Neart na Gaoithe Offshore Wind Farm

Outline Surface Water Drainage Strategy for Proposed Substation (Development Support)

Report: 1005816

Author: Kelly Wyness

Issued: 06/08/2012

Natural Power Consultants
McKinven House
George Street
Falkirk
FK2 7EY

+44 1324 616 700

Client:
Mainstream Renewable Power

Report: 1005816

Neart na Gaoithe Offshore Wind Farm – Outline Surface Water Drainage Strategy for Proposed Substation

Author:	Kelly Wyness	28/06/2012
Checked By:	Chris Robinson, Stewart Campbell	29/06/2012
Approved By:	Richard Walls	04/07/2012

Classification: COMMERCIAL IN CONFIDENCE

Distribution: File, Internal, NPC, Robert Corrigan (Mainstream Renewable Power)

Revision History

Issue	Date	Changes
A1	04/07/2012	First issue
B1	26/07/2012	Second issue following client comment
B2	06/08/2012	Final issue following client feedback

Table of Contents

1 INTRODUCTION

Natural Power Consultants (NPC) has been commissioned by Mainstream Renewable Power (the Client) to produce an outline surface water drainage strategy to support the planning application associated with the proposed substation for the Neart na Gaoithe Offshore Wind Farm.

The provision of the strategy details proposed drainage techniques designed to sustainably attenuate and treat the runoff from the substation platform prior to discharge back into the hydrological environment. Whilst no consultations have been undertaken with East Lothian Council (ELC), the main driver of preparing this outline drainage strategy is the Water Framework Directive (2000/60/EC) (WFD). The basic objectives of the WFD relevant to this drainage strategy are as follows:

- To prevent deterioration in the status of surface water bodies;
- To protect, enhance and restore all bodies of surface water with the aim of achieving good chemical status of surface waters by 2015;
- To progressively reduce discharges, emissions and losses of Priority Substances to surface water bodies;
- To ensure the cessation or phasing-out of discharges, emissions and losses of Priority Hazardous Substances to surface water bodies; and
- To achieve compliance with any relevant standards and objectives for protected areas.

As part of the Client's continuing commitment to protect all aspects of the natural environment during construction and operation of the substation it has been recommended that an outline surface water drainage strategy be produced that will help to inform the appointed Construction Contactor of the need and suitability for the site drainage systems in line with the principles of Sustainable Urban Drainage Systems (SUDS).

The drainage strategy should be considered a live document, and as such additional information should be incorporated as a result of issues identified during the detailed design stage, post consent and/or following any discussions with the Scottish Environment Protection Agency (SEPA) or Scottish Natural Heritage (SNH).

1.1 Legislation and Guidance

As described above, the primary legislation used in the preparation of this document is the WFD which resulted in the Water Environment and Water Services (Scotland) Act 2003 and consequently the Water Environment (Controlled Activities) (Scotland) Regulations 2011. The plan also takes into account up-to-date and relevant guidance published by SEPA, SNH and the Construction Industry Research and Information Association (CIRIA).

1.2 Limitations of Report

Due to the proximity of the proposed substation to the Tay Burn, the report considers the surface water management strategy that may be required to sustainably manage the runoff from the proposed substation platform upstream of the sensitive River Tweed Special Area of Conservation (SAC). Whilst best practice drainage measures are provided, this report has been prepared to inform the planning application and does not represent detailed engineering design. The primary source of information to inform the strategy is the peat stability assessment produced by URS as part of the planning application[1].

[1] URS (2012), Neart na Gaoithe Substation and Cable Corridor, Peat Stability Assessment, 46400082

2 DESCRIPTION OF THE SITE

2.1 Site Location

The substation is located in the southeast of Scotland, in East Lothian, immediately adjacent to the existing Crystal Rig II Wind Farm substation.

2.2 Existing Site

The site includes a mix of improved grassland and open moorland, currently used for livestock grazing. There are also wooded areas in the wider area surrounding the substation.

