects scoped out of assessment

Effects arising from the process of decommissioning have been scoped out since they are of a similar nature to construction issues, but of a smaller scale and shorter duration. However, the results of decommissioning (i.e. the removal of the wind farm) are taken into account in assessing both the ongoing and operational effects where appropriate.

14.3 POLICY CONTEXT

While assessing impacts and devising mitigation measures the following legislation, policies and guidance have been taken into consideration:

- *Electricity Works (Environmental Impact Assessment*) *(Scotland) Regulations 1999 & 2000* (& amendments)*;*
- *Electricity Act 1989;*
- *Water Environment and Water Services (Scotland) Act 2003*;
- *Water Environment (Controlled Activities)(Scotland) Regulations 2005*;
- *Private Water Supplies (Scotland) Regulations 2006*;
- CIRIA: Report C532 Control of water pollution from construction sites - Guidance for consultants and contractors;

- CIRIA: Report C648 Control of water pollution from linear construction projects - Technical Guidance;
- Forestry Commission: Forests and Water Guidelines, 4th Edition;
- Scottish Executive: Guidelines on Stream Crossings & Migratory fish;
- Scottish Natural Heritage (SNH): A Handbook on Environmental Impact Assessment (2005);
- Scottish Natural Heritage: Guidelines on the Environmental Impacts of Windfarms and Small Scale Hydroelectric Schemes;
- Scottish Planning Policy 7: Planning and Flooding;
- National Planning Policy Guideline 14: Natural Heritage;
- Scottish Environment Protection Agency (SEPA) Policy No. 19: Groundwater Protection Policy for Scotland;
- Scottish Environment Protection Agency Policy No. 26: Policy on the Culverting of Watercourses;
- Scottish Environment Protection Agency document: Prevention of Pollution from Civil Engineering Contracts: Special Requirements;
- Scottish Environment Protection Agency Good Practice Guide: Engineering in the Water Environment - Construction of River Crossings;

Scottish Environment Protection Agency (SEPA) (jointly with Environment Agency and Northern Ireland Environment Agency) Pollution Prevention Guidelines:

- SEPA PPG1: General guide to the prevention of pollution;
- SEPA PPG2: Above ground oil storage tanks;
- SEPA PPG3: Use and design of oil separators in surface water drainage systems;
- SEPA PPG4: Treatment and disposal of sewage where no foul sewer is available;
- SEPA PPG5: Works and maintenance in or near water;
- SEPA PPG6: Working at construction and demolition sites;
- SEPA PPG07: Refuelling facilities;
- SEPA PPG08: Safe storage and disposal of used oils;
- SEPA PPG18: Managing fire water and major spillages;
- SEPA PPG21: Pollution incident response planning;
- SEPA PPG26: Storage and handling of drums and intermediate bulk containers.

14.4 METHODOLOGY

14.4.1 Overview

The assessment has involved the following key tasks:

- consultations with the relevant statutory and non-statutory bodies to establish the significant hydrological and hydrogeological issues associated with the site;
- detailed desk studies and field surveys to ascertain the current baseline conditions on site;
- identification of potential impacts by considering the possible interactions between the proposed development and the current site conditions;
- assessment of the significance of the potential effects by taking into account the sensitivity of the receiving environment, the potential magnitude of the impact and the likelihood of that impact occurring;
- identification of measures to avoid, minimise or mitigate any significant adverse impacts identified;
- assessment of the significance of residual impacts following mitigation.

14.4.2 Baseline assessment

(a) Desk surveys

The desk study involved:

- Identification of all catchments, watercourses, springs and boreholes;
- estimation of low and peak flows;
- collation of data on public and private abstractions;
- collation of historic hydrological and flooding information for the immediate area and the main downstream watercourses;
- collation of geological and hydrogeological information;
- collation of topographic (digital terrain model) information;
- study of available aerial photography.

Data were collated from the following sources:

- 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;
- Royal Commission on the Ancient and Historical Monuments of Scotland, All Scotland Survey 1988 (Aerial Photography);
- Flood Estimation Handbook (version 2.0);
- ISIS Hydrological Software Package;
- SEPA Interactive Flood Map.

(b) **Field survey techniques**

In order to evaluate the existing soil and water conditions, site visits were undertaken during spring 2006, winter 2007-08 and autumn 2008. The visits concentrated on gaining a good overall understanding of the hydrological, hydrogeological and peat features of the area. This involved assessing catchment areas, investigating private water supplies, visual inspection of the main surface waters and morphological inspection of the peatland. Additional information relevant to stream crossings, peat stability and borrow pit assessment is provided in the respective technical appendices.

14.4.3 Effects evaluation

The significance of potential impacts has been categorised taking into account three key factors: the **sensitivity** of the receiving environment, the potential **magnitude** of the impact and the **likelihood** of that impact occurring; an approach based on guidance given in the Scottish Natural Heritage publication ‘A Handbook on Environmental Impact Assessment’ (2005).

(a) **Receptor sensitivity**

Table 14.4 Sensitivity Ratings

Sensitivity	Definition
High	The receptor has little ability to absorb change without fundamentally altering its present character, is of high environmental value, or of national importance.
Moderate	The receptor has moderate capacity to absorb change without significantly altering its present character, has some environmental value, or is of regional importance.
Low	The receptor is tolerant of change without detriment to its present character, is of low environmental value, or of local importance.

The sensitivity of a receptor represents its ability to absorb the anticipated impact without perceptible change resulting. Three levels of sensitivity have been adopted as shown in Table 14.4.

Evaluation of sensitivity of soils and water can be difficult to quantify. A significant degree of judgement, based on defined characteristics and values and calling on professional experience is accordingly applied during evaluation.

(b) **Impact Magnitude**

Magnitude includes the timing, scale, size and duration of the potential impact. Four levels of magnitude have been adopted as shown in Table 14.5.

Table 14.5 Impact Magnitude Definitions

Magnitude	**Definition**
Major	There would be fundamental changes to the hydrology, hydrogeology or soil
Moderate	There would be material but non-fundamental changes to the hydrology, hydrogeology or soil
Minor	There would be detectable but non-material changes to the hydrology, hydrogeology or soil
Negligible	There would be no perceptible changes to the hydrology, hydrogeology or soil

(c) **Likelihood**

The likelihood of an impact occurring has been evaluated as being unlikely, possible or likely, in line with guidance published by Scottish Natural Heritage (2005).

14.4.4 Effects significance

The findings in relation to the three criteria considered during the effects evaluation have been brought together to arrive at an assessment of significance for each potential effect; see Table 14.6.

Potential effects are concluded to be of major, moderate, minor or negligible significance, taking into account proposed mitigation measures.

The assessment concludes with a review of various impacts to determine if the anticipated impact would be significant in terms of the *Electricity Works* (*Environmental Impact Assessment*) *(Scotland) Regulations 2000*. Those effects assessed as major or moderate are deemed to be significant, whilst those which are assessed as minor or negligible are deemed not significant.

Table 14.6 Effects Significance Matrix

Sensitivity	Magnitude	Likelihood	Significance
High	Major	Likely	Major
		Possible	Major
		Unlikely	Moderate
	Moderate	Likely	Moderate
		Possible	Moderate
		Unlikely	Minor
	Minor	Likely	Minor
		Possible	Minor
		Unlikely	Minor
	Negligible	Likely	Minor
		Possible	Negligible
		Unlikely	Negligible
Moderate	Major	Likely	Major
		Possible	Moderate
		Unlikely	Minor
	Moderate	Likely	Moderate
		Possible	Minor
		Unlikely	Minor
	Minor	Likely	Minor
		Possible	Minor
		Unlikely	Negligible
	Negligible	Likely	Negligible
		Possible	Negligible
		Unlikely	Negligible
Low	Major	Likely	Moderate
		Possible	Minor
		Unlikely	Negligible
	Moderate	Likely	Minor
		Possible	Minor
		Unlikely	Minor
	Minor	Likely	Minor
		Possible	Negligible
		Unlikely	Negligible
	Negligible	Likely	Negligible
		Possible	Negligible
		Unlikely	Negligible

14.5 BASELINE CONDITIONS

14.5.1 Context

The proposed wind farm is located on the north Shetland Mainland, centred at the settlement of Voe, approximately 27km north of Lerwick. The area of interest is divided into four quadrants, two to the east and two to the west of the A970 route, as shown in Figure 1.1 (in Volume 3).

The altitude ranges from sea level (0m AOD) at Aith Voe and Olna Firth to the Scalla Field peak of 281m AOD.

The western area (Delting Quadrant and Kergord Quadrant) of the site is dominated by a number of steep ridges and associated valleys, with the eastern side (Collafirth Quadrant and Nesting Quadrant) consisting primarily of rounded hills. Soils are predominantly peat-related, with extensive blanket bog in the area. There are a number of watercourses draining the site, the major streams tending to run north–south or south–north due to the topography of the area. Lochs and lochans are found on hill tops, on plateaux and in valleys.

There are few residential properties within the site; these tend to be situated close to the boundaries of the four quadrants.

The predominant land use across the site is upland moor, used for rough grazing. Surrounding land uses include crofting and aquaculture, including mussel, oyster and salmon farming around the coast. Sullom Voe Oil Terminal is located approximately 3km north of the Delting Quadrant.

14.5.2 Designations

There are a number of Sites of Special Scientific Interest (SSSI) within the site and additional sites close to the site periphery. The coastal areas of Sullom Voe and Yell Sound are both designated as Special Areas of Conservation (SAC). Watercourses draining the site will flow into these coastal areas. These sites and the basis of their designations are discussed in Table 14.7. The data in this table comes from Scottish Natural Heritage (2008) and Joint Nature Conservation Council (2008).

There is also the Loch of Linga local protection area located at Ling Ness, south east of Nesting Quadrant. This is a site identified in the Shetland Local Plan for landscape value.

Table 14.7 Designated Areas

Designation	Basis of Designation
The Ayres of Swinister SSSI	The Ayres of Swinster site lies on the coast east of Delting Quadrant. It is a coastal landform and designated for its national geological importance.

Designation	**Basis of Designation**
Voxter Voe and Valayre Quarry SSSI	Voxter Voe and Valayre Quarry are on the coast, west of Delting Quadrant. This area is designated for national geological importance.
Burn of Valayre SSSI	Burn of Valayre rises within Delting Quadrant and flows west to the sea at Voxter Voe. The designated site covers 5.85ha, designated for supporting scrub habitat rare in Shetland.
Dales Voe SSSI	Dales Voe SSSI lies immediately east of the Delting Quadrant boundary. The Burn of Sandgarth and the local streams at Dale enter the sea at this location. It is designated for saltmarsh habitat.
Laxo Burn SSSI	Laxo Burn SSSI flows between Collafirth Quadrant and Nesting Quadrant, draining Nesting Quadrant. It has been designated due to the presence of hieracium attenuatifolium (hawkweed), which is not known to grow at any other location in the world.
Burn of Lunklet SSSI	Burn of Lunklet SSSI lies to west of the Kergord Quadrant. This is a 20m wide strip of habitat totalling 1.4ha and has been designated for rare hieracia (hawkweed) and native shrub species.
Sandwater SSSI	Sandwater SSSI lies south of the Kergord Quadrant. It covers 38.3ha, a relatively shallow mesotrophic loch designated for breeding waterfowl and extensive beds of Typha latifolia (common bulrush).
Catfirth SSSI	Catfirth SSSI lies south of Nesting Quadrant. It covers 0.16ha of limestone ravine, designated for being one of two sites in Shetland that support Corylus avellana (hazel).
Loch of Girlsta SSSI	Loch of Girlsta SSSI lies south of Nesting Quadrant. It covers 101.7ha and is one of the best examples of the few valley trough mesotrophic lochs in Shetland. It supports ferox brown trout (Salmo trutta fario) and the most northerly known population of Arctic char (Salvelinus alpinus alpinus) in UK.
Sullom Voe SAC	To the west of Delting quadrant, Sullom Voe SAC covers approximately 2700ha and is the only Scottish example of a ria (known locally as a 'voe'). The boreal-arctic (northern) species-rich communities of Sullom Voe are restricted to Shetland voes and are not represented elsewhere in the SAC series. The intertidal sediments display diverse faunal communities.
Yell Sound Coast SAC	Designated due to otter (*Lutra lutra*) and common seal (*Phoca vitulina*) species. Yell Sound is considered one of the densest areas for otter population in Europe. This area covers 1500ha.

14.5.3 Geology

The geology of Shetland comprises metamorphic sedimentary rocks of Moinian and Dalradian age with a steeply dipping north trending foliation and younging to the east.

A simplified solid geology map for the area of interest is shown on Figure 14.1, with the associated superficial deposits (drift geology) shown on Figure 14.2 (both in Volume 3).

The Shetland Isles are elongate and dominated by north to south trending geological units separated by similar trending faults. The rocks within the proposed development are bounded by the Walls Boundary Fault to the west and the Nesting Fault to the east.

The Walls Boundary Fault (WBF) is a continuation of the Great Glen Fault in mainland Scotland and is steeply dipping with a trend to the north-north-east. There is a shatter zone up to 1km wide across the WBF containing cataclastic rocks. The Nesting Fault is a subsidiary fault to the WBF, also steeply dipping, with a narrow shatter zone typically a few metres wide.

Between these two faults is a sequence of Dalradian rocks, striking north-north-east, younging to the east, with a dip that is predominantly either vertical or steeply dipping to the north west. The Dalradian meta-sedimentary rocks are in some areas intruded by igneous rocks and within the area of interest igneous rocks form the Brae Complex and Graven Complex.

The solid geology is covered by glacial deposits and extensive blanket bog formed of peat. Shallow rock head or rock outcrop is found in stream beds and at the summit of ridges and hills.

14.5.4 Geomorphology

In central Shetland, which is the area of interest, the landscape is dominated by north trending ridges with intervening steep sided valleys and rounded hills cut by dendritic drainage patterns. The elevation map, derived from digital terrain model data and shown on Figure 14.7 (in Volume 3), gives a good representation of regional topography.

Shetland has been extensively glaciated and the eastern area of the site (Collafirth Quadrant and Nesting Quadrant) is extensively ice-smoothed. Glaciation has largely removed the pre-existing Tertiary drainage system as the ice flow has been transverse to the trend of the main valleys. The existing drainage system therefore largely reflects topography with lochs and lochans occupying scoured areas.

Within the area of interest the geomorphology is largely a product of the geology, structure and glacial erosion of the terrain. The major landforms are:

- steep sided valleys trending north to south or north-east to south-west;
- ridges formed of more resistant rock types such as quartzite;
- hills generally formed of rounded plateaux cut by valleys, some of which show back-cutting rejuvenation features.

The steep sided valleys are formed in relatively softer rock, especially crystalline limestone, which has been differentially eroded by glacial action. There are several of these features and all are orientated north to south or north-east to south-west reflecting the strike of the foliation in the Dalradian metasediments. In several locations the valleys are partially drowned to form fiords. Peat of over 4m in depth was recorded in several valleys during the peat depth survey.

Several narrow ridges are formed on the western side of the area of interest with either steep slopes on both sides e.g. Kergord Quadrant's Mid Kame ridge, or steeply dipping on one side and more gently inclined on the other e.g. in Delting Quadrant, Scatsta – Dales Voe. These cross sections are shown on Figure 14.3 and 14.4 below, respectively.

Figure 14.3 Kergord Cross Section

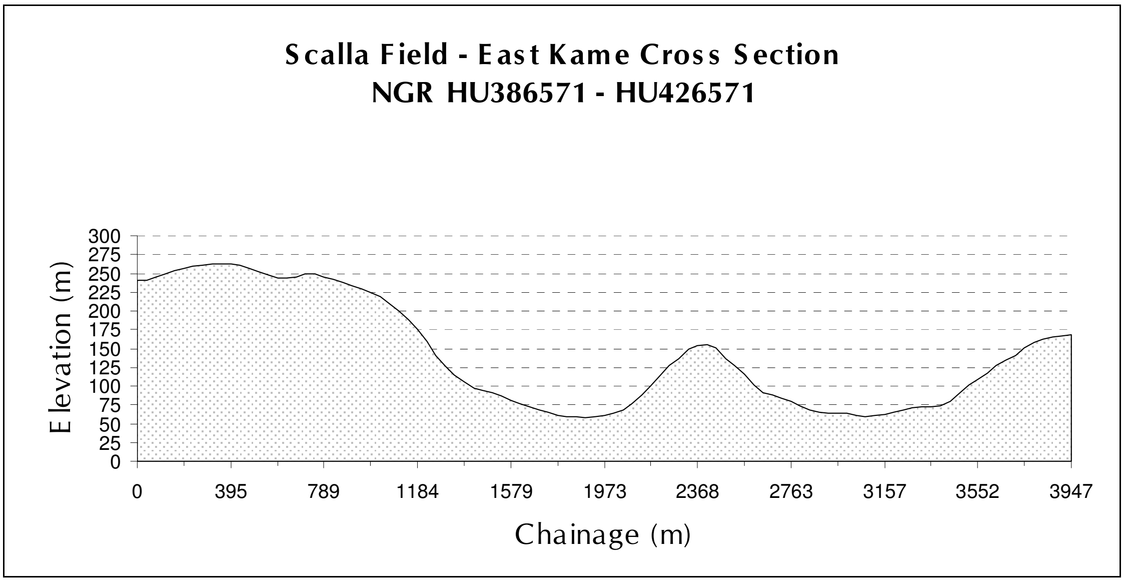
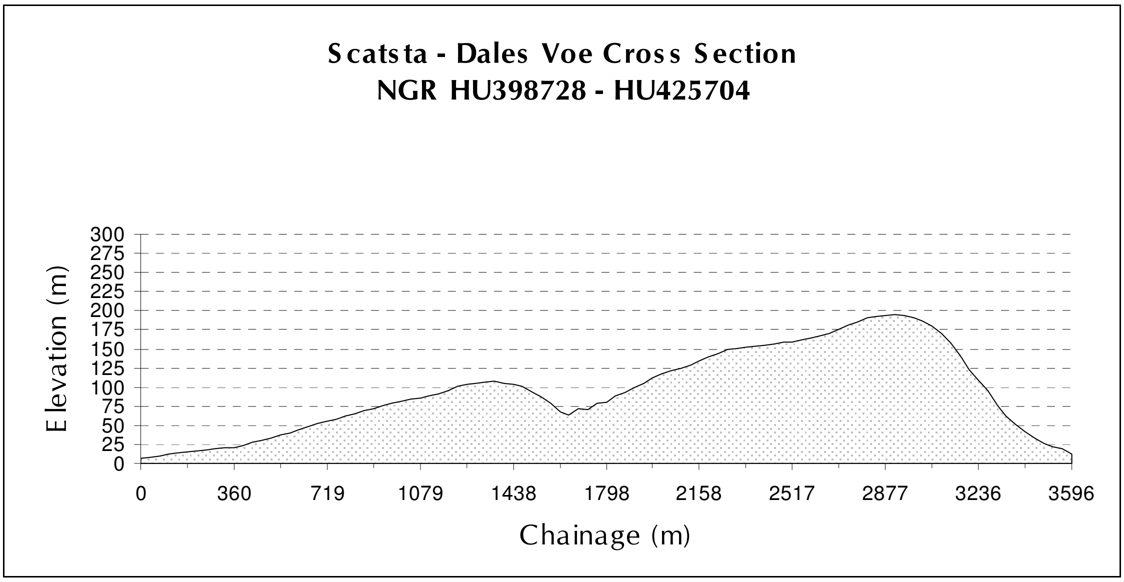


Figure 14.4 Delting Cross Section



Trellis drainage patterns are developed on many of these ridges which are predominantly formed of quartzite. Rockhead is generally very shallow.

Rounded hills, rising to between 150m and 250m AOD, form the most common feature within the site and particularly the eastern area of the site (Collafirth Quadrant and Nesting Quadrant). These are cut by dendritic drainage patterns often concordant with the trend of the foliation in the metasedimentary rocks. Some of the valleys are rejuvenated with gullies cut back into gently sloping valleys. Typical cross sections across these areas are shown in Figure 14.5 and Figure 14.6, below.

Figure 14.5 Collafirth Cross Section

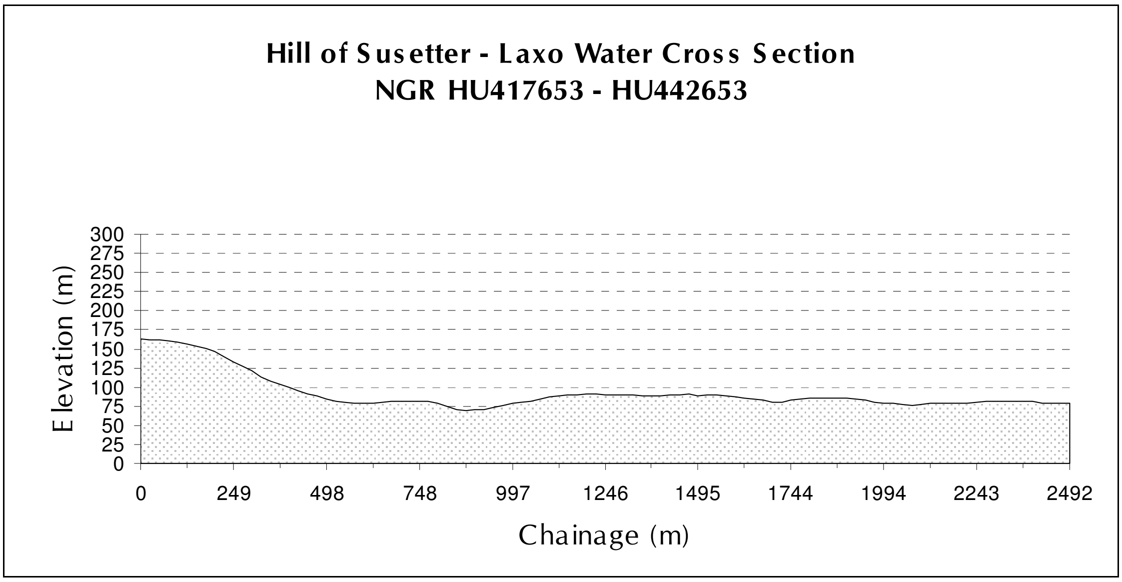
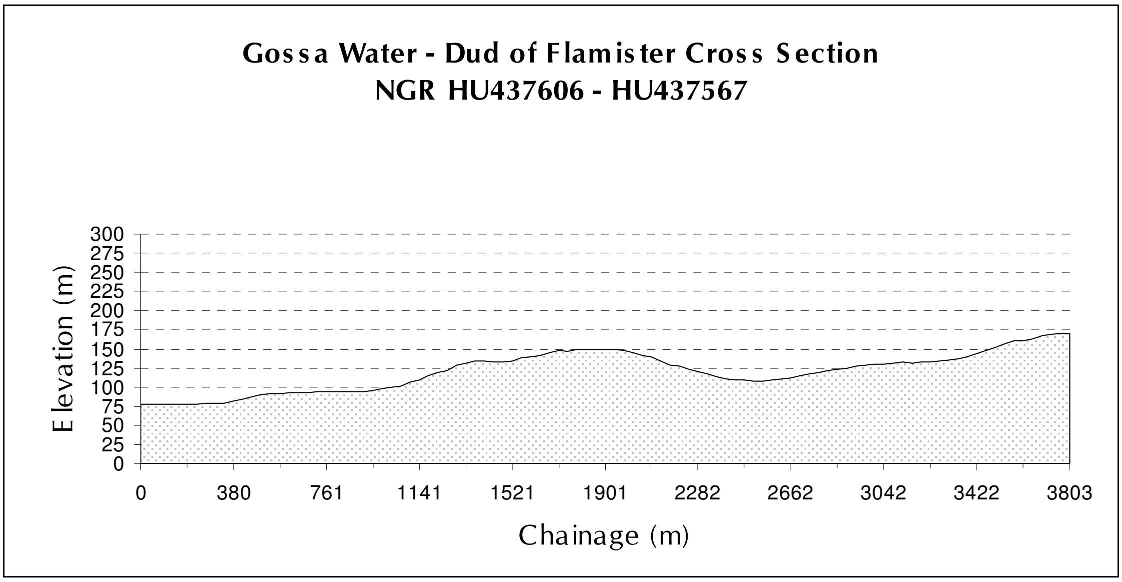


Figure 14.6 Nesting Cross Section



Locations of cross sections are shown geographically, along with elevation data, on Figure 14.7 (in Volume 3). Some further geomorphological information, including geomorphological mapping is provided in Technical Appendix 14.1 (with maps in Volume 4b).

14.5.5 Soil

The distribution of soils is dependant on the geology, topography and drainage regime of the local area, with the soil map shown on Figure 14.8 (in Volume 3). Note that the legend on this figure has been simplified to include only the soil types found within the area of interest. The information on the Soil mapping correlates closely with the Superficial Deposits map – Figure 14.2 (in Volume 3).

Regional soils consist predominantly of blanket peat and peaty units of the Arkaig Association. Some further information on the main soil types identified is provided below:

- *Blanket peat*: organic material generated from the remains of bog and fen vegetation. The wetness of the substrate leads to anaerobic acid conditions inhibiting the decay process;
- *Deep and eroded blanket peat*: deep blanket peat which may display extensive erosion features such as gullies and haggs;
- *Peaty gleys*: slowly permeable, seasonally waterlogged clay-like soils with a peaty surface horizon. Saturation of the soil results in a lack of oxygen and reducing conditions, and the subsequent reduced iron within the soil takes on a bluish colour. In the upper soil horizons, where the water table fluctuates, the soil has a mottled appearance;
- *Peaty podzols*: leached soils with a peaty surface layer. The drainage of these soils is dependant on the level of leaching. Peaty podzols are normally free-draining. However, where strong leaching has occurred, sufficient deposition of iron and aluminium in the lower soil horizons may cement the material into a hard impermeable layer, or ironpan, resulting in waterlogging of the profile above. The product of this is a soil intermediate between podzol and gley.
- *Peaty rankers*: very shallow soils over rocks with a peat surface layer but no subsoil.

There are ten main soil units found within the area. Each soil unit consists predominantly of varying proportions of the soils described above. The proportion of each soil type within a soil unit is dictated by the topography and drainage conditions, therefore each soil unit is associated with a different geographic situation. The soil units found in the region of the site are summarised in Table 14.8, where the component soils of each unit are listed in approximate order of regional dominance, with the landform that each soil unit is typically associated with described.

(a) Peat

As stated in section 14.5.5 above, peat is an important component in the majority of soil complexes found within the site boundaries and can be found on a range of slopes, from gentle to steep. Two distinct layers are recognised; an upper unstratified layer, referred to as the acrotelm, which is fibrous and permeable and a lower stratified layer, referred to as the catotelm, which is colloidal, much less permeable and often rests directly on boulder clay or solifluction deposits.

Table 14.8 Summary of Regional Soil Types

Component Soils	Soil Unit	Associated Landform	% Regional Coverage
Deep and eroded Blanket peat	605	Uplands and northern lowlands with gentle and strong slopes	68.1
Deep Blanket peat	604	Uplands and northern lowlands with gentle and strong slopes	11.4
Peat with peaty gleys with peaty podzols	24	Hills and valley sides with steep and very steep slopes: non-rocky	5.6
Peaty gleys with peat: peaty podzols with peaty rankers	29	Undulating hills with gentle and strong slopes: moderately rocky	5.4
Basin with valley peats	3	Basins and valleys	5.2
Peaty gleys with peaty podzols with peaty rankers	31	Hill sides with steep and very steep slopes: moderately and very rocky	1.8
Brown forest soils: brown rankers with noncalcareous gleys	165	Undulating lowlands and hills with gentle and strong slopes: slightly rocky to rocky	1.2
Noncalcareous gleys with peaty gleys: humic gleys with peat	19	Hills and valley sides with gentle to strong slopes: non-rocky	0.6
Peaty podzols with peat: peaty gleys with humus-iron podzols	320	Hills and lowlands with gentle to steep slopes: non-rocky	0.4
Peat with subalpine soils: alpine soils	193	Hill and mountain summits with gentle and strong slopes: slightly and moderately rocky	0.2

Blanket peat, as found on Shetland, tends to form in areas with high rainfall and low temperatures. Depending on the topography, peat deposits may be discovered at depths of greater than 6m (in hollows and as valley deposits).

On many of the ridges and at the summit of a number of hills the peat has been largely removed by erosion, as corroborated by the data shown in Table 14.8 and on Figure 14.8 (in Volume 3). In the gullies peat depths are very variable and large volumes have been removed by erosion activity. Slumping and terracing was noted during fieldwork surveys, particularly on north-west facing slopes. Examples of the types and locations of peat morphology observed during the course of Viking project fieldwork are given in Table 14.9.

Table 14.9 Examples of Peat Morphology

Feature	Location / Description	Photograph
Blanket Peat (Intact)	Hill of Flamister looking NE (Nesting Quadrant) NGR HU445567 Blanket peat covers much of the site, but its surface condition varies. In this example the peat is generally intact with occasional drainage channels.	
Bankside Erosion	Burn of Quoys, southeast of Hill of Flamister (Nesting Quadrant) NGR HU449564 Within an area of fairly uniform blanket peat the peat has been eroded (or never formed to the same extent) on the steeper banking on the sides of the stream.	
Hilltop Lochan	Summit of East Kame (Nesting Quadrant) NGR HU426573 A number of lochans are found on the hilltops. These have no inlet or outlet streams and are in effect bunded by low permeability peat.	
Drainage Fissure	Skella Dale (Delting Quadrant) NGR HU382674 There is evidence of vertical fissures in the body of the peat, which may act as preferential drainage pathways into water courses. Similar fissuring has also been observed near summits.	

Feature	Location / Description	Photograph
Peat Pipe	Northeast of Flaw Hill on Muckla Moor (Collafirth Quadrant) NGR HU448679 Large peat pipe emerging from 2 m deep blanket peat and leading to a stream. The pipe is located on the interface between the peat and mineral soil.	
Sink hole	Near watershed at north end of Valley of Kergord (Kergord Quadrant) NGR HU402600 Evidence of peat pipes are found in a number of locations across site. This sink hole is probably a partial collapse above a pipe. Note the 1m probe for scale.	
Peat Haggs	Saddle between Garder Hill and Dalescord Hill (Delting Quadrant) NGR HU383690 Large irregular channels in 3-4m deep peat with both standing water and flows from snowmelt.	
Erosion	Crest of Duddin Hill (Delting Quadrant) NGR HU384667 Large tracts of eroded peat covering several hectares along summits and watershed. In places erosion down to mineral soils with some revegetation, elsewhere to 'black' peat	

Feature	**Location / Description**	**Photograph**
Erosion	Souther Hill Trig Point (Delting Quadrant) NGR HU396667 The depth and rate of erosion clearly illustrated by exposure of trig point base over the last 50 years or so.	
Tension Fissure	Northern flank of Souther Hill (Delting Quadrant) NGR HU396668 Slumping and tension cracks at head of dished area extending over about 150m.	
Tension Fissure	Eastern flank, East Hill of Houlland (Kergord Quadrant) NGR HU362545 Intermittent extensive fissuring running parallel to contours over 100-200m	
Slumping	Wester Scord saddle between Souther Hill and Button Hill (Delting Quadrant) NGR HU399671 Slumping in peat with depth in excess of 1m located about 50m north of tension crack swarm	

Feature	Location / Description	Photograph
Slumping	Eastern side of West Kame near Gruti Field (Kergord Quadrant) NGR HU397587 Slumping, incipient slide on steep valley side. In places the scar has been re-vegetated and may somewhat disguise the effect.	
Peatslide	Above Burn of Forse on northern flank of Runn Hill (Nesting Quadrant) NGR HU453581 Large historic slip about 150m across (tension crack near skyline) now undergoing more localised slips within slumped material in foreground.	

Extensive peat depth surveys were undertaken at the site, with probing undertaken at 5745 locations. Table 14.10 shows the range of results gathered, incorporating results from representative areas of the site surveyed in 2006 to inform the design process and results from infrastructure locations subsequently surveyed following various design stages, concluding with final surveys in November 2008.

With reference to Table 14.10, results in parentheses represent 'processed depth values', these results take account of local peat micro-topography, assisting with describing the peat depth to a nominal 'surface level' taking account of local erosion features, where evident. For example:

- if peat probing on a uniform, uneroded surface - no adjustment is made;
- if peat probing in a gully location - the processed result adds the gully depth to the peat depth result;
- if peat probing occurs on an isolated hagg - the height of hagg is subtracted.

It is noted that the application of processed probing values tends to promote peat depths in the deeper ranges and is considered a more conservative approach for peat depth assessment.

The results indicate average peat depths of around 1.5m, with deeper peat typically recorded in valleys and on plateaux. Peat depth on steeper slopes and ridges is generally less than 1.5m.

Table 14.10 Peat Depth Results

Peat Depth Range (m)	Number of Locations Surveyed		Percentage of Locations Surveyed		Average depth in range (m)	
0.0 to < 0.5	931	(616)	16.2%	(10.7%)	0.21	(0.21)
0.5 to < 1.0	1095	(915)	19.1%	(15.9%)	0.68	(0.69)
1.0 to < 1.5	1176	(1137)	20.5%	(19.8%)	1.19	(1.20)
1.5 to < 2.5	1929	(2294)	33.6%	(39.9%)	1.88	(1.96)
2.5 and above	614	(783)	10.7%	(13.6%)	3.06	(3.21)
Total / Aggregate	5745	(5745)	100%	(100%)	1.37*	(1.55*)

*Average depth based on individual data for 5745 locations

The processed peat depth results found are displayed geographically on Figure 14.9 (in Volume 3), the indicative peat depth map derived from these results and based on a grid of 100m x 100m cells, is provided on Figure 14.10 (in Volume 3).

Peat probing data and field survey were also used to produce a more comprehensive assessment of peatslide risk. This assessment used both a qualitative risk assessment method and simplified slope stability calculations, as detailed in Appendix 14.1.

(b) **Land Use**

The study area is primarily used as rough pasture for hill sheep grazing, this land use may have an influence on the peatland erosion features in evidence.

Small-scale peat cutting activities in the local area were noted, assumed as providing fuel for domestic purposes. This activity would be expected to occur mainly around the site periphery, where there is ease of access for local residents.

Around the boundaries of the 4 quadrants there are a number of public roads and a small number of residential and commercial properties.

14.5.6 Hydrogeology (Groundwater)

Shetland is a relatively low-lying archipelago and in the area of interest the highest terrain is around 280m AOD. General groundwater levels can therefore be expected to be relatively close to the surface, particularly in the lower-lying areas near to the coast.

Drift deposits consisting of glacial and periglacial deposits are relatively thin and discontinuous. As such, they have limited storage potential. Boulder clay or solifluction deposits are likely to form the impermeable layer on which many of the lochs and lochans are formed.

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.

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

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

Groundwater infiltration in the study area, based on geology, topography and baseflow data is estimated to be between 100 and 300mm per year. The formations underlying the area do not widely contain groundwater in highly exploitable quantities, however, some formations can locally yield water supplies in sufficient amounts for private use.

Groundwater quality is classified as ‘Good’ on SEPA’s River Basin Management Planning website (SEPA 2008a).

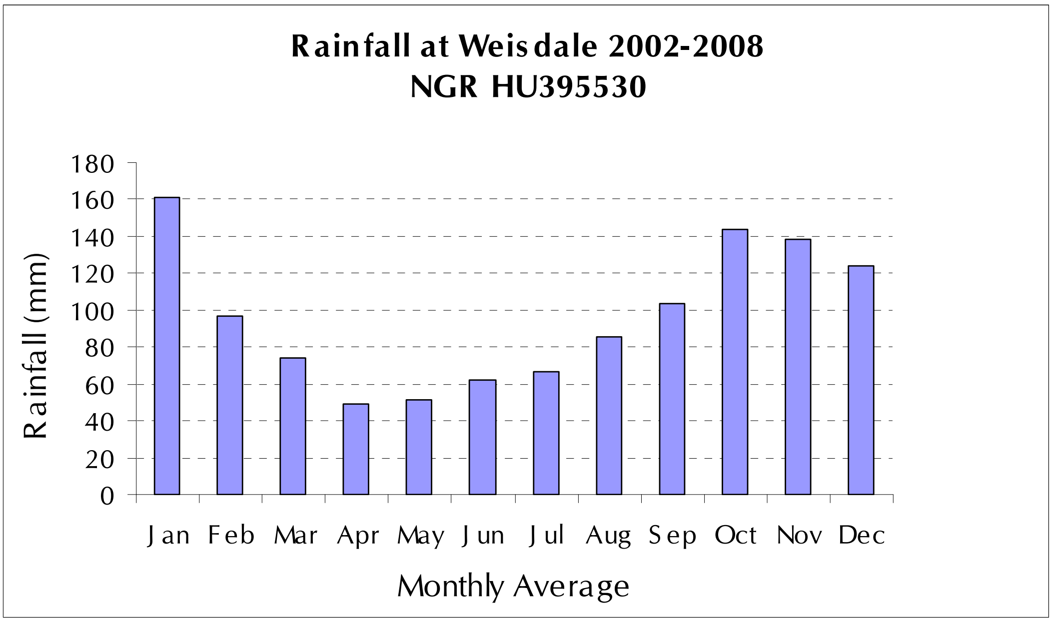
In relation to vulnerability, the groundwater in this area is dominantly classed as 4d (‘Vulnerable’) with small areas of classes 4a-c and 5 (British Geological Survey 2004). This classification reflects the low permeability and low groundwater storage capacity of the metamorphic and igneous bedrock combined with the very variable soil and drift cover, meaning that any contaminant could potentially enter the groundwater rapidly but would be slow to disperse or dilute once in the aquifer. In areas with deep peat, the peat would act as a barrier to the entry of contaminants into the groundwater although it would also serve to restrict access of water into the bedrock for dilution purposes.

14.5.7 Climate

The standard average annual rainfall (SAAR) has been estimated from the Flood Studies Report (Institute of Hydrology 1993) as varying from 1000mm to 1200mm across the site. To put this into national context, rainfall varies from over 3000mm per year in the western highlands of mainland Scotland to under 800mm per year in eastern Scottish mainland areas such as Fife.

The monthly average rainfall for the area has been calculated from daily rainfall data collected at the Weisdale Gauging Station from April 2002 to November 2008. The data are shown on Figure 14.11 below. The annual average rainfall for the years with full data (2003-2007) at the Weisdale station is 1180mm.