The terrain is dominantly undulating and varies in height by only a couple of meters. The substation platform is located in an area between 295 and 300m Above Ordnance Datum (AOD).

At its closest, the boundary of the substation is located approximately 10m from the Tay Burn which is a tributary of the River Tweed. The River Tweed is a designated SAC for supporting Atlantic salmon, brook, river and sea lamprey, otter as well as being a river with floating vegetation often dominated by water-crowfoot. The drainage measures and principles to minimise the effects of the substation on the hydrological environment are discussed in the following sections.

2.3 Proposed Development

The proposed onshore grid connection scheme comprises a proposed cable corridor of approximately 12km from Thortonloch Beach to the proposed new substation in the vicinity of the operational Crystal Rig II Wind Farm at Friardykes, East Lothian. The substation platform, which is the focus of this report, occupies approximately 3.32ha.

3 REVIEW OF TERRAIN DATA

An analysis of terrain data has also been carried out to help inform the drainage requirements of the substation. Figure 1 in Appendix 1 provides information on the flow direction of the surface runoff within the vicinity of the substation platform. Flow accumulation is calculated in the Geographical Information System (GIS) and is based on the 2m resolution Digital Terrain Model (DTM) within and surrounding the substation. The flow accumulation represents the volume of water that would flow into each 2m cell of the DTM, assuming that all water becomes runoff and there was no interception, evapotranspiration or infiltration. The volume of accumulation is represented in greyscale with higher flow accumulations being darker in shade to areas with lower flow accumulation. The figure clearly illustrates the influence of topography on the accumulation and direction of surface water runoff across the proposed substation area.

Figure 2 in Appendix 1 also provides information on how the topography influences the saturation of the peat/peaty soils across the proposed substation area. The analysis of the DTM derived a topographic wetness index (TWI). The TWI is a dimensionless index, defined by the equation:

$$TWI = \ln(a/\tan b)$$

where:

- a = area draining through a point from an upslope contributing area; and
- tan b = local slope angle

The index provides results on the hydrological similarity of the underlying peat. All points with the same value of the index are assumed to respond in a similar hydrological manner. High index values will tend to saturate first and will therefore indicate potential subsurface or high surface runoff areas.

The TWI for the proposed substation has identified those areas where water is likely to accumulate on site and result in saturation of the surrounding peat/peaty soils. Areas that have the highest tendency to become saturated are shown in blue and will have a TWI of 20 or above. The dark blue linear channels are considered to show achievable flow rates that are likely to occur throughout the year or during extreme rainfall events. The lighter blue areas are likely to represent areas of the site where the topography allows the accumulation and saturation of peat or soils from subsurface or surface means during prolonged and/or intense rainfall events. Areas where there may be less tendency for the ground to saturate are shown in orange and red.

4 OUTLINE SURFACE WATER DRAINAGE STRATEGY

An outline drainage strategy has been prepared to help inform the planning application associated with the proposed Neart na Gaoithe substation. The strategy is required to provide information on the sustainable management of surface water that will help to minimise effects of the development on the existing hydrological regime.

It is recognised that consideration of drainage and flood issues should not be confined to the floodplains. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in the catchment, particularly water quality and quantity downstream. For example, replacing vegetated areas with roofs, roads and other impermeable areas can increase both the total and the peak flow of surface water runoff from the development site. Changes of land use on previously undeveloped land can also have significant downstream impacts where the existing drainage system may not have sufficient capacity for the additional drainage.

Careful management of the surface water as well as protection of existing surface water is therefore required during each phase of the development. This can be achieved by incorporating the drainage measures discussed in this document, specifically in sections 4.1, 4.2 and 4.3 as well as carrying out detailed design prior to construction and utilising best practice throughout all phases of the substation development.

4.1 Surface Water Runoff from Adjacent Moorland

The substation will be cut into an existing area of sloping ground, which as shown in Figure 2, currently drains in a north easterly direction. Surface water from this area is currently collected in a series of existing drainage ditches which channel the water flow into the Tay Burn.

The substation development will comprise excavation into the existing sloping ground to depths up to approximately 5m maximum, and construction of a level platform approximately 3.32ha in size. To facilitate construction of the substation platform a cut-off ditch, with the purpose of intercepting runoff will be constructed above the excavation. The indicative location of the cut off ditch is provided in Figure 1 in Appendix 1. The ditch will be trapezoidal in profile and unlined, allowing infiltration where possible. The ditches will also outfall into temporary settlement lagoons designed to intercept sediment arising through the construction stage, prior to the water flowing into existing nearby channels into the Tay Burn.

Runoff attenuation and sediment management measures will also be installed along the length of the cut-off drains.

Due to the sensitivity of the downstream hydrology, it is imperative that the drainage channels are designed with the principles of maintaining the existing regime. An example of poor drainage installation is provided in Photograph 1. The photograph shows a single drainage ditch with inadequate provision for runoff or attenuation measures. The figures also show that the ditch has been constructed to a depth that is likely to encourage water table drawdown in the surrounding peat. Whilst the photograph does not relate to substation drainage, the principles remain the same.

Photograph 1: Example of poor drainage (provided for illustrative purposes only) a) single linear feature with no attenuation or sediment management measures and b) depth of drainage ditch encouraging water table drawdown

4.2 Substation Platform Drainage

The surface of the substation compound is likely to be predominantly gravel based, with the only true impermeable surfaces associated with the building roofs. The gravel platform will still permit some filtration together with providing storage attenuation.

As shown in Figures 2 and 3, the topography of the substation platform falls in a north east direction and it is proposed that filter drains will be constructed around the perimeter of the substation platform area to collect surface runoff from the platform and the adjacent side slopes. The filter drains have the potential to accommodate a degree of infiltration along their length, with any water flow carried through the pipe system being discharged into the temporary settlement lagoon during construction and into the existing drainage channels and ditches during operation.

Due to the size of the proposed substation, it is recommended that multiple discharge points are implemented during the operational phase. Implementing multiple discharge points will help reduce the erosive potential of the runoff as it will be dispersed across a wider area.

Photograph 2 shows the existing discharge point associated with the Crystal Rig II substation.

Photograph 2: Existing drainage from Crystal Rig II Wind Farm Substation (provided for illustrative purposes only) a) Perimeter drain to direct runoff to discharge point and b) Catch pit located at discharge point to help attenuate flow prior to downstream discharge into the Tay Burn

The suitability of perimeter filter drains will be determined during the detailed design stage, post consent. If filter drains are not suitable due to percolation tests determining that the infiltration rates are insufficient, it is proposed that perimeter drains are still constructed, but they will serve the purpose of channelling runoff to the settlement lagoon and/or discharge points into the existing drainage. As per the information presented in 4.1, scour protection and runoff attenuation measures are recommended to be installed at regular intervals along the length of the perimeter drains.

4.3 Foul Water Strategy

Foul water associated with the substation will be collected in a full retention septic tank that will be emptied periodically by a licensed contractor. Implementing such a strategy will reduce the potential for effluent to enter the natural drainage system and contaminating the Tay Burn and River Tweed SAC.

5 PROPOSED MONITORING

It is recommended that a programme of surface water quality monitoring is carried out prior to and during construction of the proposed Neart na Gaoithe substation. The exact methodologies and locations of the monitoring points will be agreed following consultation with SEPA.

The purpose of the monitoring is to ensure that effects on the hydrological environment as well as the SAC are closely monitored and known effects can potentially be isolated and appropriately mitigated. This will also help to ensure that appropriate mitigation and construction management measures can be implemented throughout the construction and operational phases of the substation.