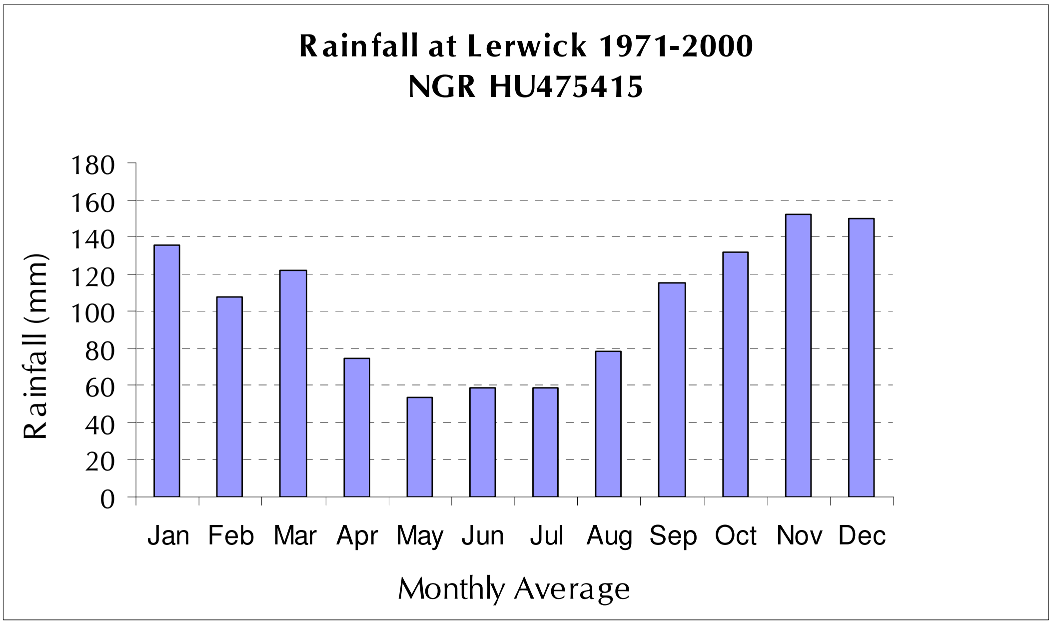
Figure 14.11 Average Monthly Rainfall for Weisdale



As the Weisdale station commenced operation relatively recently, additional longer term information from the Lerwick raingauge has been provided, shown on Figure 14.12 below. The average annual rainfall at Lerwick over the 1971-2000 period is 1238mm. The trends shown in both graphs for relative monthly rainfall are similar.

Examination of rainfall data shows a trend of increasing average annual rainfall over recent decades.

Figure 14.12 Average Monthly Rainfall for Lerwick



14.5.8 Hydrology (Surface Water)

When describing the surface water hydrology it was thought appropriate to consider all watercourses from source to sea in the site area using a hydrological catchment-based system. Therefore, it is recognised that site activities may influence watercourses and locations beyond the proposed site boundary and the assessment includes areas downstream. When considering all site-related catchments these aggregate to an area of approximately 158km^2 and over 500km of watercourses and loch frontage.

Hydrological catchment boundaries were mapped with guidance from the Flood Estimation Handbook (Centre for Ecology and Hydrology 2006). Information on each catchment is summarised in Table 14.11. These catchments are shown geographically on Figure 14.13 with more detailed and additional hydrological information provided on Figure 14.14 (both sets of figures in Volume 3). Numeric identifiers for the catchments are based on unit area; with catchment 1 the largest and catchment 30 the smallest.

Table 14.11 Summary of Hydrological Catchment Key Characteristics

Catchment ID	Catchment Name	Area (km^2)	Site Quadrant	Flooding Potential	SEPA Class	Supply	Fisheries Interest	Sites of Special Scientific Interest
1	Laxo Burn	20.86	Collafirth/Nesting	Yes	A2		Yes	Laxo Burn
2	Burn of Lunklet / S Burn of Burrafirth	18.47	Kergord	Yes	A2		Yes	Burn of Lunklet
3	Pettawater/Sandwater	14.69	Kergord/Nesting	Yes	A2		Yes	Sandwater
4	Burn of Weisdale	13.17	Kergord	Yes	A2		Yes	
5	Burn of Laxobigging	11.33	Delting	Yes	A1		Yes	
6	Burn of Grunnafirth	10.60	Nesting	Yes	A2		Yes	
7	Catfirth	6.79	Nesting	Yes			Yes	Catfirth
8	Burn of Kirkhouse	5.88	Kergord	Yes				
9	Burn of Skelladale	4.82	Delting	Yes			Yes	
10	Burn of Helligill / Trondavoe	4.72	Delting	Yes				
11	Burn of Wester Filla / Daal	4.46	Collafirth/Nesting/ Kergord	Yes				
12	Scatsta	4.27	Delting					
13	Burn of Sandgarth	4.04	Delting/Collafirth	Yes		Yes		Dales Voe
14	Burn of Susetter	3.95	Delting/Collafirth	Yes				
15	Burn of Voxter	3.26	Kergord				Yes	
16	Burn of Gonfirth	2.90	Kergord				Yes	
17	Burn of Quoys	2.91	Nesting				Yes	
18	Burn of Firth	2.69	Delting					
19	Burn of Laxfirth	2.61	Nesting				Yes	
20	Burn of Tactigill	2.69	Kergord					
21	Burn of the Dale	2.13	Nesting				Yes	
22	Burn of Valayre	2.01	Delting					Burn of Valayre

Catchment ID	Catchment Name	Area (km^2)	Site Quadrant	Flooding Potential	SEPA Class	Supply	Fisheries Interest	Sites of Special Scientific Interest
23	Mill Burn	1.66	Delting				Yes	
24	Loch of Skellister	1.69	Nesting				Yes	
25	Atler Burn	1.73	Nesting					
26	Burn of Foulawick	1.34	Delting					
27	Burn of Grunnawater	0.93	Nesting				Yes	
28	Burn of Scudillswick	0.51	Nesting					
29	West Hill of Graven	0.43	Delting					
30	Scord of Sound	0.36	Kergord					

Details on flows and flooding potential, SEPA water quality classification, water supplies and fisheries interests are provided in following sections. Sites of Special Scientific Interest (SSSI) were detailed in the Designations section earlier in this chapter.

There are many small streams, rivers, lochs and lochans throughout the site. However, the water features are not uniformly distributed. In particular, when considering lochs, the majority of bodies of water visible on the 1:50,000 scale map lie within Kergord Quadrant. In contrast, Delting Quadrant has the fewest lochs. In addition to lochs shown at 1:50,000 scale, there are numerous lochans found particularly in the southern sector of the study area. Many of these are ‘perched’ in depressions within the predominantly peat-covered terrain and may indeed be dammed by adjacent peat.

There are also numerous peat bodies, flush zones (areas where surface water travels downhill as diffuse overland flow, outwith a defined channel) and other areas of diffuse surface runoff.

As the majority of the site is covered in peat which may be saturated throughout the year and dependent on local underlying geology, there may be little direct rainfall infiltration to groundwater in a number of areas. As a result a large proportion of rainfall becomes surface runoff and catchments are likely to have a very ‘flashy’ response to rainfall events. This response is characterised by rapid response times and high peak flows.

(a) Description of Representative Hydrological Catchments

All site catchments display upland moor characteristics. Due to the large number of catchments across the study area, the largest catchments plus representative samples of the smaller catchments have been described in more detail below. These catchments were assessed against size, location and hydrological features to ensure a representative selection. The selected catchments, using the numbering system applied in Table 14.11, with relative locations shown on Figures 14.13 and 14.14 (both in Volume 3), are 1, 2, 3, 4, 5, 6, 7, 22 and 24.

Catchment 1 - Laxo Burn (Collafirth and Nesting Quadrants)

The largest of the study area catchments covers an extent of approximately 20.86km^2 (2086 hectares). This catchment is characterised by rounded hills and dendritic stream channels with peat haggs and gullies in evidence. There are also a number of lochs of mixed size. Within this large area there are two distinct subcatchments, situated north and south of the settlement of Laxo. There is 59.7km of watercourse length and loch frontage in this catchment.

Based on surface area, the largest of the lochs are Gossa Water (0.23km^2) in the southern subcatchment and Laxo Water (0.17km^2) in the northern subcatchment. Both of these large lochs are fed via direct stream flow and outflows from smaller lochs upstream.

In addition to the outflows from the lochs identified above, the main watercourses in the catchment are the Seggie Burn, the Gossawater Burn and Easter Filla Burn. These meet the Laxo Burn which reaches the sea at the settlement of Laxo on the east coast.

This catchment area contains Laxo Burn SSSI, located at the mouth of the watercourse, designated due to the presence of rare terrestrial hawkweed species on land adjacent to the burn.

The Gossawater Burn and Laxo Burn are classified by SEPA as being of A2 (‘Good’) quality. Water quality classifications are described further in the Water Resources section.

Photograph 14.1 Dendritic Drainage at Laxo Hill

Photograph 14.2 Thomas Jamieson's Burn, tributary of the Laxo Burn

Photograph 14.3 Outlet Channel from Laxo Water

Catchment 2 –Burn of Lunklet/South Burn of Burrafirth (Kergord Quadrant)

This large catchment covers an area of approximately 18.47km^2 (1847 hectares) and it is notable that this catchment includes a number of large freshwater lochs, including the largest in the study area; Maa Water. There is 60.63km of watercourse length and loch frontage in this catchment. This catchment has minimal development features.

The watercourses in this catchment drain the western slopes of West Kame, Scala Field and West Hill of Weisdale. The main streams in the catchment are the South Burn of Burrafirth, Burn of Lambawater and Burn of Marrofield. These converge with the Burn of Lunklet which flows west into the sea at East Burrafirth.

The relatively large lochs in this catchment; Maa Water (0.25km^2), Lamba Water (0.15km^2), Truggles Water (0.07km^2), Marrofield Water (0.06km^2) and Loch of Lunklet (0.03km^2) would be expected to regulate the flow into their respective outflowing streams which will have a steadying influence on the overall catchment flow characteristics.

Photograph 14.4 South Burn of Burrafirth

This catchment area contains Burn of Lunklet SSSI, covering the area immediately adjacent to the watercourse channel for 600m as it joins with the South Burn of Burrafirth and approaches the settlement of East Burrafirth. This is designated due to terrestrial hawkweed and native scrub vegetation on land adjacent to the burn.

South Burn of Burrafirth is classed by SEPA as A2 (‘Good’) quality.

Catchment 3 – Pettawater/Sandwater (Kergord and Nesting Quadrants)

This catchment covers an area of approximately 14.69km^2 (1469 hectares) within the fjord-like valley known as Petta Dale. There is 33.98km of watercourse length and loch frontage in this catchment.

Water flows through this valley from north to south with the wide flat valley floor bound by steep slopes to the east and west. The Geomorphology section of the chapter discusses these features and Figure 14.3 (above) shows the local topography.

There are two notable waterbodies in the catchment, Petta Water (0.11km^2) and Sandwater (0.37km^2). Sandwater is fed by the Burn of Pettawater. Sandwater is located midway along the valley and is a shallow loch classed as being ‘mesotrophic’, which represents natural, mid-productivity, mid-nutrient status lochs which are generally very sensitive to nutrient-enrichment. Mesotrophic lochs are generally found in the north and west of Scotland and are becoming less common due to nutrient enrichment in their catchments which leads to reclassification as eutrophic. Mesotrophic lochs often contain diverse natural populations of non-algal vegetation, macroinvertebrates and fish. Sandwater has good quality habitat and displays good populations of bulrush and breeding waterfowl. The Burn of Sandwater flows southward from Sandwater to reach the coast at Stromfirth.

Sandwater SSSI has been designated on the basis of the mesotrophic status plus habitat and waterfowl.

Burn of Pettawater and Burn of Sandwater are both classed by SEPA as A2 (‘Good’) quality.

Photograph 14.5 Sandwater and peat erosion features

Catchment 4 - Burn of Weisdale (Kergord Quadrant)

This catchment is bound between the parallel N-S ridges of West Kame and Mid Kame, known as the Valley of Kergord. The Valley of Kergord is a glaciated 'u-shaped' valley feature which collects drainage from both slopes, with runoff draining to the south. The catchment area is approximately 13.17km^2 (1317 hectares). The watercourses in this catchment total 7.26km in length.

The Valley of Kergord presently contains a number of channels such as the Burn of Kergord, the Burn of Droswall and the Burn of Swirtas. These streams meet to become known as the Burn of Weisdale. The Burn of Weisdale flows on to the south, meeting the sea at the settlement of Weisdale.

There is a weir located Weisdale (HU396531), this structure will influence flow regime in this catchment and an artificial waterbody has been created upstream.

Kergord Hatchery, a commercial fish farming enterprise, is situated immediately downstream of the weir identified above, approximately 1km from the mouth of the Weisdale Burn. Further info was requested from the proprietor on operational practices and information to assist in baseline reporting. Whilst awaiting details it is assumed that water is diverted/pumped from the Burn of Weisdale through the operation, at least on an intermittent basis, and that no treatment of water is undertaken prior to exposure to fish stocks.

Burn of Weisdale is classed by SEPA as A2 ('Good') quality. There is a SEPA rain gauge and river flow gauging station situated at Weisdale Mill on this catchment.

Photograph 14.6 Burn of Weisdale

Catchment 5 - Burn of Laxobigging (Delting Quadrant)

The upper reaches of this catchment are drained by the Burns of Easterbutton and Westerbutton. These watercourses form a confluence at the Meadow of Fitchen. The topography in this area is gently sloping to the north east and these watercourses follow this, meeting with other drainage features to become the Burn of Laxobigging. The catchment covers an area of approximately 11.33km^2 (1133 hectares). There is 41.51km of watercourse length and loch frontage in this catchment.

These watercourses (and their tributaries) drain the western slopes of the Hill of Dale, Hill of Oxnabool and Hill of Neegarth. The Burn of Laxobigging enters the sea at Garths Voe, adjacent to the settlement of Laxobigging on the west coast.

Photograph 14.7 Burn of Westerbutton, tributary of Burn of Laxobigging

On the Burn of Laxobigging there is a redundant dam situated close to Graven (HU417726). This artifical feature forms pool habitats upstream which may be considered of value and may contribute to water flow moderation at higher water levels.

Burn of Laxobigging is classed by SEPA as A1 ('Excellent') quality and is the only watercourse to hold this classification status in north mainland Shetland.

Photograph 14.8 Dam on the Burn of Laxobigging

Catchment 6 – Burn of Grunnafirth (Nesting Quadrant)

This catchment covers approximately 10.60km^2 (1060 hectares) and enters the sea at Dury. The main feeder stream is the Burn of Forse. There is 28.52km of watercourse length and loch frontage in this catchment.

Quinni Loch (0.02km^2) is the largest waterbody in the catchment, this feeds the Quinni Burn which flows east into the Burn of Grunnafirth.

In the lower reaches, close to the settlement of Grunnafirth, there is evidence of modification with a large number of artificial drainage channels.

Photograph 14.9 Burn of Grunnafirth

Photograph 14.10 Confluence of Twart Burn and Burn of Forse

Catchment 7 – Catfirth (Nesting Quadrant)

This catchment covers an area of approximately 6.79km^2 (679 hectares). The Burn of Flamister and Burn of Gill converge to form the Burn of Catfirth which joins the Burn of Crookadale approximately 400m from the coast. The Burn of Crookadale enters the sea at the settlement of Catfirth. There is 20.49km of watercourse length and loch frontage in this catchment.

Photograph 14.11 Upper Reaches of Gill Burn

The north west of this catchment, drained by the Burn of Crookadale, is characterised by a number of lochans and waterholes/sinkholes. The largest of these lochans is the Loch of the Andris (0.013km^2 surface area). The sinkholes are likely to be evidence of sub-surface channels, known as peat pipes, which have collapsed. In some instances sinkholes are surrounded by peat material which may suggest the channels are intermittently discharging peat to the surface during high flow periods.

Photograph 14.12 Sinkhole north of Loch of the Andris

Catfirth SSSI is adjacent to the lower reaches of the Burn of Crookadale. This site has been designated due to the existence of scrub habitat, rare to Shetland, within a ravine which is inaccessible to sheep.

Catchment 22 - Burn of Valayre (Delting Quadrant)

This small catchment area has two main drainage features, the Burn of Valayre and the smaller Burn of Dounadale. The catchment area is approximately 2.01km^2 (201 hectares). There is 6.02km of watercourse length and loch frontage in this catchment.

The Burn of Valayre drains the Meadow of Valayre and the eastern and northern slopes of the Hill of Dounadale, this feature has characteristic incised valleys which form steep slopes above the stream channel.

Photograph 14.13 Eroded Channel of Burn of Valayre

The Burn of Dounadale collects drainage from the western and southern slopes of the Hill of Dounadale. The Burn of Valayre and Burn of Dounadale meet south of the Hill of Hardwall and flow north west to the coast at Voxter Voe.

Burn of Valayre SSSI is designated due to the presence of scrub habitat, inaccessible to sheep due to gully slopes, adjacent to the stream.

Catchment 24 – Loch of Skellister (Nesting Quadrant)

This small catchment of approximately 1.69km^2 (169 hectares) is dominated by the Loch of Skellister (0.19km^2), forming the major hydrological feature. This loch has two feeder streams which flow from the nearby lochs of Moo Water and South Black Water. There is 6.55km of watercourse length and loch frontage in this catchment.

The Mill Burn flows from the Loch of Skellister east to meet the sea. This stream appears to have been artificially modified, with two distinct channels created, possibly enabling the water to be utilised as a water power source, as the stream name may suggest. Both these channels have a relatively steep fall of around 60m over their 600m course to the sea.

Photograph 14.14 Loch of Skellister

(b) **Water Resources**

Water Quality

The Water Framework Directive came into force in December 2003 and is implemented in Scotland through the *Water Environment and Water Services (Scotland) Act 2003*. A key objective of this Directive is the achievement of 'good ecological status' (as a minimum) of all natural waterbodies by 2015. This involves a move towards a risk-based classification system (Scottish Environment Protection Agency 2008a). This risk-based system highlights additional issues such as stream morphology and existing artificial structures. However, chemical water status for Shetland streams have yet to be established under the new system.

Up to 2006 SEPA had based their approach on a national River Water Quality Classification system, using a 5 point scale to define water quality as being 'Excellent' (A1), 'Good' (A2), 'Moderate' (B), 'Poor' (C) and 'Seriously Polluted' (D) (Scottish Environment Protection Agency 2008b). In the area of interest this classified a number of site watercourses as being of 'Good' chemical status, with a single watercourse (Burn of Laxobigging) defined as of 'Excellent' chemical status.

Given these alternative systems, local SEPA staff were consulted for guidance on the best approach to use for the basis of this assessment; it was agreed that the (former) 2006 water quality classification system provided the best method to gauge local water chemistry as this included historic water chemistry data. This system excludes issues such as obstructions in streams within the overall classification.

As part of this study, samples were collected from streams in December 2008 and January 2009. Sampling locations and SEPA classified watercourses are shown on Figure 14.15

(in Volume 3). These samples were analysed for the parameters used by SEPA in their 2006 chemical classification of water quality.

Table 14.12 displays the analytical results from these single samples evaluated against SEPA's 2006 system classification and also states watercourses historically classified under SEPA's 2006 system for cross-reference purposes. The results indicate that streams in the local area are generally of at least 'Good' (A2) quality with the majority (22 out of 30 locations) at 'Excellent' standard (A1).

In reference to this table, some streams display downgraded quality (e.g. at sampling locations NH02 and NH10c) due to naturally acidic pH levels. All watercourses, being located within areas of similar land use and taking a precautionary approach, are assumed to be of, at least, 'Good' (A2) status.

Full hydrochemistry methods, results and limitations are provided in Appendix 14.5.