It is recommended that the following elements be included within the established surface water monitoring programme:

- Monthly water sampling downstream of the substation construction activities;
- Regular visual inspection of surface water management features such as culverts, discharge points and receiving watercourses in order to establish whether there is increased erosion or deposition of sediment;
- Regular visual inspection of watercourses post construction of the substation, particularly during periods of high rainfall, in order to establish that levels of suspended solids have not been increased by on-site activities; and
- Additional water sampling during a known pollution event to record the effects on on-site and downstream water quality.

It is recognised that the impacts of the development will be deemed acceptable if there is no significant net deviation from the baseline monitoring results.

6 CONCLUSIONS AND RECOMMENDATIONS

This report presents an outline drainage strategy, required to help support the planning application of the substation associated with the proposed Neart na Gaoithe Offshore Wind Farm. Current guidance promotes sustainable water management through the use of SUDS. This assessment has been based on information gathered as part of a desktop exercise and site walkover and does not constitute engineering design. This information should only be used as a guide and the results of the detailed site investigations carried out post consent will determine the runoff storage and/or infiltration requirements.

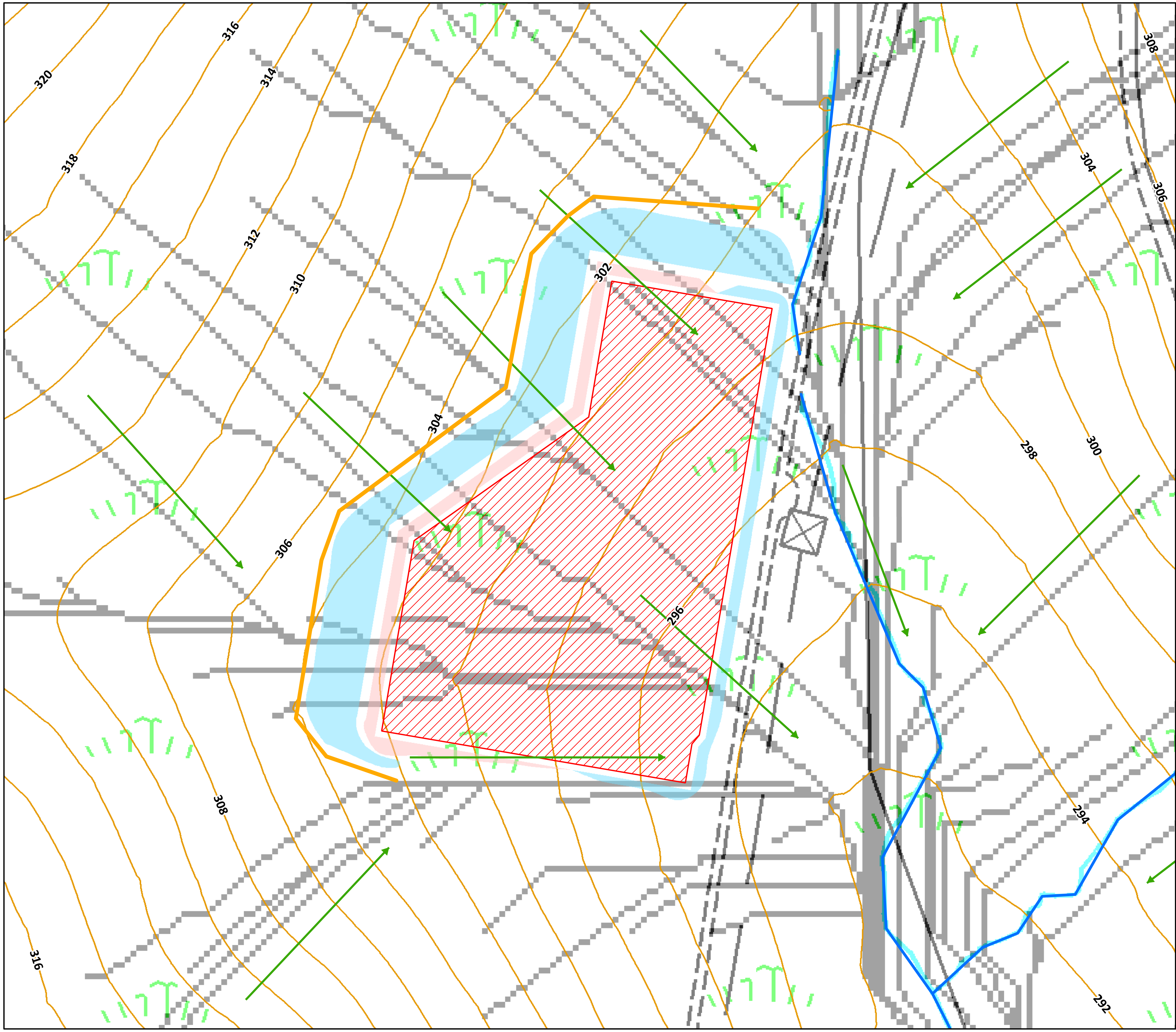
The results of a desktop study have determined that the substation platform is situated in an area underlain by peat or peaty soils. Such soils will have poor permeability due to either being ephemerally or perennially saturated and such conditions are unlikely to support infiltration drainage techniques. The assessment has therefore assumed an infiltration coefficient of 0.005m/hr.

The results have indicated that the volume required to infiltrate the 30year development runoff rate, plus a 20% allowance for climate change to Greenfield levels does not significantly differ between storage and infiltration SUDS techniques. The modelling exercise was therefore undertaken assuming that storage techniques would be adopted.

The following is recommended to establish the detailed drainage requirements of the substation platform:

- Carry out detailed engineering design post consent to determine the suitability and location of individual drainage techniques;
- Carry out sensitivity testing of the drainage system to establish the effectiveness of such measures during varying return periods;
- Whilst combining drainage between the proposed Neart na Gaoithe substation and the proposed SPT substation extension has not been discussed in this report it is recommended that, where practical, such measures between both substations are designed concurrently to maximise efficiency; and
- Adoption of a suitable monitoring strategy to ensure that effects on the Tay Burn and the River Tweed SAC are appropriately monitored.

APPENDIX 1: FIGURES



Project:

Neart na Gaoithe Offshore Wind Farm Substation

Title:

Figure 1: Flow Accumulation & Direction

Key

- Substation
- Groundworks - Cut
- Groundworks - Fill
- Indicative cut off ditch
- Flow direction
- Watercourse (Tay Burn)
- 2m contour

Notes:

a) Information on this map is directly reproduced from digital and non-digital material from different sources. Minor discrepancies may therefore occur. Where further clarification is considered necessary, this is noted through the use of text boxes on the map itself.

b) For the avoidance of doubt and unless otherwise stated:

1. where a line recorded in the key demarcates a boundary on this plan, the boundary edge is the outside edge of the line.
2. where a line or feature recorded in the key of this plan is also shown as a line or feature by the Ordnance Survey, and that line or feature is located in a different position on the ground than shown by the Ordnance Survey, then the line or feature shall be deemed to follow the position as existing on the ground.
3. this plan should be used for identification purposes only, unless specifically stated above or in accompanying documentation.

Scale: 1:2,000 @ A3

N

0 25 50 100 m

Date: 04/07/12	Prepared by: KW	Checked by: CR
Ref: 936_M_001	Rev. No.	