Table 14.12 Water Quality Results

Catchment ID	Sampling Location ID	National Grid Coordinates	Watercourse	2006 SEPA Class	Equivalent to 2006 SEPA Class
1	CH02	HU 43326490	Seggie Burn		B
1	NH01	HU 43726265	Gossawater/Laxo Burn	A2	A1
1	NH02	HU 43156258	Thomas Jamieson's Burn		B
1	NH03	HU 42426240	Easter Filla Burn		A1
2	KH02	HU 36865739	Burn of Lunklet		A1
2	KH03	HU 36765732	South Burn of Burrafirth	A2	A1
2	KH04	HU 38515591	Unnamed burn into Lamba Water		A2
3	KH05	HU 41605536	Burn of Pettawater	A2	A1
4	KH06	HU 40125472	Burn of Weisdale	A2	A1
4	KH07	HU 39455301	Burn of Weisdale	A2	A1
5	DH01	HU 42157326	Stenswall Burn		A1
5	DH02	HU 41417242	Burn of Laxobigging	A1	A1
5	DH03	HU 40087069	Burn of Laxobigging	A1	B
6	NH05	HU 45345947	Quinni Burn		A1
6	NH06	HU 45985936	Burn of Grunnafirth	A2	A1
7	NH09	HU 43625390	Burn of Crookadale/ Catfirth		A2
8	KH01	HU 40296243	Burn of Kirkhouse		A1
9	DH06	HU 36456697	Burn of Skelladale		A1

Catchment ID	Sampling Location ID	National Grid Coordinates	Watercourse	2006 SEPA Class	Equivalent to 2006 SEPA Class
11	NH04	HU 41566204	Wester Fill Burn		A1
12	DH04	HU 39687267	Leegill/Berdigill Burn		A1
13	CH01	HU 41186660	Burn of Sandgarth		A1
17	NH08	HU 44405438	Burn of Quoys		A1
20	KH08	HU 37145100	Burn of Tactigill		A1
22	DH05	HU 37916883	Burn of Valayre		A1
23	DH07	HU 37696640	Burns of Duddin		A2
24	NH07	HU 46725583	Mill Burn		A1
29	DH08	HU 39807290	Unnamed burn from West Hill of Graven		A2
30	KH09	HU 37925029	Unnamed burn at Scord of Sound		A1
Off-Catchment 'Control'	CH03c	HU 45766667	Swining Burn		A1
Off-Catchment 'Control'	NH10c	HU 45006282	Burn of Tararet		B

Related to water quality, there was also a Freshwater Invertebrate Survey undertaken in 2008 for this proposal, the details of this study are provided as Appendix 10.7, relating to the Ecology section of the report.

Public Water Supplies

Within the local area there are no public water supply sources, as confirmed by Scottish Water. The local Scottish Water supply is fed by trunk main from the Eela Water Water Treatment Works, Northmavine. Eela Water is situated approximately 9km to the north west of the Delting Quadrant, across Sullom Voe.

Evidence was noted of a former reservoir at Whitelaw Loch (HU358542).

Private Water Supplies

Shetland Islands Council provided locations of private water supplies in the vicinity of the initial study area. Following examination, a number of these supplies were deemed not relevant with respect to impact from the proposed development. This decision was based on location, topography and water catchment area in relation to the indicative development site.

Six private water supplies were considered to be worthy of further investigation given initial study area. The locations of these sources and the respective properties served are shown on Figure 14.14.

The private water supplies are clustered around the settlements of Dale and Burrafirth, with isolated supplies at Brae and Grobsness. This includes a property which was visited and discovered to be derelict (with non-operational water supply infrastructure) during our April 2006 survey. There are no private water supplies located close to either Collafirth or Nesting Quadrants.

Each of the private water supplies include a source, storage vessel and associated pipework between the source, storage vessel and supplied property, details of each are provided in Table 14.13.

Table 14.13 Private Water Supply Descriptions

Property	Location / Description	Photograph
Grutin	Near Dale (Delting Quadrant) NGR - HU403684 Located near Dale, this well source supplies a single property. The well is located at the base of a steep slope to the east of Delting Quadrant. This source is located within site hydrological catchment 13.	Supply Tank and Flexible Pipework  Covered Well Source 

Property	Location / Description	Photograph
Pund of Grutin	Near Dale (Delting Quadrant) NGR HU408690 Located near Dale, this water supply provides water for the two properties at Pund of Grutin, The source is a spring located at the base of a steep slope to the east of Delting Quadrant.	Supply Tank 
Parkview	Brae (Delting Quadrant) NGR HU361677 The Parkview property in Brae is supplied by a spring source. The source location is downslope of the western boundary of Delting Quadrant.	Hatch over Source 
Easthouse	Grobsness (Kergord Quadrant) NGR HU370633 The Easthouse at Grobsness is supplied by a hillside spring source located to the north west of Kergord Quadrant.	Source and Supply Tank 

Property	Location / Description	Photograph
Lea of Burrafirth	East Burrafirth (Kergord Quadrant) NGR HU352586 Lea of Burrafirth, East Burrafirth, is supplied by a spring source located downslope and to the west of Kergord Quadrant.	Supply Tank 
'Abandoned Property'	South of Selie Ness (Kergord Quadrant) NGR HU351596 This property, 1km north of the Lea of Burrafirth property appeared abandoned and in a derelict state on our visit in April 2006. There was evidence of water supply infrastructure at the location but this did not appear to be fit for operation.	Supply Infrastructure 

Freshwater Fish

Shetland freshwater resources are recognised as of high quality, as shown by the SEPA River Quality Classification system. Further evidence is provided in the number of freshwater fishing interests in and around the site.

Shetland Anglers Association have provided information on their activities (Shetland Anglers Association 2006); these activities are distributed across the four quadrant areas. The locations and comments are listed in Table 14.14, with comments on summary Table 14.11, using standard site catchment identifiers. The locations identified are a mixture of freshwater lochs and burns used for fishing, plus spawning burns used by salmonid species. Note that, in addition to the aforementioned table, all lochs in the Nesting Quadrant are owned by Shetland Anglers Association, hence these should all be considered of importance to fisheries.

As part of this proposal a (freshwater) Fish Survey was undertaken in 2008; results are provided in Appendix 10.6 relating to the Ecology chapter.

In addition to the amenity fisheries above, there is the commercial freshwater hatchery located at Weisdale (Kergord Hatchery), within catchment 4. This hatchery will require water of an appropriate standard and quantity for their continued operation.

Table 14.14 Freshwater Fishery Interests

Catchment ID	Quadrant	Location Name	Shetland Anglers Association Comment	Comment
1	Collafirth	Seggie Burn	Important feeder burn for Laxo sea trout system. An important sea trout burn.	
1	Nesting	Laxo Water & burns	Important headwater loch for sea trout spawning burns also contains good stocks of indigenous wild brown trout.	
1	Nesting	Gossa Water & inlet & outlet burns	Main spawning area for sea trout in this area. Also has a stock of indigenous wild trout.	
2	Kergord	Burns & Lochs draining into East Burrafirth	Important sea trout system. Lochs hold indigenous stocks of wild brown trout.	
3	Kergord	Petta Water	Popular trout loch.	
3	Kergord	Burn of Petta Water feeding into Sand Water	Important sea trout spawning burn.	
4	Kergord	Burns draining into Kergord Burn system	Important sea trout system.	Location of commercial freshwater fish hatchery
5	Delting	Burn of Laxobigging & tributaries	Important spawning burn for sea trout.	
6	Nesting	Burn of Grunnafirth & tributaries	Main spawning burns for Dury Voe sea trout.	
7	Nesting	Burn of Flamister & Crookadale	Main spawning burn for Cat Firth stock of sea trout.	
9	Delting	Skelladale Burn	Important spawning burn for sea trout.	
15, 16 and Off-catchment	Kergord	Burns & Lochs draining into Gonfirth Voe	Important sea trout system. Lochs hold indigenous stocks of wild brown trout.	
17	Nesting	Burn of Quoys	Important spawning burn for sea trout.	
23	Delting	Mill Loch	Popular trout loch.	

(c) **Freshwater Runoff**

Flow Values

Low flows and mean daily flows were calculated using the Low Flows software (Wallingford HydroSolutions 2007). The software has been developed to enable the user to estimate river flows for ungauged catchments. The result of the low flow estimate is the $Q_{95}(10)$, which is the flow exceeded 95% of the time, as observed over a 10 day period. Peak flows have been estimated using the Flood Estimation Handbook (Centre for Ecology and Hydrology 2006) rainfall-runoff method in conjunction with the ISIS hydrological software package (Halcrow/HR Wallingford 2004) for a range of return periods. The key flow characteristics of site water catchments are provided in Table 14.15. Note that the Flood Estimation Handbook (FEH) system employed does not cover catchment sizes smaller that 0.5km^2. Where small catchment data was required a pro-rata interpolation on unit runoff was made and results extrapolated from other watercourses. The data provided relates to the flow from each catchment at the coast.

It is useful to make a comparison between the FEH method and a second method to ensure consistency. The Flood Studies Report (Institute of Hydrology 1993) method was selected for this review. Results generated using the Flood Studies Report method provide good corroboration with FEH, giving confidence in the estimated flows in the site catchments.

SEPA have operated a flow gauge on the Weisdale Burn catchment (catchment 4) since 2002. Although admittedly a short period of recording, the data from this station has been collated to enable comparison between the, estimated FEH-derived flows and actual gauged flows at this catchment. Comparison shows that the theoretical method employed yields results consistent with the actual mean daily flows and low flows recorded in this catchment. Therefore, the comparison provides comfort that catchment estimations are sufficiently accurate to provide a good indication of actual flow values.

Flooding

SEPA provide a Scottish Flood Map (SEPA, 2008c), which has been reviewed to ascertain the likelihood of river flooding in the study area. Based on a 1:200 year event, there are small areas immediately adjacent to some site streams which are at risk of freshwater flood inundation; these watercourses are detailed in Table 14.16.

The locations identified tend to be at the base of valleys where the topography has shallow slopes and numerous streams merge. These flooding events would be expected to be restricted to the area immediately adjacent to the stream channel. No large adjacent areas are anticipated to be flooded.

It is notable that only the larger site catchments have identified flooding potential; it may be the case that smaller catchments are also potentially influenced. SEPA's flood mapping does not incorporate data from catchments (or tributary subcatchments) of less than 3km^2.

Note that there are a small number of additional areas immediately adjacent to the coast that are currently classified as 'at risk' from 1:200 year event coastal flooding events (SEPA, 2008c).

Table 14.15 Catchment Flow Values

Catchment ID	Area (km^2)	Mean Daily Flow (m^3/s)	Low Flow Q_{95} (10) (m^3/s)	Estimated Peak Runoff (m^3/s) for each Return Period (years)						
				2	5	10	25	50	100	200
1	20.86	0.578	0.115	10.32	14.04	16.31	19.46	22.11	24.70	28.59
2	18.47	0.489	0.108	9.60	13.16	15.33	18.36	20.92	23.32	26.69
3	14.69	0.399	0.0792	6.42	8.74	10.16	12.13	13.78	15.55	18.01
4	13.17	0.385	0.0514	5.66	7.70	8.95	10.68	12.15	13.52	16.06
5	11.33	0.302	0.0493	5.39	7.34	8.53	10.18	11.57	12.87	14.79
6	10.60	0.265	0.0423	5.11	6.98	8.12	9.72	11.06	12.31	14.22
7	6.79	0.181	0.0249	3.64	4.99	5.82	6.98	7.95	8.87	10.12
8	5.88	0.164	0.0218	2.68	3.67	4.27	5.11	5.82	6.48	7.36
9	4.82	0.145	0.018	2.62	3.60	4.19	5.03	5.73	6.39	7.26
10	4.72	0.127	0.0202	2.75	3.78	4.42	5.31	6.06	6.76	7.69
11	4.46	0.126	0.0273	2.586	3.556	4.150	4.979	5.678	6.335	7.20
12	4.27	0.111	0.0167	2.59	3.57	4.18	5.02	5.73	6.40	7.29
13	4.04	0.125	0.015	1.82	2.49	2.91	3.49	3.98	4.44	5.05
14	3.95	0.12	0.0183	1.76	2.41	2.81	3.37	3.84	4.28	4.86
15	3.26	0.0843	0.0214	2.16	2.99	3.50	4.20	4.80	5.36	6.11
16	2.90	0.079	0.0171	1.84	2.53	2.95	3.55	4.05	4.51	5.13
17	2.91	0.0744	0.00879	1.65	2.28	2.66	3.19	3.64	4.07	4.63
18	2.69	0.0665	0.0123	1.43	1.97	2.30	2.76	3.15	3.52	4.01
19	2.61	0.062	0.0121	1.51	2.09	2.44	2.93	3.35	3.74	4.23
20	2.69	0.0689	0.0088	1.65	2.28	2.66	3.30	3.77	4.21	4.52
21	2.13	0.0493	0..00980	1.35	1.87	2.19	2.64	3.02	3.37	3.88
22	2.01	0.0569	0.00856	1.25	1.72	2.01	2.41	2.75	3.07	3.50
23	1.66	0.0561	0.0108	1.14	1.57	1.84	2.21	2.52	2.82	3.21
24	1.69	0.0446	0.00598	1.08	1.49	1.75	2.11	2.41	2.69	3.07
25	1.73	0.0438	0.0066	1.20	1.66	1.94	2.34	2.67	2.99	3.41
26	1.34	0.0385	0.00276	0.82	1.14	1.33	1.60	1.83	2.04	2.33
27	0.93	0.0238	0.0028	0.41	0.56	0.66	0.79	0.91	1.02	1.16
28	0.51	0.0123	0.00165	0.38	0.53	0.63	0.76	0.87	0.97	1.11
29	0.43	0.0111	0.00167	0.40	0.53	0.67	0.85	1.03	1.11	1.34
30	0.36	0.0096	*	0.37	0.49	0.57	0.74	0.90	1.02	1.23

All figures are based on catchment flows at coast, flow rates upstream of mouth will accordingly be lower

*Too small a catchment for Low Flow software to generate a value

Table 14.16 Watercourses with Predicted 1:200 Year Flood Event

Catchment ID	Quadrant	Watercourse
1	Collafirth / Nesting	Gossawater, Laxo Burn and Seggie Burn
2	Kergord	South Burn of Burrafirth and Burn of Lunklet
3	Kergord	Burn of Pettawater and Burn of Sandwater
4	Kergord	Burn of Weisdale
5	Delting	Burn of Laxobigging
6	Nesting	Burn of Grunnafirth
7	Nesting	Burn of Crookadale
8	Kergord	Burn of Kirkhouse
9	Delting	Skelladale Burn
10	Delting	Loch Burn
11	Collafirth / Nesting/ Kergord	Outflow from Loch Voe
13	Delting	Burn of Sandgarth
14	Delting	Burn of Susetter

14.5.9 Modifying influences

As peat and peat soils are composed of vegetation remains and are almost entirely organic they contain a high proportion of carbon compared to other soil types. Thus the process that forms peat effectively locks away atmospheric carbon. It is believed that loss of good quality peatland will lead to the release of carbon into the atmosphere contributing to increased greenhouse gas concentrations which are believed to be one of the main drivers of climate change. However, it is recognised that the current state of site peatland is not of uniform good quality. These issues are discussed further in the Air and Climate chapter of this report, Chapter 16.

Anticipated climate change suggests slightly increased temperatures, an increased capacity for the atmosphere to hold water vapour and resultant increases in fluxes of precipitation and evaporation. It is thought this may result in a reduction of summer precipitation and an increase during winter. Modelling data provided by the British-Irish Council (2007) suggest that over the next 100 years Shetland will see a reduction in summer rainfall of 19%, with an increase in winter precipitation of 10%, giving an overall increase in precipitation of 4% per annum. Temperatures are predicted to rise by 1.8ºC over the same period.

Thus, in winter months there could be an increase in rainfall and reduction in snowfall. If climate change leads to drier summers and there is increased demand on the public and private water supplies, water shortages may occur during prolonged periods of dry weather. There has also been suggestion that summer storms are likely to be more intense and frequent in Scotland, this may lead to more extreme flow values during and immediately following such events, with consequential issues such as flooding or a possible increase in peat instability.

14.5.10 Limitations of Baseline Assessment

The fieldwork carried out was a standard reconnaissance level walkover survey. Due to the geographical extent of the area it was not practical to traverse the whole site. However, various representative locations and features such as peat bodies, watercourses and geological exposures were assessed and this information was extrapolated for areas not visited.

The soil mapping does not include the northern and southern extremities of access tracks into the site, as soils are noted to be fairly consistent across the area (and generally peat), this is not felt to make a material difference to this study.

There are a very small number of turbine and track locations that have not been surveyed for peat depth, due to final layout amendments combined with poor weather in autumn 2008 preventing survey completion. Close inspection of peat depth results on Figure 14.9 shows infrastructure locations without peat depth data. None of the unvisited locations is greater than 220m from previously gathered results and given the large existing dataset and specific positions involved this is not judged to make any material difference to our conclusions and recommendations.

Private water supply information was provided by Shetland Islands Council as the statutory record holders for such information. There is a possibility that other private water supplies could exist, such as at abandoned properties. It is also possible that there are non-potable water supplies, such as for livestock, which were not identified by the council.

14.5.11 Interactions Between 'Soil and Water' and Other Sections

There are close links between hydrology and ecology aspects of the environmental baseline. For example water quality and flow issues have the potential to influence downstream ecological features and peat depth mapping was provided for ecological habitat studies.

At an early stage a range of soil and water mapping datasets were developed and made available to inform transportation and layout planning phases.

14.5.12 Summary of Baseline Assessment

The site displays extensive blanket peat, much of which is degraded and with obvious erosion features. Peat depths recorded averaged around 1.5m, depths of greater than 4m were discovered in a number of valley and plateau locations, and shallower peat was typically found on ridges and steep slopes.

Small lochans feature in the peatland, with a number of larger lochs found in Kergord and Nesting quadrants. There are a large number of good water quality streams. Due to ground conditions and the low permeability of peat, these are likely to display flashy response to rainfall events. Some site streams have flooding potential, primarily in the area immediately adjacent to channels.

There are a small number of isolated private water supplies but no public supply source in the area. Fisheries interests were identified across the site in general.

Although there are a number of designated areas identified within site catchments, most of them are designated due to geological or adjacent habitat features. The exception to this is Sandwater SSSI, designated for mesotrophic loch status.

14.6 EFFECTS EVALUATION

14.6.1 Basis of assessment

(a) Development characteristics

The construction phase of the wind farm development will require the creation of hardstanding construction compounds and borrow pits for generation of aggregate for the construction of suitable access tracks to enable transportation and installation of wind turbines. At each turbine location there will be a requirement for hardstanding (concrete) for turbine bases and for crane pads. Substations will also require to be built on hardstanding, with cables laid to connect them to individual turbines. Anemometers will be installed on masts, distributed across the site, to gauge wind information for efficient facility operation.

Construction of the Viking Wind Farm development is anticipated to be phased over a period of 5 years and involves:

- Creation of 8 construction compounds, including use of existing hardstanding adjacent to Sella Ness;
- Creation of an estimated 11 borrow pits and reopening of 3 existing borrow pits from close to site, enabling extraction of c1.5m^3 of aggregate;
- Construction of 118km of access track, of which 28km is planned as double width. Track construction methods will include both ‘cut and fill’ and ‘floating’ methods depending on local conditions;
- As tracks will inevitably require to cross site streams there are an anticipated 94 stream crossings;
- Installation of 150 turbines and associated hardstanding for turbine bases and crane pads;
- Installation of electrical cables, generally located alongside tracks, connecting turbines to substations;
- Construction of 3 substations;

- Installation of 11 permanent met-masts (anemometers).

Table 14.17 shows the infrastructure planned for each site hydrological catchment.

(b) **Assumed design, management and mitigation measures**

A number of planning, design and construction proposals have been identified whilst undertaking the assessment. These are described below and have been assumed as part of the proposals when reporting the residual effects and their significance.

Layout design

At the outset the team responsible for detailing soil and water issues on the site were provided with a site study area. The purpose of this was to enable layout design to avoid constraints identified from desk study and fieldwork. Layout constraints included items such as hydrological features, water supplies, deep peat and potential peat instability.

At various stages during the progress of the iterative design process fieldwork was undertaken in order to provide feedback to the development design team.

Peat Constraints

Before a preliminary layout was produced an initial peat depth survey was undertaken to gain an understanding of the peat issues across the site and to inform the design process. Peat depths were sampled at 50m intervals along a selected number of transects, chosen to traverse different terrain types found across the site. In addition to peat probing data, information was gathered at each location on basic vegetation, local peat erosion features, micro-location of probing (i.e. in gully), with photographs taken at appropriate locations.

Using this site data, with digital terrain model (DTM), aerial photography and field observations, peat depths were extrapolated across the study area in peat depth ranges. Because of the size of the study area this extrapolation was carried out on a grid of 100m x 100m cells to produce a preliminary indicative peat depth map. Based on the findings, and where practicable, the preliminary layout located the various elements of the development away from identified areas of deep peat.