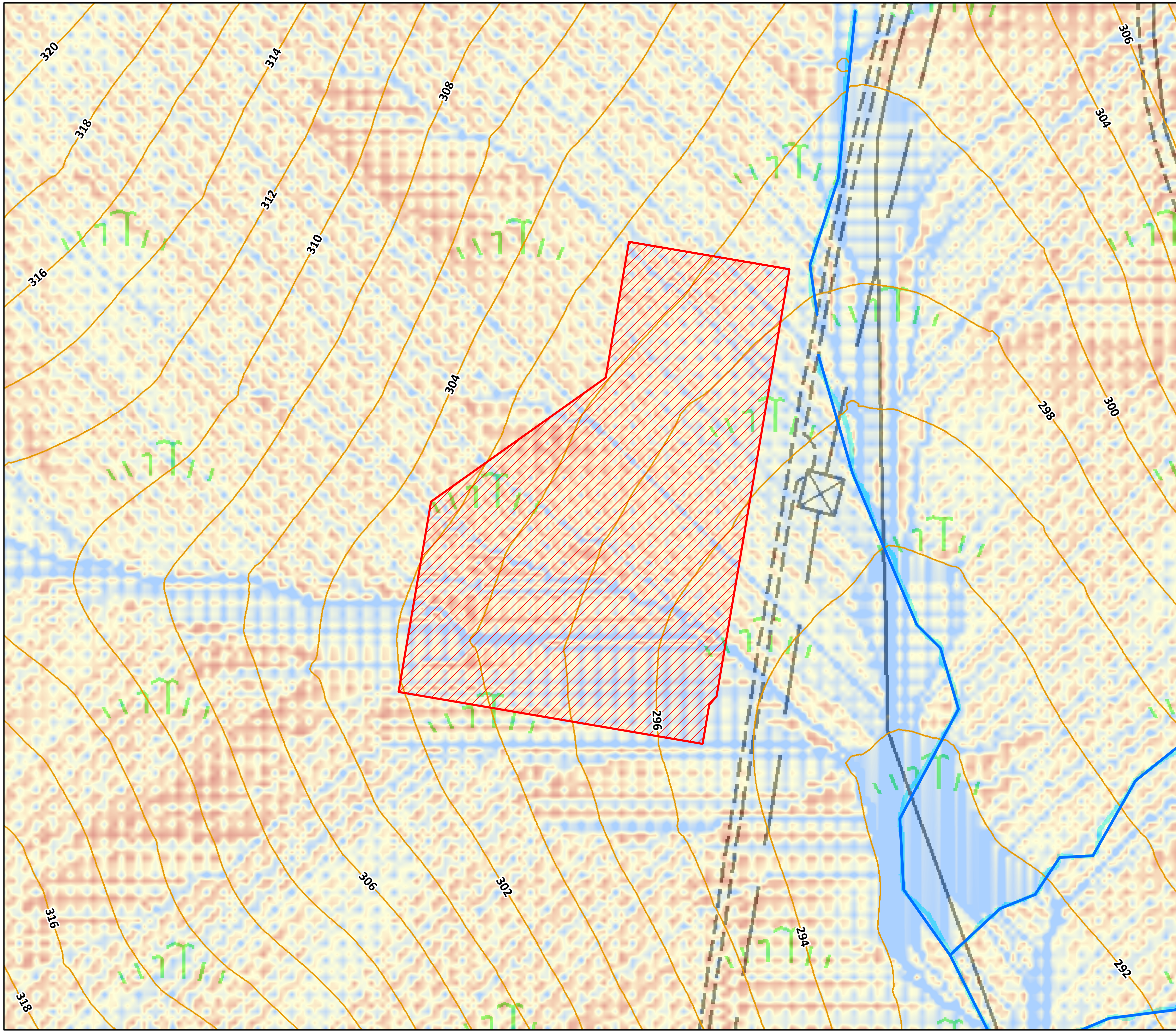
Drawing by:

Natural Power Consultants Ltd
The Green House
Forrest Estate, Dalry
Castle Douglas, DG7 3XS, UK
Tel: 01644 430008
Fax: 01644 430009
Email: post@naturalpower.com
www.naturalpower.com

natural power

Client:

MAINSTREAM RENEWABLE POWER



Project:

Neart na Gaoithe Offshore Wind Farm Substation

Title:

Figure 2: Topographc Wetness Index

Key

- Substation
- Watercourse (Tay Burn)
- 2m contour

Topographic Wetness Index

21 — High
11
1 — Low

Index of hydrological similarity:
High index values (blue) = tendency to saturate first/ areas of known saturation (watercourses/waterbodies).
Low index values (red) = unlikely to become saturated (dependent upon climatic conditions)

Notes:

a) Information on this map is directly reproduced from digital and non-digital material from different sources. Minor discrepancies may therefore occur. Where further clarification is considered necessary, this is noted through the use of text boxes on the map itself.

b) For the avoidance of doubt and unless otherwise stated:
1. where a line recorded in the key demarcates a boundary on this plan, the boundary edge is the outside edge of the line.
2. where a line or feature recorded in the key of this plan is also shown as a line or feature by the Ordnance Survey, and that line or feature is located in a different position on the ground than shown by the Ordnance Survey, then the line or feature shall be deemed to follow the position as existing on the ground.
3. this plan should be used for identification purposes only, unless specifically stated above or in accompanying documentation.

Scale: 1:2,000 @ A3

N

0 25 50 100 m

Date: 04/07/12	Prepared by: KW	Checked by: CR
Ref: 936_M_002	Rev. No.	

Drawing by:

Natural Power Consultants Ltd
The Green House
Forrest Estate, Dalry
Castle Douglas, DG7 3XS, UK
Tel: 01644 430008
Fax: 01644 430009
Email: post@naturalpower.com
www.naturalpower.com

natural power

Client:

MAINSTREAM RENEWABLE POWER

APPENDIX 2: RUNOFF CALCULATIONS

Introduction

To facilitate the design of the settlement pond and to provide information on the storage required to sufficiently attenuate runoff from the site an assessment on "Greenfield" runoff rates has been undertaken. The calculation of the runoff rates has been based on a landtake of 3.32ha.

The runoff rates from the substation platform have been calculated using the Micro Drainage WinDes software suite. These rates are based on the guidelines as outlined in the Interim Code of Practice for SUDS[2].

The following parameters have been incorporated into the calculations:

- Standard Average Annual Rainfall (SAAR): 850mm/year[3];
- Soil: 0.5 (Soil Class 4)[4];
- Urban: 0% to best represent Greenfield conditions[5]; and
- Region No: 2[6].

It is preferable that the developed runoff rate is returned to "Greenfield" rates. It is standard practice that the post development runoff rate will be attenuated to the equivalent Greenfield rate. For example, and for the purposes of this report, a 30 year storm should be attenuated to a 30 year return period. The Greenfield runoff rate that will be chosen as part of the detailed design of the drainage measures will be determined post consent, in consultation with SEPA and ELC.

The runoff from a developed site should in principle mimic the quality and quantity of the runoff from the site in its predevelopment "Greenfield" state. Whilst it is reasonable to suspect that the gravel based substation platform will allow a degree of attenuation and filtration, attenuating flow down to the Greenfield rate is applicable to the Neart na Gaoithe substation platform as its construction and operation will represent a change to the baseline conditions and is likely to alter the existing hydrological regime.

Table 1 provides the Greenfield runoff rates for a number of return periods based on the total landtake of the substation platform.