Following production of the preliminary layout a second phase of peat probing was carried out along the route of the proposed site tracks and during the course of this site work it was found that some of the proposed tracks crossed exceptionally deep peat. Where possible these sections of track were realigned, taking into account other constraints such as minimising stream crossings, ornithology and landscape.

During this second phase of peat probing the preliminary turbine locations were probed at their centre point and at points around 25m from the centre on the major compass points (i.e. north, south, east and west). Deep peat (depth greater than 2.5m) using the precautionary processed peat depth method discussed in 14.5.5(a)) was found at a number of these probing points, as shown on Figure 14.9 (in Volume 3). Where possible turbine locations were moved away from these areas before the layout was finalised.

The final set of fieldwork was undertaken in November 2008 following the design fix, this element of fieldwork investigated items such as final design stream crossing locations and peat depths on finalised sections of tracks, turbine locations and construction compounds. At this stage ground condition surveys at representative locations were undertaken to feed into the peat stability assessment process.

Table 14.17 Development Features Proposed in Hydrological Catchments

Catchment ID	Quadrant	Proposed Development Features
1	Collafirth/Nesting	Track, 18 stream crossings, 26 turbines, 2 anemometers
2	Kergord	Track, 18 stream crossings, 2 borrow pits, 28 turbines, 2 anemometers
3	Kergord/ Nesting	Track (on catchment margin), 2 borrow pits (both pre-existing), 10 turbines (on catchment margin), anemometer,
4	Kergord	Track, 8 stream crossings, 8 turbines, substation (adjacent to convertor station) anemometer
5	Delting	Track, 17 stream crossings, borrow pit, 20 turbines, anemometer
6	Nesting	Track, 6 stream crossings, 24 turbines, borrow pit (on boundary with catchment 7), anemometer
7	Nesting	Track, 3 stream crossings, borrow pit (on boundary with catchment 6), construction compound, 10 turbines, anemometer, substation
8	Kergord	Track, 2 stream crossings, Borrow Pit, 1 Turbine
9	Delting	Track, 6 stream crossings, Borrow Pit (on boundary with catchment 23), Construction Compound, 4 Turbines, Substation
10	Delting	3 Turbines (on catchment margin), Anemometer
11	Collafirth/Nesting/ Kergord	Track, 4 stream crossings, Borrow Pit, 2 Construction Compounds, 4 Turbines
12	Delting	Track, 4 stream crossings, 1 Turbine
13	Delting/Collafirth	Track, Borrow Pit, Construction Compound
14	Delting/Collafirth	None
15	Kergord	None (Track on catchment margin)
16	Kergord	None
17	Nesting	Track, 3 stream crossings, 5 Turbines
18	Delting	Track, 1 stream crossing
19	Nesting	None (Track and Turbine on catchment margin)
20	Kergord	Track
21	Nesting	None (Track on catchment margin)
22	Delting	Track, Borrow Pit (existing, on catchment margin), 2 Turbines
23	Delting	Track, Borrow Pit (on boundary with catchment 9), 1 Turbine, Anemometer
24	Nesting	Track, 3 stream crossings, 2 Borrow Pits, 1 Turbine
25	Nesting	None (Track on catchment margin)
26	Delting	Track (upgrading of existing track), 2 stream crossings
27	Nesting	None
28	Nesting	None
29	Delting	Track, 1 stream crossing, Construction Compound (on catchment margin), 2 Turbines
30	Kergord	Track, 1 stream crossing, Borrow Pit, Construction Compound

The additional peat probing and field survey data were used to produce a more comprehensive assessment of peatslide risk in the proposed areas of wind farm construction. This assessment used both quantitative and, where areas of high risk were identified, qualitative assessment, as detailed in Appendix 14.1.

Hydrological Constraints

From design phase, wherever possible, all wind farm construction has been sited with an objective to maintain at least a 50m 'buffer zone' from streams and waterbodies. This approach is complementary, in respect of protection, to that which would apply to ecology and bird features.

Where access necessitates essential stream crossings, construction features have been limited in these buffers as far as possible, for example minimising tracks running parallel to streams and trying to avoid track junctions being constructed in these zones. During detailed design and construction phases sections of track will surveyed and microsited to optimise the distances from the waterbodies, taking into account local micro-topography.

Construction compounds will be sited to maximise distance from adjacent watercourses and will be appropriately sized (with maximum dimensions of 100m by 100m). Wherever possible, a 50m buffer shall be installed, with a minimum of 10m buffer.

To enable the avoidance of areas susceptible to flooding, locations were identified from SEPA's interactive Flood Map. No infrastructure is planned for locations susceptible to flooding.

Careful design and recognition of water resource issues has helped ensure that the location of the proposed wind farm infrastructure does not affect any public or private water supplies.

Site Tracks

A development of this size will require extensive construction of access tracks, with various purposes; single width (incorporating passing places) and double width dimensions for turbine transit, small stretches of tracks constructed to enable access to borrow pits, and narrower operational tracks for ongoing 4x4 vehicle use. There will also be the requirement to upgrade some short sections of existing track.

The construction of new tracks will vary depending on the ground conditions and duties. Cut tracks will be constructed on harder ground, typically less than 1.0m of peat, or on steeper gradients. Cut tracks will have drains cut on upslope bank. 'Floating' tracks will be constructed on softer areas, where peat depth is typically greater than 1.0m. Using suitable geotextiles in the construction of the track, the weight of the road and its load should be sufficiently spread to minimise compression of the peat and disruption to peat pipes and subsurface flow. To ensure this the specification of the floating track may need to be higher than is usual. Some compression of the upper layers of the peat is likely to occur, although the majority of subsurface flow is likely to be through peat pipes that generally occur deeper in peat, usually close to its base where compression effects should be negligible. To maintain the surface flow the base layers of the floating track will be made as permeable as possible, using large-sized aggregate which will allow surface water to percolate through the base of the track. Floating track does not usually require construction of drainage ditches as track drainage is best achieved by use of an appropriate camber. During storm events there may be some ponding on the uphill side of tracks, as percolation alone is unlikely to be able accommodate surface flows. Therefore small diameter cross drains (similar to plastic pipe field drains) will be incorporated into the track base at regular intervals to allow more flow to pass through the track and maintain the current flow regime. The tracks will be constructed with sufficient camber or crossfall to minimise ponding of surface water on the track surface. Tracks constructed on steep gradients will have waterbars installed at regular intervals to divert longitudinal runoff from the track surface and into the drainage network. These measures will minimise the risk of erosion of the track surface and the consequent risk of sedimentation.

At some locations site access tracks will cross valley mires, i.e. sloping deep peat habitats usually with an insubstantial stream or sheet flow or water movement through the peat. During the walkover surveys peat piping was identified in these valley mires, which were also found typically to have predominantly deep peat. Therefore the tracks are likely to be of floating construction in these areas.

Based on the peat probing carried out along the route of the proposed access tracks it is likely that approximately 87km (representing 74%) of the tracks will be of floating construction. Table 14.18 shows an estimate of site track construction methods across the site quadrants.

Table 14.18 Summary of Proposed Track Construction Methods

Track Method	**Collafirth**		**Delting**		**Kergord**		**Nesting**		**Overall Site**		
	Cut (km)	Float (km)	Cut (km)	Float (km)	Cut (km)	Float (km)	Cut (km)	Float (km)	**Cut (km)**	**Float (km)**	**TOTAL (km)**
Single Width	0.51	5.57	4.34	17.00	9.85	18.71	2.83	24.85	**17.53**	**66.14**	**83.67**
Double Width			3.62	4.07	1.62	5.30	4.70	9.11	**9.93**	**18.47**	**28.40**
Operational					2.04	0.62		0.78	**2.04**	**1.40**	**3.44**
Borrow Pit Access and Operational			1.36				0.66		**2.02**		**2.02**
TOTAL	**0.51**	**5.57**	**9.32**	**21.07**	**13.51**	**24.63**	**8.18**	**34.74**	**31.51**	**86.01**	**117.52**

Note – All values are rounded to 2 decimal places, totals are aggregated from original data and subsequently rounded to 2 decimal places.

Local distribution of cut and floating tracks will greatly depend on specific peatland erosion features to enable best practice methods to be employed on the site. Maximising the use of floating roads would be expected to minimise the opportunity for preferential pathways for surface water runoff which can occur with cut tracks and would reduce the volumes of peat to be excavated and managed during construction. This information has also fed into the excavated peat volume calculations provided in Appendix 14.4.

Where cut banks of peat are exposed, i.e. during cut track construction, the upper layer of removed peat (acrotelm) will be carefully replaced over banks as soon as possible, minimising exposure to runoff or wind erosive forces which could lead to sedimentation of watercourses and enable the peat the opportunity to ‘knit together’.

Stream Crossings

Following the production of the layout a desk study was carried out to identify watercourses marked on the OS 1:50,000 mapping, as per the *Water Environment (Controlled Activities) (Scotland) Regulations 2005* (known as CAR), that require access track crossings. A total of 53 crossing points were identified. Subsequent to the desk study a walkover survey of the entire proposed site track network was carried out and the 1:50,000 mapped stream crossings catalogued.

In addition, crossing locations of smaller and ephemeral streams noted on OS 1:10,000 mapping were surveyed and data collated. Additional stream crossings, where there was an apparent channel, were also noted when encountered on site. The 44 stream crossings identified in addition to those shown on the 1:50,000 mapping were generally of very small ephemeral streams or flushes with little or no defined channel. The survey of these crossings gives a representative coverage but cannot be comprehensive as the presence and size of these features is so dependent on time of year and antecedent weather patterns.

Each crossing has been characterised, the 53 on the 1:50,000 maps in more detail whilst the 44 additional crossings have been summarised. In each case an evaluation has been made of the type of crossing required. The detailed assessments and the methodology used for characterisation and crossing type selection are provided in Technical Appendix 14.3. The findings for the crossings of the 53 streams (as CAR-regulated) are summarised in Table 14.19, with definitions for large, medium and small stream sizes given in Appendix 14.3.

Due to the boggy nature of some of the site, there are areas where effectively ephemeral sheet flow occurs. These locations have not been mentioned specifically within the stream crossing assessment but will need to have appropriate drainage installed during construction to prevent disruption to surface flows and damage to the track. It is anticipated that this will take a similar form to that discussed above for a floating track crossing of valley mire.

The type and design of stream crossing is dependant on the stream morphology, peak flows, local topography and ecological requirements and will be finalised at the detailed design stage. Discussions will be held with SEPA to agree designs and construction methodologies for each stream crossing. This information will form one element of the data to be submitted to SEPA in support of the CAR licence applications, which will be completed at the detailed design stage.

All structures will be designed and constructed using best practice techniques and will be of sufficient capacity to accommodate storm flows, with an allowance for increased flows that may occur as a result of climate change. By ensuring that structures have sufficient capacity the risk of upstream flooding and increased erosion and sedimentation will be reduced.

Crossing structures will not form a barrier to fish migration, and will be designed and constructed following design guidance given by Scottish Executive (2000) and SEPA (2008d) relating to river crossings and migratory fish. Where the structure has a floor within the stream channel, e.g. precast concrete box section, the floor will be at the same level and gradient and carry similar bed material and flow as the original stream bed. Crossings will not have a hanging outflow and erosion protection measures will not prohibit fish passage during low flows (the use of gabion baskets for erosion protection can result in the stream passing through the baskets, rather than over them, during low flows, preventing fish migration). Similarly, crossings will be constructed with a mammal ledge or similar to ensure the unobstructed movement of mammals in the riparian corridor.

Wherever construction programme requirements permit, on proposed double width track sections the crossings will be limited to single-width dimensions to minimise disturbance

As cables shall generally be laid alongside access tracks, cable crossings will normally be incorporated as part of track crossing structures. Where cables are required to cross streams shown on Ordnance Survey 1:50,000 scale map at locations without any associated track crossing structure, directional drilling techniques shall be employed to enable cable crossing below the stream bed in order to minimise disruption.

Table 14.19 Summary of Stream Crossings shown on OS 1:50,000 Mapping

Crossing Type	**Stream Size (Defined in Appendix A)**			
	Large	**Medium**	**Small**	**Total**
Bridge	3			**3**
Rectangular culvert / arch		10	9	**19**
Rectangular culvert /arch with mammal passage		1	1	**2**
Circular culvert		3	11	**14**
Multiple circular culverts		3	2	**5**
Circular pipe			1	**1**
Multiple circular pipes				
Circular pipe with mammal passage				
Drainage layer (narrow crossing)				
Drainage layer and pipes (broad crossing)		4		**4**
Total new crossings	**3**	**21**	**24**	**48**
Existing crossing structures, with probable upgrade requirement		*2*	*3*	***5***
TOTAL (new + upgraded existing)	**3**	**23**	**27**	**53**

Turbines

Because of the low permeability of the peat there is unlikely to be significant groundwater ingress to the turbine excavations. Surface water ingress will be minimised by the use of upslope cut-off trenches. Any water resulting from ingress or direct rainfall into the excavations will be pumped out. It is likely that the water will have a significant suspended solids content and therefore will be passed through balancing tanks and one or more 'siltbusters' (or similar proprietary sediment removal systems) placed in series, as necessary, to settle out the worst of the sediment load. Further details of sediment management mitigation are provided in the Sediment Management section, below.

Geochemical testing will be undertaken to establish the likelihood of sulphate attack on concrete. If necessary, sulphate resistant concrete will be used in the construction of the turbine foundations.

Following the final layout amendments, there remain 38 turbine locations in areas where deep peat (depth greater than 2.5m) was found at some or all of the probing locations. Of these, 26 turbines had a single point where deep peat was recorded, with the remainder (12 turbines – D3, D10, D30, C38, C39, K50, K51, K53, K72, K74, N93 and N143) recording a number of deep peat results within 25m of the turbine centre point. Note that due to poor weather conditions a small number of turbines were not surveyed following final turbine layout amendment, adjacent peat depth information was used to inform this process, where available. Further peat probing will be carried out at each of these locations at the detailed design and construction stage to allow micrositing of the turbines to the shallowest peat possible.

Peat removed during the excavation of the turbine foundations will be stored nearby in such a manner that it will not dry out or degrade. Consideration will also be given to the site of the storage locations to avoid slippage and damage to underlying material. Gradient of storage locations will be considered to avoid further erosion or potential sediment transport into watercourse. This material will be used to reinstate the excavation area. Excess peat will be used in the re-contouring and restoration of borrow pits, landscaping alongside tracks, recontouring turbine bases and temporary crane pads, with further information provided in Technical Appendix 14.4. Peat Management is discussed further within the Habitat Management Plan at Appendix 10.9.

Drainage

Surface drainage ditches will be installed alongside cut tracks only where necessary. The length, depth and gradient of individual drains will be minimised to avoid intercepting large volumes of diffuse overland flow and generating high velocity flows during storm events.

Access tracks crossing slopes will disrupt surface flow that consequently will collect in drains constructed up-slope of the tracks. Cross drains will be constructed at regular intervals to conduct this surface flow across the road where it will be discharged from the drainage system. Regular discharge points will limit the concentration of surface runoff and the diversion of flows between sub-catchments.

Check dams, silt traps, settlement ponds and buffer strips that will be incorporated into the drainage system as necessary will have the dual purpose of attenuating peak flows, slowing the flow of runoff through the drainage system and allowing sediment to settle before water is discharged from the drainage system.

The constructed drainage system will not discharge directly to any natural watercourse, but will discharge to buffer strips/trenches, preferably on flat ground. These buffers will act as filters minimising sediment transport, attenuating flows and maximising infiltration back into the peat. Erosion protection will be installed at appropriate discharge points.

The sizing and location of the various elements of the drainage system will be influenced by the topography, gradient, catchment runoff characteristics and the volumes of runoff intercepted by each drain. These factors will be determined at the detailed design stage.

Drainage from any concrete batching plants, site compounds and laydown areas will be collected and treated separately, as the runoff from these areas is more likely to be contaminated and therefore to require treatment. Appropriate treatment, such as oil interceptors and treatment for high alkalinity will be installed. The same approach shall be applied to drainage from substations.

Borrow Pits

Information on the methodology for identifying borrow pit location and specific details for each suggested location can be gained from Appendix 14.2; Borrow Pit Report.

Approximately 1,500,000m^3 of aggregate is required for the construction of the access tracks (this includes a contingency amount of 10%). Material is anticipated to be gained from 14 borrow pits. Three of these locations involve reopening existing borrow pits close to the site margins, with new borrow pits located across the site adjacent to the planned access tracks, including a number close to site entry points.

It is intended that the number of borrow pits opened will be minimised. However, this will depend on a number of factors including the volume and quality of rock available at each location; and the balance between minimising the visual impact at any one location and reducing haulage distances, which would in turn reduce carbon emissions and possible compaction of the peat under floating tracks.

During the detailed design stage ground investigations including trial pits will be carried out to assess the suitability of the rock as an aggregate, slope stability and the potential for groundwater ingress. The latter investigations will inform the final design of the borrow pits.

Prior to excavation the surface soils and peat will be removed and stockpiled for use in the reinstatement of the borrow pits. The stockpiles will be located and battered so as to limit instability and erosion. Silt fences and mats will be used to minimise sediment levels in runoff from the stockpiles. Further details on this technique is provided in the Sediment Management section.

Temporary interception bunds and drainage ditches will be constructed upslope of the borrow pits to prevent surface runoff ingress. As with the trackside drainage these ditches will be of minimal length, depth and gradient; silt traps and buffer strips will be utilised to minimise erosion, sedimentation and peak flows.

Given the low permeability of the overlying peat deposits it is not anticipated that groundwater ingress from the peat will be significant. However the borrow pit floors will be designed such that they drain by gravity, with all floor water draining to an adequately sized settling sump before being pumped into a sediment settling system similar to that described above for the turbine excavations.

Concrete Batching Plant

Concrete batching is recognised as having the potential for causing a considerable pollution incident. Provisional concrete batching locations at this pre-detailed design stage are proposed as the construction compounds servicing north Delting, south Kergord, north Nesting and south Nesting. Collafirth will be provided with concrete from north Nesting batching plant. At the detailed design stage it may become apparent that there are particular sites that have clear advantages for concrete batching and the number of batching locations may be reduced or alternative locations suggested.

It may be possible to abstract the quantities of water required for concrete mixing from a nearby watercourse or waterbody. However this will be subject to assessment of low flow conditions in the watercourse or waterbody at the detailed design stage; and of water quality; and the approval of SEPA under the *Water Environment (Controlled Activities) (Scotland) Regulations 2005* (known as CAR). In order to assess the site low flow conditions flow gauging will be carried out on a selection of candidate water sources over a representative period (not less than 6 months) which could be compared to the long-term SEPA flows gauged at Weisdale. However the significance of such monitoring has the potential to have errors if exceptional (dry) weather conditions prevail. Therefore while real site data are extremely useful the results of such monitoring must be seen within a broader context of available historical data and climate trends.

As discussed above, detailed calculations of low flows and water demand will be carried out at the detailed design stage as part of the CAR licence application process. However, some preliminary estimates have been calculated to gain a broad insight into the likely abstraction rates required. In Chapter 2 of the Transport Statement, Appendix 15.1 to this ES, the estimated concrete demand for the whole development has been calculated as 74,252m^3, primarily for turbine foundations.

The ratio of cement : sand : aggregate is given in Table 2.2 of Appendix 15.1 as 1 : 2 : 2, with a cement requirement of 29,700 tonnes. The ratio of cement : water intended to be used is approximately 1 : 0.55 which leads to an estimated requirement of 16,500m^3 of water to produce the concrete required. The water volume required for concrete production has been multiplied by three, as a conservative value, to allow for washdown, welfare and other factors; giving a total water requirement of approximately 50,000m^3 (around 325m^3 per turbine).

If it is assumed that one turbine foundation will be poured every 2.5 days, and that water will be abstracted continuously and stored for use during batching operations, a constant abstraction rate of 130m^3/day (or 0.0015m^3/s) applies over the 2.5 day period. Comparing this with the mean flow and low flow (Q_{95}) rate for site stream catchments (as shown on Table 14.15), the abstraction requirement is considerably less than the low flow value for downstream areas of the larger local streams, although there may be a need for restrictions during prolonged dry periods or where abstraction takes place in upper reaches.

Alternatively, freshwater loch abstraction can be considered. The surface areas of the Loch of Voe (HU415627), Sae Water (HU423629), Loch of Skellister (HU460562) and Maa Water (HU378552), as examples, are approximately 181,000m^2, 45,000m^2, 193,000m^2 and 243,000m^2, respectively. The depths of these lochs are not known, nor are subsurface profiles. However, if an assumption is made that these lochs have a vertical profile (i.e. sides perpendicular to the base) and that there is no input from streams or rainfall during the abstraction period a rough estimate of the instantaneous (‘worst case’) drawdown can be calculated using the following equation:

Volume required (m^3) / surface area (m^2) = drawdown value (m)

Abstracting the estimated volume of water required for a single turbine instantaneously would result in a drawdown of 0.0018m (1.8mm) in Loch Voe, 0.0072m in Sae Water, 0.0017m in Loch of Skellister and 0.0013m in Maa Water. In practice, drawdown values would be considerably reduced with abstraction undertaken over a period of hours and the combination of continuous input from feeder streams and intermittent input from direct rainfall.

The abstraction estimates above suggest that local water abstraction is feasible. Abstraction conditions are likely to be required restricting the total volume and rate of abstraction, and further limiting abstraction during prolonged dry spells, which would be subject to discussion at the detailed design stage.

If a requirement is determined to use potable (drinking) water then this material will be treated for storage and use as per other site chemicals, as it is recognised that chlorine and other chemical additives introduced to potable water may have adverse effect on natural water systems.

Batching plants will be located at least 50m from the nearest watercourse, located in a secure contained area that has a separate drainage system. A settlement and re-circulation system for water reuse will be considered and the washing out of mixing plant will be carried out in a contained area. Wash water and surface runoff from this area will be adequately treated to deal with suspended solids and high alkalinity before discharge. Lined settlement ponds will be used to prevent infiltration of alkaline runoff. Consultations will be carried out with SEPA at the detailed design stage regarding the discharge licensing requirements and agreement for precise locations.

Cable Trenches

Wherever possible cable trenches will be laid in the disturbed material adjacent to tracks. Cable trenches may form groundwater conduits as a consequence of their greater permeability compared to the surrounding materials. To minimise this, two methods of cable trenching will be used as appropriate. Where conditions are suitable, that is on deeper subsoil and peat, cable will be laid using a plough "lift and turn" process which lifts and turns the required depth of material over, exposing the trench. The cable is immediately laid and the overlying material is turned back to its original position burying the cable. This method is effective and swift and produces very little damage to the surface. However, it is not possible to use this method where the subsoil is uneven or rocky. In these circumstances conventional trenches will have to be dug and then backfilled with the excavated material. In some locations where the underlying surface may be detrimental to the cable a bed of support material (typically sand) will have to be laid to protect the cable. Such material has the potential to act as a drainage conduit, particularly in areas where cable trenches are on steep slopes. In these areas clay bunds will be installed for every 50cm change in altitude along the length of the cable trench to minimise down-slope groundwater flow. The trenches will be backfilled with the excavated peat and compacted to a suitable level. Laying the cables will be done in short discrete section with the excavation, cable laying and backfilling happening over a short period of time. This will prevent the excavated peat drying out and will allow the backfilled peat to 'key' into the in-situ peat, avoiding the formation of preferential flow paths along the contact surface i.e. the walls and base of the cable trench.

Environmental Management

A Framework Site Environmental Management Plan (SEMP) / Pollution Prevention Planning (PPP) document will ensure that mitigation measures are put in place and activities carried out in such a manner as to minimise or prevent effects on the surface and ground waters. This framework plan will apply to all phases of the wind farm, construction through operation to decommissioning. Further details of the Framework SEMP and PPP are included in Appendix 14.6 but will incorporate the following principles:

- 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. Measures to ensure this are discussed in the assessment section. 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.

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 to ensure that these measures are carried out effectively to minimise the risk of a pollution incident

Waste Management

A Framework Site Waste Management Plan (SWMP) will ensure that mitigation measures are put in place and activities carried out in such a manner as to minimise waste generation and where waste is generated; ensure appropriate disposal.

As for the SEMP/PPP, this framework plan will apply to all phases of the wind farm, construction through operation to decommissioning and would be the responsibility of the site Environmental Manager.

Systems employed will conform to all appropriate waste management regulatory controls and adhere to the 'Waste Hierarchy' (Scottish Environment Protection Agency, 2008e). Further details of the Framework SWMP are included in Appendix 14.7.

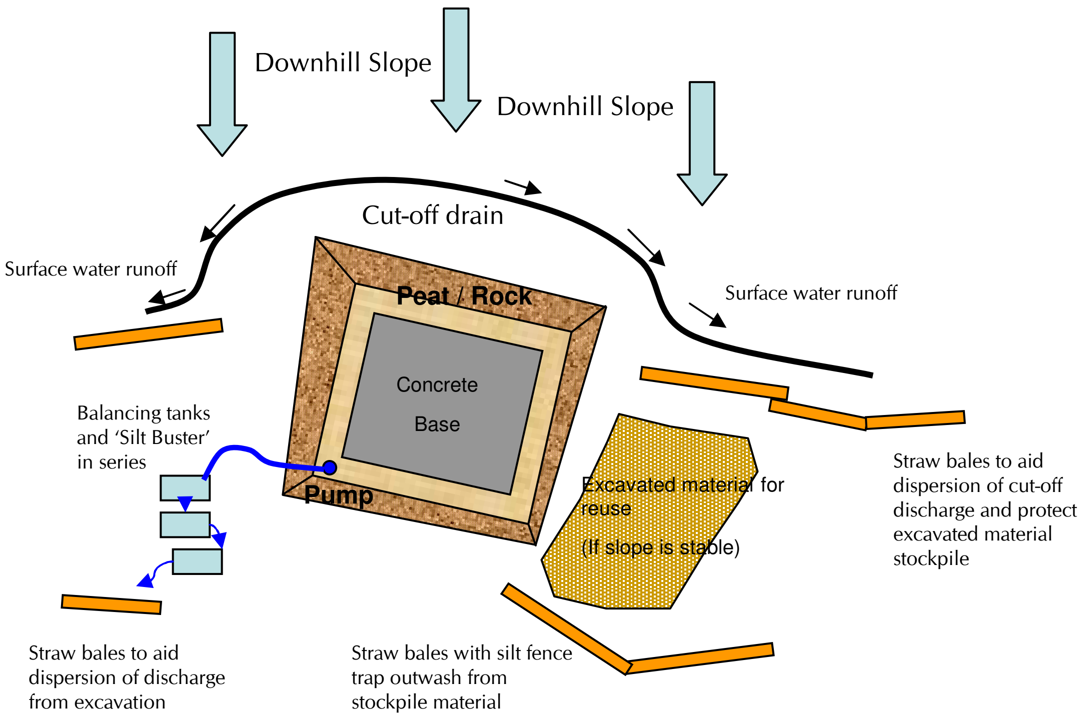
Sediment Management

Water ingress to the turbine excavations during the construction phase will be mitigated as shown in Diagram 14.1. Upslope cut-off trenches will be used to minimise water ingress to the excavation, and any water resulting from ingress or direct rainfall into the excavations will be pumped out. It is likely that the water will have a significant suspended solids content and therefore will be passed through balancing tanks and one or more 'siltbusters', or similar, in series as necessary to settle out the worst of the sediment load. Straw bales will be utilised in a systematic array (in shallow trench or staked into ground) to aid reduction of flow velocity at the upslope discharge points to minimise erosion potential, silt mats and fences (plus straw bales) will be used downslope of peat stockpiles to prevent mobilisation of sediment.

Similar methods will be used and adapted as appropriate for all likely sediment generating activities on site, such as borrow pit excavation and track construction. The method of using recently removed acrotelmic peat as a method to protect the surface of banks of peat storage is also suggested as best practice.

To evaluate the efficacy of these mitigation measures it is useful to consider the likely volumes of sediment-laden water that will be generated versus the treatment capacity of the sediment settlement unit, as discussed further below.

Diagram 14.1 Schematic of proposed turbine excavation water management



Water Ingress to Turbine Excavations

To assess the likely quantities of water which may have to be dealt with during various rainfall events it is necessary to make some general assumptions about the configuration of a typical turbine excavation, and also to consider the excavation at one point in time. It was considered that the maximum water ingress is likely to be when the base was fully excavated, but prior to the civil engineering construction. It was also assumed the excavation area would be prepared with cut-off trench and silt traps prior to commencing the work, as described above.

In terms of dimensions it has been assumed that the 'flat' area of the excavation is 25m x 25m (which allows for working space around the base itself) and that the average depth is 3m with a 45° batter on the sides of the excavation, giving about 31m across the top. From these basic dimensions the areas of sloping surfaces have been calculated.

With this concept in mind, using guidance from CIRIA Report C648 (2006), calculations have been undertaken for the following inflow components:

- Horizontal interflow from the exposed faces of peat and rock around the excavation. Estimated seepage rates were derived from CIRIA report C648, Table 18.1;
- Fissure flow from the exposed peat and rock faces. There is no means of calculating these and indeed their presence is unlikely, but for this exercise individual figures have been assumed from peat and from rock;
- Direct perimeter runoff from a strip around the excavation. A recommendation for unit runoff has been taken from CIRIA Report C648, Table 18.2;
- Direct rainfall falling into the excavation. Rainfall rates from the table below have been considered.

The response of these inflows will vary with rainfall intensity and antecedent conditions. The interflow and deeper fissure flows will lag direct runoff and actual rainfall events, but for the purpose of the calculations these have been taken as concurrent. From CIRIA Report C648, the recommended return period for estimating flows during construction is given as 1:10 years and this has been used to derive rainfall intensity.

Table 14.20 Rainfall Intensity/Duration Data

Duration (hrs)	Return Period	Season	Peak Rate (mm/hr)	Average Rate (mm/hr)	Total (mm)
1	10	W	33.53	13.81	13.81
1	10	S	50.79	13.42	13.42
24	10	W	5.52	2.27	33.98
24	10	S	8.63	2.20	33.01

A range of rainfall intensities was calculated using the Wallingford HydroSolutions Rainfall Generator method (2008) and are shown in Table 14.20. Following an initial evaluation of catchments 1-10, Catchment 2 details have been used. This catchment displays the highest rainfall data and is taken as a conservative approach for maximum rainfall on the site. This table shows two different event durations (1 hour and 24 hours) for summer and winter rainfalll. These storms have both an instantaneous peak precipitation and an event average. The 24 hour storms have lower peaks but higher total rainfall than the 1 hour storm.

Table 14.21 provides a summary of the volumes of water that may enter a turbine base for a 1 hour and a 24 hour period arising from a 1 in 10 year storm event.

Table 14.21 Estimates of Water Ingress to Base Excavations

Inflow Component	**1 hour Event (m^3)**	**24 hour Event (m^3)**	**% of total flow for 24 hour event**
Horizontal Interflow	0.6	15.0	6.76%
Perimeter runoff	12.3	48.5	21.81%
Direct rainfall	12.9	50.8	22.84%
Fissure flow (from peat)	0.9	21.6	9.72%
Fissure flow (from rock)	3.6	86.4	38.87%
Total Flow	**30.3**	**222.3**	**100%**
Total (excluding fissure flow)	*25.8*	*114.3*	*51.42%*

These basic figures need to be put in context. The first observation is that fissure flows, which are highly speculative, amount to almost 49% of the total in the day. This distorts the estimates because if fissure flow was encountered then measures would be taken to deal with it. If the flow was emanating from the peat layer then it would probably be possible to modify the cut-off drain to intercept the flow before it entered the excavation. If the fissure flow was from the rock horizon then the strategy would probably be to plug or grout the fissure to stop the flow into the excavation.

Thus, the anticipated volumes of water ingress to a turbine base excavation, on a very wet day with a 1:10 year return period is approx 26m^3 in an hour or 114m^3 in the day. The degree of sediment load within this volume of water will be determined to a significant extent by the activity in the base excavation. If the base has been excavated, blinding concrete poured and there is no excavation taking place, then the colouration and sediment load within the water could be minimal, or at least no more than would arise from the rainfall event itself. It is normal construction practice to cease ground disturbing activities during heavy rainfall and this would likely be written into the Construction Method Statement and in fact be triggered at rainfall intensities less than the 1:10 year event. Also, in many cases the excavation may in fact be allowed to act as a settlement basin and the discharge pumps shut down for a period particularly if there is no ongoing critical activity. Finally, as the illustration shows, the discharge would be passed through balancing tanks and then a 'siltbuster' device to settle out the worst of the sediment load.

Settlement Unit Discharges

It is recognised that no device will completely remove all sediment down to colloidal sized particles; however the technical performance for a 'Siltbuster' claims that, "for a simulated construction site runoff the unit removed 75% of the solids at a flow rate of

30m^3 per hour." This compares well with the 26m^3 per hour value estimated above. At Viking the throughput flow rate could be reduced to give a longer settlement time by allowing accumulation of water within the excavation, by using balancing tanks to even out flow peaks and multiple settlement units.

It has been reported that in some areas of Scotland, such as Lewis, a very fine clayey gley material has been encountered beneath the peat, which when disturbed can result in very fine suspended sediment that does not settle out within reasonable timeframes. The incidence of this material is highly variable and it is not known at this time whether any is present at the proposed Viking wind farm site. It is proposed that this will be investigated as part of the ground investigation works which will be carried out at the detailed design phase of the development. If this fine gley material is present, then in certain conditions the silt load may require further treatment including the use of chemical flocculants. These chemicals can be extremely toxic to aquatic life and require an informed understanding in their use and strict control within bunded containers.

The settlement unit itself has two discharge streams:

- the settled sediment (sludge) drawn off from the base of the tank;
- the supernatant water (from which sludge has settled out) which is spread to the vegetated surface of the hillside.

Estimating the volume of sludge is not an exact science and depends upon the mass of solids and their water content when drawn off from the settlement unit. Base construction requires peat / mineral soils and rock to be excavated and their propensity to generate sediment differ. However, if say 2% (by volume) of the material was trapped in the settlement unit(s) and discharged at 85% water content the volume of sludge from one base construction would be approximately 350m^3. The proposed option for managing this sludge is to discharge it into previously completed bases; at a post base construction, but pre-backfill stage. This technique of putting the sediment back to its point of origin has been used elsewhere. Calculations show that the net volume in a base excavation after the construction of the base is of the order of 1350m^3, which means that there is adequate space to hold sludge; and also undertake some backfill with crushed rock to aid settlement, if required. However, it is likely that some temporary storage will be required whilst the initial bases are constructed. This storage may be in the form of tanks or settlement lagoons, to be sited at a suitable location on the site, well away from any waterbody.

The supernatant water from the settling unit will be discharged onto adjacent vegetated ground and directed away from burns and major ditches so as to avoid direct entry of this water into watercourses. The water chemistry of this supernatant discharge will be monitored for potential adverse effects on the receiving environment. Where flocculants have been used this monitoring will ensure that the correct chemical dosing has been carried out to ensure that no surplus flocculent is released into the environment. Any sediment carried over with the supernatant is likely to be a very fine material. CIRIA Report C648 provides some typical infiltration rates ranging from 500 l/min/ha for silty-clay to 1300 l/min/ha for Clay loam. Peat is not mentioned, and although it is generally regarded as having a low permeability, the permeability varies with depth. The acrotelm (upper) layer, which has a high fibrous content, does allow water to penetrate more easily, when not saturated. However, the filtration of the supernatant stream is not dependant on infiltration alone as the vegetative material on the surface offers a large surface area for adhesion and deposition. An important aspect is the effective spreading of the discharge, rather than concentrating the discharge in one area. This is normally achieved through the use of a number of discharge points, straw bales to spread and attenuate flow (as illustrated in Diagram 14.1) and also the use of spray irrigation 'Rain Guns'. The latter provide a means of rapid and flexible deployment of discharge points.

It is proposed that the above methods would be trialled on-site for mitigation efficacy prior to commencement of construction in earnest, particularly if gley material underlying the peat is widespread across the site. The on-site trial will allow the proposed mitigation to be tested and modified as necessary in a controlled manner and establish a standard procedure for dealing with suspended sediment and other possible pollution sources which might have an impact on waterbodies.

Monitoring activities

To ensure that key soil and water related issues such as water quality, peat instability and soil loss are being effectively managed a monitoring programme shall be created. This will set out routine tasks at identified locations of concern, reporting regularly to the developer and their site Environmental Manager. The locations and frequency of monitoring shall be discussed with SEPA and SNH, with data made available as requested.

Site monitoring will be undertaken in a phased approach relating to the construction programme, prior to any construction in a particular area to give good seasonal baseline information prior to development.

The water quality monitoring will primarily use locations identified and sampled in December 2008 (see Table 14.12) for continuity, these locations were chosen on the basis of proposed catchment development and include 2 'control' locations.

Decommissioning preferences

The decommissioning activities are similar in nature to the construction activities, therefore various mitigation measures and best practice techniques outlined above for construction will also be applied during the decommissioning phase. This is a conservative approach as it is possible that new techniques may be available at the decommissioning phase that reduce impacts in terms of likelihood and magnitude compared to the construction phase.

Should decommissioning occur it is preferable to leave buried structures and equipment such as foundations and cables *in situ*, thus minimising ground disturbance. Prior to decommissioning consultations will be held with the planning authority, statutory consultees and landowners to establish whether they wish the tracks and stream crossings to remain, providing access. If this is the case, ownership and responsibility of the upkeep of the tracks and stream crossings will pass to the landowner. However, if a landowner does not wish to maintain access to the site the stream crossings will be removed. This will prevent detrimental effects such as flooding caused by the blockage of crossings not being maintained. Attempting to remove and reinstate the pre-existing vegetation is likely to result in a footprint of altered vegetation which is unlikely to revert to pre-wind farm conditions. In addition, there is the issue of where to source the peat required for the reinstatement. It is felt that the minimal benefit gained from this will be outweighed by the ground disturbance involved in removing the tracks. With this in mind it is proposed that access tracks will also be left *in situ*.

14.6.2 Effects on Surface Water

(a) Receptor Sensitivity

The catchment-based approach recognises that an incident effecting the catchment of any of these locations could lead to adverse effect on the respective designated area.

There are a number of A1 and A2 ('Excellent' and 'Good') status freshwater streams on the site. In a number of these watercourses, associated waterbodies and other site hydrological features there are wild fish and aquaculture resources which have important ecological, amenity and commercial elements.

Loch of Girlsta SSSI is not located within any site hydrological catchment. Laxo Burn, Burn of Lunklet, Catfirth, Kergord Plantation and Burn of Valayre SSSIs are all designated due to adjacent terrestrial vegetation, Dales Voe SSSI due to saltmarsh habitat and the others (Ayres of Swinister and Voxter Voe SSSIs) designated due to geological features. It is however recognised that these could be indirectly influenced by the proposed development.

The key designated area concern relates to Sandwater SSSI which, as a mesotrophic loch, is susceptible to pollution and, particularly, nutrient-enrichment. Nutrient-enrichment can be caused by pollution, sedimentation or by abstraction upstream increasing water residence time in the downstream waterbody. Sandwater SSSI is located downstream of the development within hydrological catchment 3. No construction is planned within 250m of any watercourses in this catchment (as per OS 1:10,000 mapping). Although two borrow pit locations have been identified, these are both existing features adjacent to the A970 road. There are 10 turbines proposed within this catchment, all on marginal (watershed) catchment locations, along the Mid Kame ridge to the west and Hoo Kame to the east. Similarly, track locations are marginal with no stream crossings planned in this catchment.

Kergord Hatchery, located on the Burn of Weisdale in Catchment 4, has also been identified as a significant receptor, with the hatchery located downstream of planned infrastructure. This catchment has 8 turbines planned within, plus 9 turbines along Mid Kame ridge which are on the catchment boundary (with catchment 3). Access tracks are found in the western sector of the catchment and although there are no stream crossings planned over the Burn of Weisdale itself, there are stream crossings planned on a number of unnamed streams and the Burn of Droswall, all of which act as tributaries to the Burn of Weisdale. This receptor will be sensitive to pollution, alterations in runoff (particularly flow reduction during natural low flow periods) and sedimentation.

The local water quality, water resources and downstream locations of Sandwater SSSI and Kergord Hatchery lead to the sensitivity of surface waters being classed as high.

Note, water supply issues are dealt with separately in section 14.6.3.

(b) Construction effects

Pollution

During the construction of the wind farm there will be a number of activities taking place that could impact upon surface waters. Construction will necessarily occur upslope of streams and lochs, which may leave them vulnerable to accidental pollution. A number of potential pollutants will be present on site, including oil, fuels, chemicals, cement and unset concrete as well as waste and wastewater from staff facilities. Any pollution incident occurring on the site may adversely affect the quality of nearby surface waters.

Flooding locations have been identified as limited areas immediately adjacent to channels. Mitigation measures would be employed to ensure flooding (including coastal flooding) does not lead to or exacerbate any pollution incident.

Without the proposed mitigation measures and layout features described in sections above, the magnitude of a pollution incident has the potential to be major and the likelihood of such an incident occurring possible. With the mitigation measures in place the potential magnitude will be reduced to moderate and the likelihood for this to occur as unlikely, resulting in the anticipated significance of effect being minor (in reference to Table 14.6).

Erosion and sedimentation

Increased levels of sediment may be generated through the excavation of borrow pits and turbine foundations and erosion of stockpiled soils and peat, bare ground, site tracks and drainage ditches. If this sediment reaches the natural watercourses on the site it could cause high turbidity levels thus reducing light and oxygen levels or alter the nutrient-loading entering these systems with consequent impact upon the water quality and ecology of the streams and upon existing populations, including fish. The deposition of material could also blanket fish spawning grounds and reduce the flood storage capacity of the stream channel, increasing flood risk.

Peat instability or sliding could also lead to increases in sedimentation. This is a process that is occurring at the site and would be expected to continue to occur naturally as a baseline process. Control measures have been identified in the associated technical appendix (14.1) which will reduce likelihood. Suggested mitigation measures will reduce the severity of any such event during construction.

Without mitigation the magnitude of impact potentially could be moderate, given that this process is already occurring naturally, with it likely to occur. With the proposed mitigation in place sedimentation potential will be considerably reduced. However it is anticipated that there will be occasional discrete minor incidents of sedimentation scattered across the site. As the proposals outlined above provide the optimum sediment management, with rapid response, it is expected that the residual effect will be of minor magnitude albeit likely to occur. Therefore the anticipated order of residual effect will be minor.

Impediments to flows

Improperly designed watercourse crossings on site may restrict flow in the stream channels and reduce hydraulic capacity. The results of this could be increased flood risk upstream, promotion of erosion and sedimentation processes, with potential impediment to fish migration. The magnitude of impact related to such effects associated with poorly designed stream crossings could be moderate, and the likelihood of impact occurring, possible.

Major peat instability events could lead to partial or complete channel blockage. The placement of infrastructure away from stream channels will mitigate against this. Peat stability mitigation measures are discussed in Appendix 14.1.

Design checks and liaison with statutory agencies will ensure that such structures are adequately sized and designed. The magnitude of impact and likelihood of occurrence will accordingly be limited to minor and possible, and the anticipated residual effects will be minor.

Modification of surface runoff

Temporary drains associated with the borrow pits, construction compounds and turbines will intercept diffuse overland flow, interrupting the natural drainage regime by concentrating flows and potentially increasing runoff rates, peak flows and response times during storm events. Temporary site drainage, if improperly designed, could also promote erosion and sedimentation.

Without mitigation the potential impact on the surface waters from modifications to runoff will be of moderate magnitude and possible likelihood. However as the site drainage will be designed according to best practice the magnitude of impact will be reduced to minor and the likelihood unlikely. The anticipated residual effect will accordingly be minor.

(c) **Predicted ongoing and operational impacts**

Pollution

The risk of pollution is substantially lower during operation than during construction because of the decreased levels of activity in the operational phase. The majority of potential pollutants will have been removed when construction is complete. However, lubricants for turbine gearboxes, transformer oils and maintenance vehicle fuels will remain.

The reduced number of potential pollutants leads to the magnitude of a pollution incident without mitigation in place being classed as moderate. The implementation of the proposed pollution prevention plan will reduce the potential impact of a pollution incident to a minor magnitude with an unlikely probability of occurrence. Residues and emissions resulting from operation of the wind farm are expected to be negligible. The anticipated order of effect will be minor.

Erosion and sedimentation

Levels of erosion and sedimentation will be much lower than during construction as there will be no excavations or bare exposed ground. Some erosion and sedimentation may still occur on the site tracks and drainage ditches due to scouring during extreme rainfall events. Similarly there may be some erosion and sedimentation around new stream crossings as watercourses find a new equilibrium.

Assuming that the site tracks and drainage have been designed and constructed according to best practice and regular inspection and maintenance of silt traps etc are carried out, the potential effect of erosion and sedimentation will be minor.

Modification of surface runoff

Modification of the surface runoff of the site will occur as a result of the construction of the wind farm infrastructure.

Site tracks and associated drains will intercept diffuse overland flow, interrupting the natural drainage regime by concentrating flows and potentially diverting them from one catchment to another. Poorly designed site tracks and associated drainage could allow surface water to travel through a catchment much faster than if it were to travel as diffuse overland flow. Such preferential pathways could result in an increase in runoff rates, peak flows and response times during storm events.

The total landtake for the wind farm will be approximately 1.88km^2 (188 hectares), incorporating impermeable (concrete and hardstanding) surfaces and taking a precautionary approach that all partially permeable (i.e. unbound paved track and borrow pit) surfaces will also act as impermeable surfaces.

The percentage of landtake in relation to hydrological catchments is given in Table 14.22. These landtake values take account of the indicative borrow pit details as provided in Appendix 14.2 - Borrow Pit Report (rather than preferred areas of search). Thus, if landtake value were to include the entire original borrow pit search areas the overall landtake would be increased (by around 1.3km^2).

Table 14.22 Proposed Landtake of Development

Catchment ID	Landtake in Catchment (km^2)	Landtake as Percentage of Catchment	% of Total Development within Catchment
1	0.213	1.02%	11.32%
2	0.293	1.59%	15.57%
3	0.093	0.63%	4.92%
4	0.104	0.79%	5.54%
5	0.216	1.91%	11.50%
6	0.257	2.43%	13.67%
7	0.130	1.92%	6.93%
8	0.044	0.75%	2.34%
9	0.112	2.32%	5.95%
10	0.018	0.38%	0.95%
11	0.077	1.72%	4.08%
12	0.029	0.69%	1.57%
13	0.026	0.65%	1.39%
14	0.001	0.04%	0.07%
15	0.000	0.00%	0.00%
16	0.000	0.00%	0.00%
17	0.069	2.36%	3.64%
18	0.013	0.50%	0.71%
19	0.000	0.00%	0.00%
20	0.019	0.72%	1.02%
21	0.000	0.00%	0.00%
22	0.035	1.72%	1.84%
23	0.013	0.77%	0.68%
24	0.057	3.40%	3.05%
25	0.000	0.00%	0.00%
26	0.009	0.68%	0.48%
27	0.000	0.00%	0.00%
28	0.000	0.00%	0.00%
29	0.031	7.13%	1.63%
30	0.021	5.96%	1.14%
Total	**1.881**	**-**	**100.00%**

The smallest catchments, 29 and 30, both display small coastal catchment features with short streams leading directly to the coast. These catchments have the largest percentage of catchment-specific landtake, in part due to their small respective sizes. In catchment 29, the allocation of the construction compound on a catchment-marginal location has been assigned entirely to this small catchment in addition to 1.5km of single width access track, turbine D01 and the marginal turbine D02. Catchment 30 incorporates a 300m section of single width track plus a borrow pit and a construction compound within the smallest site catchment area. Best practice drainage methods to replicate, as far as possible, the natural flow regime and ensuring erosion control of development-related outflows should minimise any modification to surface flow. Neither catchment 29 or 30 is hydrologically-connected to any designated area, any location identified as at risk of flooding or has been highlighted as an area of fisheries interest.

Given the above and the generally very small percentages of each catchment that will be modified, in addition to the relative natural impermeability of site soils and non-surfacing of the borrow pits, the increase in runoff volume as a result of the development is expected to be, at worst, minor and more likely negligible.

Without mitigation the potential long-term impact on the surface waters from modifications to runoff will be of moderate magnitude and likely to occur. However as the site drainage will be designed according to best practice the magnitude of impact will be reduced to minor with the likelihood remaining as likely. For drainage relating to borrow pits, crane pads and substations the likelihood is reduced to possible. The anticipated residual effect will accordingly be minor for all these features.

Flooding due to obstruction caused by new crossing structures is possible but of minor magnitude given careful design and location, resulting in a minor significance effect.

(d) Decommissioning effects

Decommissioning activity is suggested as being similar in effect to construction phase activity. This is a conservative approach as some issues relating to construction would be expected to be reduced in terms of complexity and/or time at the decommissioning phase.

Pollution

The potential risk of pollution during decommissioning is similar to that during the construction phase, due to similar levels and types of activity on site. During the decommissioning of the wind farm there will be a number of activities taking place that may impact upon surface waters. A number of potential pollutants will be present on site, including oil, fuels and chemicals as well as waste and wastewater from staff facilities. Any pollution incident occurring on the site may adversely affect the quality of nearby surface waters.

Without the proposed mitigation measures described above, the magnitude of a pollution incident has the potential to be major and the likelihood of such an incident occurring possible. With the mitigation measures in place the potential magnitude will be reduced to moderate and the likelihood to unlikely, making the anticipated residual effect minor.

Erosion and sedimentation

Some sediment is likely to be generated through the demolition of the control building, removal of turbines, breaking out of the turbine foundations to below ground level and possible removal of stream crossing structures. If this sediment reaches the natural watercourses on the site it may cause similar problems to those discussed in the construction section. As with the operational phase there is likely to be low level erosion and sedimentation related to scouring of site tracks and drainage during and following intense rainfall with consequent high velocity flow events.

As discussed for the construction-phase, peat instability could cause extreme sedimentation but this would be considerably less likely at the decommissioning phase of the project.

Without mitigation the magnitude of impact potentially could be moderate and the likelihood likely. With the proposed mitigation in place sedimentation will be considerably reduced. As the proposals outlined above provide the optimum sediment management, with rapid response, it is expected that the residual effect will be of minor magnitude and possible. Therefore the anticipated order of residual effect will be minor.

Impediments to flows

Lack of maintenance of the stream crossing structures following decommissioning may result in blockages and subsequent flooding, erosion and sedimentation. The magnitude of impact related to such effects may potentially be moderate, and the likelihood of impact occurring, possible.

If stream crossings are to remain *in situ* to provide access to the land, ownership and responsibility for the maintenance of the stream crossing will pass to the landowner. The developer will provide details of the design, construction and maintenance regimes required for each stream crossing. If continued access to the land is not required the developer will remove the stream crossings, using best practice techniques, thereby removing the need for continued maintenance. With either of these proposals in place the magnitude of impact and likelihood of occurrence will be limited to minor and unlikely, and the anticipated residual effects will be minor.

Modification of surface runoff

The long term modification of surface run-off identified as an operational effect will continue following decommissioning due to the continued presence of the tracks and associated drainage. It is also likely some foundations will remain *in situ*. However, as for the operational phase the increase in runoff volume is likely to be negligible, and with the use of best practice techniques the magnitude of impact will be minor although likely to occur in localised areas. The anticipated residual effect will accordingly be minor.

(e) Summary of effect on surface water

The assessment of potential impacts on surface water during construction, operation and decommissioning of the proposed wind farm has indicated there will be no impacts of an order greater than minor. As such anticipated effects on surface water will not be significant.

14.6.3 Effects on water supplies

(a) Receptor Sensitivity

Public water supply sources within the local area have been investigated and there are no source locations hydrologically connected to the proposed development. Eela Water, the supply source for Scottish Water, is situated across Sullom Voe and outwith the influence of site activity. However, public water supplies use distribution networks alongside public highways which may have to be crossed, primarily at site entry locations, during development.

As shown on Table 14.23, only a single private water supply is within a site-related catchment, namely the supply at Grutin. The closest infrastructure to the Grutin supply source is a section of track leading to turbine D23 over 900m north-west of this source. This distance, in combination with examination of the local site topography and geology, lead to the conclusion that this supply is very unlikely to be influenced by the development.

As a source of drinking water this receptor has to be considered to be of high sensitivity.

Table 14.23 Private Water Supply Effects

Catchment ID	Name of Property	Development Effect	Comment
13	Grutin	Potential	Located within site catchment 13 but upslope from intra-catchment development. Closest development in other catchment (catchment 5) is 900m NW.
N/A	Pund of Grutin	None	Off site catchment, no pollutant pathway or risk to supply yield, due to intervening distance and topography.
N/A	Parkview, Brae	None	Off site catchment, no pollutant pathway or risk to supply yield, due to intervening distance and topography.
N/A	East House, Grobsness	None	Off site catchment, no pollutant pathway or risk to supply yield, due to intervening distance and topography.
N/A	Lea of Burrafirth	None	Off site catchment, no pollutant pathway or risk to supply yield, due to intervening distance and topography.
N/A	East Burrafirth	None	Off site catchment, no pollutant pathway or risk to supply yield, due to intervening distance and topography.

(b) **Construction effects**

Pollution

There is no on-catchment source of public water supply but there is potential for pollution to the private water supply at Grutin, as discussed in Table 14.23.

Accidental spillage of chemicals, fuel or wastewater could lead to contamination of the Grutin private supply. This supply is from a well which could also be affected by adverse influences on the hydrological regime. These could lead to reduction in water quality or yield from this supply. The bedrock geology at this location would suggest water flow through the rock would be minimal, with the water table likely to closely follow surface topography away from the supply source.

Without mitigation the impact magnitude would be major although unlikely to occur, with mitigation the magnitude is reduced to moderate due to better management of chemicals etc, remaining unlikely, with an overall minor significance.

Disruption to supply

There is potential for damage to Scottish Water distribution networks during the construction phase. Network locations must be re-assessed and discussions held with operational personnel prior to construction to ensure latest alterations to the network are taken account of and appropriate protective measures employed to prevent supply damage. No aspect of the development would be expected to impact on the supply infrastructure to any private supply.

Without mitigation the magnitude of this impact would be major (relating to public water supply) with the likelihood unlikely. As mitigation would involve discussion with Scottish Water to ensure best practice the likelihood will remain unlikely but the magnitude level will be reduced to moderate, consequently this is of minor significance.

(c) **Ongoing and operational effects**

Pollution

Considerably less likely during operation than during the construction phase as there will be less activity on site and a smaller number and/or quantity of polluting materials available. This effect remains unlikely to occur and, due to reduced site activity, the magnitude is reduced to minor; with a resultant minor significance.

Disruption to supply

Less likely than during the construction phase. However, the movement of heavy loads or the requirement to maintain access tracks may lead to an incident causing disruption of supply. With careful planning, discussions and checks of latest Scottish Water distribution network plans this issue should be minimised. Once again this is not relevant to any private supply.

Thus, the magnitude is moderate, with an incident unlikely to occur, resulting in a minor significance rating.

(d) Decommissioning effects

Similar effects are likely to occur during decommissioning as during the construction phase in relation to water supplies, with a resultant minor significance.

(e) Summary of effect on water supplies

The assessment of potential impacts on public water supplies during construction, operation and decommissioning of the proposed wind farm has indicated there will be no impacts of an order greater than minor, the main concern being adjacent Scottish Water distribution networks. Therefore, anticipated effects on public or private water supplies will not be significant.

14.6.4 Effects on marine waters

Marine effects have not been specifically dealt with in this report. There are Special Areas of Conservation at Yell Sound and Sullom Voe, with Dales Voe SSSI, Voxter Voe SSSI and Ayres of Swinister SSSI all designated coastal features.

It is expected that the combination of distance downstream, freshwater dilution and subsequent coastal seawater dilution would reduce any effect to, at most, minor significance, and more likely negligible when mitigation measures are in place. Applying the environmental management and pollution prevention principles discussed in section 14.6.1, with the application of pollution prevention at source, reinforces this judgement.

Coastal flooding would not be influenced by site activity, although flood controls should be considered by the developer to mitigate against pollution incident. Only small sections of site access are planned adjacent to coastal locations, with the key location being the access and construction compound at Scatsta (in the Delting quadrant).

14.6.5 Effects on groundwater

As the groundwater resources for the Viking wind farm site are largely within the peat deposits the impacts on groundwater are considered as peat impacts and are discussed in section 14.6.6.

14.6.6 Effects on soil/peat

(a) Receptor Sensitivity

Bog and peatland habitats are susceptible to damage because of changes in water levels and water chemistry. As there are no areas designated for peat habitat in the study area the soil (peat) sensitivity in relation to pollution is classed as moderate.

As shown on the soil map (Figure 14.8 in Volume 3) and confirmed during field studies, the infrastructure planned for this development is found almost entirely on areas classified as ‘deep blanket peat’ and ‘deep and eroded blanket peat’. Large areas of this peatland are currently subject to strong erosive forces and display extensive erosion features. This is a natural process but the proposed development may lead to exacerbation of these processes. Accordingly, the receptor sensitivity is classed as high in relation to erosion issues.

In recent years, with an increase in developments on sites with a cover of peat, the significance of impacts on peatlands and, in particular, the impact on peat stability and the associated increased risk of peatslides or bog bursts has been acknowledged. A peatslide occurs when a portion of the peat mass becomes detached and flows downhill, usually as blocks of solid peat rafted upon a slurry of semi-liquid peat. A peatslide may have a significant effect on river water quality and ecology, particularly fish stocks. The land affected by peat slides usually re-vegetates quite rapidly, but the original balance of vegetation species is unlikely to be re-established as a consequence of the changes in local topography and drainage patterns. Although peatslides occur naturally, with examples at various locations in Mainland Shetland (e.g. Channerwick), they are thought to be relatively uncommon. However, because of the remote nature of most peatlands the frequency of natural peatslides may be under reported. As a result, peatslides and their causal factors are relatively poorly understood, although it is recognised that they are the result of multiple causes. With recognition of the relationship between slope and peat depth, plus examples of peat instability both regionally and locally, peat instability has been accorded a sensitivity of high.

Groundwater is classed as vulnerable and will often ‘feed’ surface water (classified as a receptor of high sensitivity in 14.6.2), accordingly it is classed as of high sensitivity.

(b) **Construction effects**

Pollution

A pollution incident could impact on the peat in the vicinity of the incident. Because of the low infiltration potential of the peat, contaminants are unlikely to penetrate into the deep peat or groundwater. However, high surface runoff coefficients mean a large area of the surface of the peat could be affected. Contaminants could damage the water quality and ecology of the peat and reduce its ecological value.

Without the proposed mitigation measures described above, such pollution incidents will be likely and their magnitude potentially will be major. With the measures in place the potential magnitude will be reduced to moderate and the likelihood to possible for the peat and unlikely in relation to groundwater. The anticipated residual effect against the moderate sensitivity rating will accordingly be minor for both peat and groundwater.

Modification of groundwater flows

Deep excavations such as those needed for turbine bases and borrow pits are likely to locally disrupt any shallow groundwater systems within the peat. Temporary groundwater controls such as dewatering or physical cut-offs may be required to prevent the excavations filling with water. This would be likely to result in the lowering of groundwater levels in the immediate vicinity of the excavations. The effects would be temporary at turbine locations and have little impact once the turbine foundation has been constructed and the excavation back-filled.

Cable laying could also inadvertently enable short term modification during the construction phase.

The layout of the wind farm has been designed to avoid areas of deep and sensitive peat, wherever practicable, and best practice construction techniques will be used for the entire wind farm development minimising the impact on groundwater flows. It is anticipated that impacts will be likely to occur but will be of minor magnitude and that the anticipated residual effects will be minor.

Compaction and erosion

Soil erosion is actively occurring on this site at present, with some locations where serious loss of soil has taken place, without development this process would be expected to continue to occur.

Where soil is covered by floating tracks, or excavated for cut tracks and turbines there will be a small element of soil loss. These issues have been discussed in the associated Technical Appendix 14.4 - Excavated Peat Volumes and Potential Reuse.

Where cut banks of peat are exposed, i.e. during cut track construction, the upper layer of removed peat (acrotelm) will be carefully replaced over banks as soon as possible, minimising exposure to runoff or wind erosive forces.

The movement of construction traffic throughout the site may cause localised soil compaction in the peat soils affecting hydrology and hydrogeology. The effects of compaction would be likely to be highly localised but would damage the vegetation and result in a reduction in soil permeability and rainfall infiltration, consequently increasing the potential for erosion. Stockpiled and exposed areas of peat may be at risk of erosion and desiccation. Given the poor and eroded baseline condition of peat in some areas of this site peat this may exacerbate current active erosive processes.

This impact would likely be localised but given the large number of turbines and length of access tracks this will have a site-wide cumulative effect. With proposed construction management measures in place impact remains possible with moderate magnitude. The anticipated residual effect would be moderate.

Peat Instability

Peat instability is a natural phenomenon that can occur independent of human influence. Evidence of this phenomenon was found on the site at the baseline stage, indicating that this is a current and active process which would be expected to continue to occur without development.

As discussed earlier in this report, Technical Appendix 14.1 provides details on the methods and results from this element of work. The findings of this report are summarised below.

Within the vicinity of the wind farm development 54 areas were identified as having a potential peatslide risk prior to mitigation. Ground investigation works were commissioned at 15 representative locations, undertaking *in-situ* shear vane measurements, coring and sampling, von Post classification and lab tests to determine bulk density. Using these data and the information previously collated a detailed assessment of the 54 locations of concern was made. In a number of cases it was found upon detailed inspection that there was little risk of peat landslide and no specific mitigation was required. For all other locations recommendations have been made for appropriate mitigation measures at each location in order to reduce the potential risk to an acceptable level.

In addition to the location specific mitigation, site-wide best practice measures have been outlined, including the need for ongoing re-appraisal of the peat landslide risk assessment throughout the detailed design and construction stages. A geotechnical engineer will also be employed onsite during construction to undertake advance inspection, carry out regular monitoring and provide advice. The creation and management of a geotechnical risk register will form an important aspect of the project.

Finally, the hazard ranking of the 54 locations identified for detailed assessment has been reappraised. Provided the recommended mitigation measures are put in place the risk of peat landslide occurring at any of these locations is insignificant.

The potential magnitude of impact of a peatslide on both the peat and the nearby watercourses is major without mitigation. Provided the mitigation measures discussed above are put in place it is unlikely that a peatslide will occur as a direct result of the wind farm construction. In view of the high sensitivity of both soil and watercourse receptors and the major magnitude of the impact should a peatslide occur, the anticipated effect would be moderate.

(c) **Ongoing and operational effects**

Pollution

The potential risk of pollution to peat and groundwater 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.

Despite the reduction in the number of potential pollutants the magnitude of a pollution incident, without mitigation in place, is moderate. The implementation of the proposed pollution prevention plan will reduce the potential impact of a pollution incident to one of minor magnitude and of possible occurrence. Residues and emissions resulting from operation of the wind farm are expected to be negligible. With the probability of occurrence being unlikely the anticipated order of effect is minor for both peat and groundwater.

Modification of surface and groundwater flows

The interception of diffuse overland flow by the tracks and their drainage will disrupt the natural drainage regime of the site, concentrating flows and potentially diverting flows from one catchment to another. This could result in bog and peatland habitats being deprived of the surface flows which feed them and maintain their water levels, thereby impacting upon the ecology of these areas. These impacts are long term and could take years to fully manifest.

Cable routes could lead to preferential pathways leading to changes in hydrological regime and concentration of flows leading to erosion.

Cut tracks and their drainage and borrow pits will potentially alter the water table within the adjacent peat mass. The result of lowering the water table either side of cut tracks, borrow pits and associated drainage features will be the formation of zones of altered vegetation and ecology and if subject to 'drying out' may become vulnerable to accelerated erosive forces. The effect could be permanent at borrow pits and alongside cut track margins, depending on the erosion features evident (i.e. local hagged terrain is likely to display disrupted groundwater flows *in situ*), peat depth, reinstated profile and nature of material used for backfill. Borrow pits have a limited distribution but the extent of access tracks would be of greater concern. The extent of these zones may vary, but given the large scale of this development there is likely to be the potential that a number of localised areas shall be impacted.

For surface water flows, taking into account the proposed adoption of best practice design and construction methods it is likely that there will be some ongoing impact on flows but that it will be of minor magnitude. The anticipated residual significance will be minor.

In relation to groundwater flows and access tracks, floating track is planned for areas of peat of depths greater than 1 metre, thus removing the requirement for cut tracks and associated drains in peat depths greater than this threshold value. This and other mitigation measures would be expected to reduce the track magnitude of effect to, at most, moderate, with the effect deemed likely to occur on the site, albeit localised. Therefore, the overall residual significance for tracks has been given a precautionary evaluation of moderate. For borrow pits the effects would be very isolated given limited number of locations and overall significance would be minor.

(d) **Decommissioning effects**

Decommissioning activity is suggested as being similar in effect to construction phase activity. This is a conservative approach as some issues relating to construction would be expected to be reduced in terms of complexity and/or time at the decommissioning phase.

Pollution

The risk of pollution during decommissioning is similar to that during the construction phase, due to similar scale and type of site activity.

As a consequence the significance of a pollution incident, with mitigation in place, is minor for both peat and groundwater.

Compaction and erosion

The movement of heavy plant throughout the site could cause compaction in the peat soils affecting both hydrology and hydrogeology. However as the plant will be restricted to the existing access tracks and hardstanding areas the area affected will be localised.

With proposed construction management measures in place the impact will be possible and of minor magnitude. The anticipated residual effect will be minor.

Peat instability

Peat instability is less likely to occur during the decommissioning stage than during construction. The movement of plant and potential removal from the site of heavy loads may cause instability through unusual loading or unloading of the peat in susceptible areas. Restriction of specific activities of concern during and immediately after high intensity rainfall events and other mitigation measures discussed previously would lead to a residual minor effect during the decommissioning phase.

Modification of surface and groundwater flows

As with the operational phase of the wind farm, the natural drainage regime of the site will continue to be disrupted by the remaining borrow pits and tracks and associated drainage. Taking into account the proposed adoption of best practice design and construction methods it is likely that there will be some impact but that it will be of minor magnitude. This will manifest itself as zones of altered vegetation and ecology either side of the tracks and borrow pits and at the locations of the decommissioned infrastructure.

The anticipated residual effect will be minor for borrow pits but moderate for tracks.

(e) **Summary of effects on peat**

The assessment of potential impacts on peat during construction and operation phases of the proposed wind farm has indicated that most impacts will be minor.

However, it has been identified that in relation to construction that peat erosion and peat instability issues there is the potential for moderate adverse effects. Track-side alterations in groundwater have been evaluated to have a moderate significance effect from the operational phase into the decommissioning phase.

These are matters that require to be highlighted and appropriately dealt with in order to minimise the likelihood of such events occurring and their magnitude if they do.

14.6.7 Cumulative Effects

The application of hydrological catchment assessment methodology enables a logical evaluation of the potential for cumulative effects on soil and water issues.

The 30 site catchments display limited development features and there are no plans for development that have been identified or notified during discussions with stakeholders. Therefore, it is judged that there is no cumulative (adverse) effect on soil and water.

14.7 SUMMARY OF ASSESSMENT

An assessment has been carried out of the likely impacts of the proposed Viking Wind Farm on the soil and water environments. The assessment has considered site preparation, borrow pit excavation, construction, operation and decommissioning of the wind farm.

The potential effects on the surface waters, groundwater, peat and private water supplies that have been considered are:

- Pollution incidents;
- erosion and sedimentation;
- changes to water resources i.e. private water supplies;
- modification of surface water and groundwater flows;
- modification of natural drainage patterns;
- impediments to flows and flood risk;
- peat instability;
- compaction of soils.

A number of layout, design and construction proposals have been identified that will minimise, mitigate or offset these effects.

It is concluded that with the proposed mitigation in place the majority of impacts on the soil and water environment will not be significant, as summarised in Tables 14.24-14.26. There are however three effects evaluated as being of significance, based on significance criteria provided in Table 14.6.

During the assessment it has become apparent that there are two currently active site processes which during the construction phase have been evaluated, using the precautionary principle in line with SNH's (2006) guidance, as having potentially significant effects: soil (peat) erosion and peat instability. It should be noted that, although these processes have been assessed as having potentially significant effects, neither has been assessed as being likely to occur. It should also be noted that these two processes will continue to occur at this site without development proceeding and hence the environmental baseline must incorporate this ongoing situation.

Erosion is occurring naturally on the site at present, as exhibited in extensive erosion features such as haggs and gullies. There is concern that construction activities may exacerbate this situation and these should be monitored at this development. Following the precautionary principle, soil (peat) erosion caused by construction has been identified as having a potentially significant (moderate significance) effect. The Peat Management Plan, within the Habitat Management Plan (Technical Appendix 10.9) gives advice on best practice for this issue along with some innovative techniques that may beneficially influence local peatland habitat and could result in a positive environmental effect in localised areas.

There are historical examples of peat instability on the Viking site and documented examples identified nearby, such as at Channerwick. It was noted that there are a number of features associated with active peat instability on the site, such as tension cracks. The Peat Stability Technical Appendix (Technical Appendix 14.1) has been prepared to provide further details on this matter. Locations of these features have been identified and ongoing monitoring should be undertaken in order to instigate mitigation measures, as may become necessary. It has been identified that, should a peatslide occur, the impact will be significant (moderate significance). This would also have a significant (moderate significance) impact on local watercourses as could lead to extreme sedimentation and possible channel blockage. The Peat Stability report concluded that the likelihood of a peatslide occurring, as a consequence of the wind farm construction, is unlikely provided the proposed mitigation measures are put in place.

There is also the potential for a significant adverse impact (moderate significance) from lowering of groundwater levels in the areas adjacent to cut tracks and associated drainage features. It would be expected to be localised and the impact may be more limited in areas exhibiting erosion features and/or shallow peat depth. This is a process that has occurred to varying degrees at other peatland developments and should be carefully mitigated against and monitored at this site in order to minimise the long-term effects. Following construction of tracks, this effect is likely to become manifest over a longer-term than the other significant effects identified and may become evident during the operational phase and could continue as a permanent feature into the decommissioning phase.

14.8 REFERENCES

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Table 14.24 Summary of Residual Construction Effects

Construction Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Receptor Sensitivity	Impact Magnitude	Impact Likelihood	Effect Significance
General	Suspended solids discharge from stockpiles	Effects on water quality of closest watercourses and waterbodies	Watercourses, waterbodies and peatland	High	Minor	Likely	Minor
		Impact on salmon spawning beds and gravels		High	Minor	Likely	Minor
Mobile plant operations	Soil disturbance and potential erosion	Soil loss or disturbance		High	Moderate	Possible	Moderate
	Suspended solids discharge	Effects on water quality of closest watercourses and waterbodies.		High	Minor	Likely	Minor
	Potential fuel or hydraulic oil spillage	Surface water pollution		High	Moderate	Unlikely	Minor
		Water supply pollution		High	Moderate	Unlikely	Minor
		Groundwater pollution		High	Moderate	Unlikely	Minor
		Soil contamination		Moderate	Moderate	Possible	Minor
	Damage to water supply infrastructure	Disruption to water supply		High	Moderate	Unlikely	Minor
	Construction activities triggering peatslide events	Soil loss, damage to plant and infrastructure and adjacent properties		High	Major	Unlikely	Moderate
		Extreme sedimentation or disruption of local watercourses		High	Major	Unlikely	Moderate

Construction Effects	**Impact**	**Potential Effects on Receptors**	**Specific Receptor Identified in Scoping**	**Receptor Sensitivity**	**Impact Magnitude**	**Impact Likelihood**	**Effect Significance**
Borrow pit operations	Increased surface runoff	Change to hydrological regime	Watercourses, water bodies and peatland	High	Minor	Unlikely	Minor
	Suspended solid discharge	Effects on water quality of closest watercourses and waterbodies.		High	Minor	Likely	Minor
	Potential dewatering	Changes to groundwater regime		High	Minor	Likely	Minor
Access track construction	Construction works altering hydrological pathways within peat deposits	Change to hydrological regime		High	Minor	Likely	Minor
	New stream crossing structures impeding surface flows	Change to hydrological regime and continuity of the watercourse, increase in flood risk		High	Minor	Possible	Minor
Cable laying	Creation of temporary drainage route	Change to hydrological regime		High	Minor	Likely	Minor
Construction compounds	Increased surface runoff	Change to hydrological regime		High	Minor	Unlikely	Minor
	Potential fuel, oil or chemical spillage	Surface water pollution		High	Moderate	Unlikely	Minor
		Water supply pollution		High	Moderate	Unlikely	Minor
		Groundwater pollution		High	Moderate	Unlikely	Minor
		Soil contamination		Moderate	Moderate	Possible	Minor

Construction Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Receptor Sensitivity	Impact Magnitude	Impact Likelihood	Effect Significance
Turbine and substation foundations	Potential dewatering	Change to hydrological regime	Watercourses, water bodies and peatland	High	Minor	Likely	Minor
	Concrete or cement spillage	Surface water pollution		High	Moderate	Unlikely	Minor
		Water supply pollution		High	Moderate	Unlikely	Minor
		Groundwater pollution		High	Moderate	Unlikely	Minor
		Soil contamination		Moderate	Moderate	Possible	Minor

Table 14.25 Summary of Residual Ongoing Effects

Ongoing Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Sensitivity	Impact Magnitude	Impact Likelihood	Effects Significance
General	Operation vehicle fuel spillage	Water pollution	Watercourses, water bodies and peatland	High	Minor	Unlikely	Minor
		Water supply pollution		High	Minor	Unlikely	Minor
		Groundwater pollution		High	Minor	Possible	Minor
		Soil contamination		Moderate	Minor	Possible	Minor
Turbines	Potential spillage from transformer oil or gearbox lubricant	Surface water pollution		High	Minor	Unlikely	Minor
		Water supply pollution		High	Minor	Unlikely	Minor
		Groundwater pollution		High	Minor	Possible	Minor
		Soil contamination		Moderate	Minor	Possible	Minor
	Decreased infiltration due to turbine foundations	Change to hydrological regime		High	Minor	Likely	Minor

Ongoing Effects	**Impact**	**Potential Effects on Receptors**	**Specific Receptor Identified in Scoping**	**Sensitivity**	**Impact Magnitude**	**Impact Likelihood**	**Effects Significance**
Tracks	Increased surface runoff	Change to hydrological regime	Watercourses, water bodies and peatland	High	Minor	Likely	Minor
	Land drainage adjacent to cut track and drainage ditches	Change to groundwater hydrological regime, localised drying out		High	Moderate	Likely	Moderate
	Flooding due to impeded flows and sedimentation from stream crossing structures	Change to hydrological regime and increase in flood risk		High	Minor	Possible	Minor
	Damage to water supply infrastructure during ongoing track maintenance	Loss of supply		High	Moderate	Unlikely	Minor
Cables	None (trenches reinstated)	-		-	-	-	-
Anemometers	None	-		-	-	-	-
Sub-station / control building	Increased surface runoff	Change to hydrological regime		High	Minor	Possible	Minor
	Potential transformer oil spillage	Water pollution		High	Minor	Unlikely	Minor
		Water supply pollution		High	Minor	Unlikely	Minor
		Groundwater pollution		High	Minor	Possible	Minor
		Soil contamination		Moderate	Minor	Possible	Minor

Ongoing Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Sensitivity	Impact Magnitude	Impact Likelihood	Effects Significance
Crane pads	Increased surface runoff	Change to hydrological regime	Watercourses, water bodies and peatland	High	Minor	Possible	Minor
Borrow pits	Increased surface runoff	Change to hydrological regime		High	Minor	Possible	Minor
	Land drainage adjacent to borrow pit locations	Change to groundwater hydrological regime, localised drying out		High	Minor	Likely	Minor

Table 14.26 Summary of Residual Decommissioning Effects

Decomm. Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Sensitivity	Impact Magnitude	Impact Likelihood	Effects Significance
Mobile plant operations	Soil disturbance and potential erosion	Soil loss or disturbance	Watercourses, water bodies and peatland	High	Minor	Possible	Minor
	Suspended solids discharge	Effects on water quality of closest watercourses and waterbodies.		High	Minor	Possible	Minor
	Potential fuel or hydraulic oil spillage	Surface water pollution		High	Moderate	Unlikely	Minor
		Water supply pollution		High	Moderate	Unlikely	Minor
		Groundwater pollution		High	Moderate	Unlikely	Minor
		Soil contamination		Moderate	Moderate	Possible	Minor
	Disruption to water supply	Loss of supply		High	Moderate	Unlikely	Minor
	Decommissioning activities triggering peatslide events	Soil loss, damage to plant and infrastructure and adjacent properties		High	Moderate	Unlikely	Minor
		Extreme sedimentation or disruption of local watercourses		High	Moderate	Unlikely	Minor

Decomm. Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Sensitivity	Impact Magnitude	Impact Likelihood	Effects Significance
Turbine, Sub-station & Anemometer Removal / Demolition	Suspended solids discharge	Effects on water quality of closest watercourses and waterbodies.	Watercourses, water bodies and peatland	High	Minor	Likely	Minor
	Potential fuel or hydraulic oil spillage	Surface water pollution		High	Moderate	Unlikely	Minor
		Water supply pollution		High	Moderate	Unlikely	Minor
		Groundwater pollution		High	Moderate	Unlikely	Minor
		Soil contamination		Moderate	Moderate	Possible	Minor
Turbine Foundations	Decreased infiltration	Change to hydrological regime		High	Minor	Likely	Minor
Tracks	Increased surface runoff	Change to hydrological regime		High	Minor	Likely	Minor
	Land drainage adjacent to drainage ditches	Change to hydrological regime		High	Moderate	Likely	Moderate
	Flooding due to impeded flows from stream crossing structures (if removed)	Change to hydrological regime and increase in flood risk		High	Minor	Unlikely	Minor
Cables	None	-		-	-	-	-

Decomm. Effects	Impact	Potential Effects on Receptors	Specific Receptor Identified in Scoping	Sensitivity	Impact Magnitude	Impact Likelihood	Effects Significance
Decomm. compounds	Suspended solid discharge	Effects on water quality of closest watercourses and waterbodies.	Watercourses, water bodies and peatland	High	Minor	Possible	Minor
	Potential fuel or hydraulic oil spillage	Surface water pollution		High	Moderate	Unlikely	Minor
		Water supply pollution		High	Moderate	Unlikely	Minor
		Groundwater pollution		High	Moderate	Unlikely	Minor
		Soil contamination		Moderate	Moderate	Possible	Minor
Borrow pits	Increased surface runoff	Change to hydrological regime		High	Minor	Possible	Minor
	Land drainage adjacent to borrow pit locations	Change to groundwater hydrological regime, localised drying out		High	Minor	Likely	Minor