[2] Office of the Deputy Prime Minister, National SUDS Working Group, July 2004, Interim Code of Practice for sustainable drainage systems.
[3] The SAAR figure used was derived for a 1km grid square to represent the general site area, rather than individual catchments that would have provided a larger area. This was derived using the FEH CD-ROM which provided the figure of 850mm
[4] The soil class was derived from Volume 3 of the Wallingford Procedure. The map defines the soil underlying the substation as *Soils of the wet uplands ((i) with peaty or humose surface horizons and impermeable layers at shallow depth, (ii) deep raw peat associated with gentle upland slopes or basin sites, (iii) bare rock cliffs and screes (iV) shallow, permeable rocky soils on steep slopes*
[5] Proportion of area urbanised expressed as a decimal 0.000
[6] Region number of the catchment based on Flood Studies Report Figure I.2.4

Table 1: Summary of Greenfield runoff rates for a range of return periods

Return Period	Greenfield Runoff Rate (l/s)
QBAR[7]	23.0
Q (1yrs)	20.0
Q (30yrs)	43.6
Q (100yrs)	60.5

QBAR, assuming no proportion of the catchment is urbanised, is calculated using the following equation:

$$QBAR_{rural} = 0.00108 \times AREA_{0.89} \times SAAR_{1.17} \times SOIL_{2.17}$$

The results of the equation yield flow values in m^3/s.

Sustainable Drainage Options

Current guidance promotes sustainable water management through the use of SUDS, as set out in CIRIA 697 and Scottish Planning Policy[8]. Scottish Planning Policy states that:

"The Water Environment (Controlled Activities) (Scotland) Regulations 2005 require all surface water from new development to be treated by a sustainable drainage system (SUDS) before it is discharged into the water environment, except for single houses or where the discharge will be into coastal water."

Whilst the above quote refers to the 2005 Regulations, these have now been superseded by The Water Environment (Controlled Activities) (Scotland) Regulations 2011 and the requirement for new developments to consider SUDS as part of drainage management remains unchanged.

Such SUDS techniques can include, but is not limited to:

- Water butts;
- Porous and pervious paving;
- Rainwater harvesting;
- Filter strips;
- Swales;
- Infiltration basins;
- Detention basins;
- Retention ponds; and
- Wetlands.

A hierarchy of techniques is identified[9]:

1. **Prevention** – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hardstanding);
2. **Source Control** – control of runoff at or very near its source (such as the use of rainwater harvesting);
3. **Site Control** – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site); and
4. **Regional Control** – management of runoff from several sites, typically in a detention pond or wetland.

[7] Average Annual Maximum Flood
[8] Scottish Government (2010), Scottish Planning Policy
[9] CIRIA (2004) Report C609, Sustainable Drainage Systems – Hydraulic, Structural and Water Quality Advice

It is generally accepted that the implementation of SUDS as opposed to conventional drainage systems, provides several benefits by:

- Reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- Reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- Improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- Reducing potable water demand through rainwater harvesting;
- Improving amenity through the provision of public open spaces and wildlife habitat; and
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

The attenuation volume required to restrict runoff from the developed site to the Greenfield runoff rate has been based on a 30yr return period and has been calculated using the industry standard MicroDrainage WinDes software suite.

Figure 3 illustrates the storage required for varying discharge rates based on the landtake of the substation platform (3.32ha) and a 30yr return period. Based upon the parameters listed in the Introduction of this Appendix, the figure is produced using the Quick Storage Estimate (QSE) function with the MicroDrainage WinDes software. Storage varies with different configurations of controls (outflow, overflow control etc) and storage structure (storage pond, infiltration trench etc). The QSE function looks at two extreme cases to provide an estimate of the range of storage required. The estimated values may be used as a starting point for detailed design but must never be used as a final design as the variables it assumes are significant.

Due to the dominance of peat and/or peaty soils across the substation area an assumed percolation value of 0.005m/hr has been adopted when considering the attenuation requirements. The figure has been based on the information presented within the Neart na Gaoithe Substation and Cable Corridor – Peat Stability Assessment[1] and the Crystal Rig II Wind Farm Substation Site Investigation Report[10]. Both reports provide information that states that the substation area is dominated by peaty deposits. Such deposits can potentially allow groundwater flow but are perennially or ephemerally saturated and may limit the potential for infiltration.

[10] Natural Power Consultants (2007), Crystal Rig II Wind Farm Substation Site Investigation Report

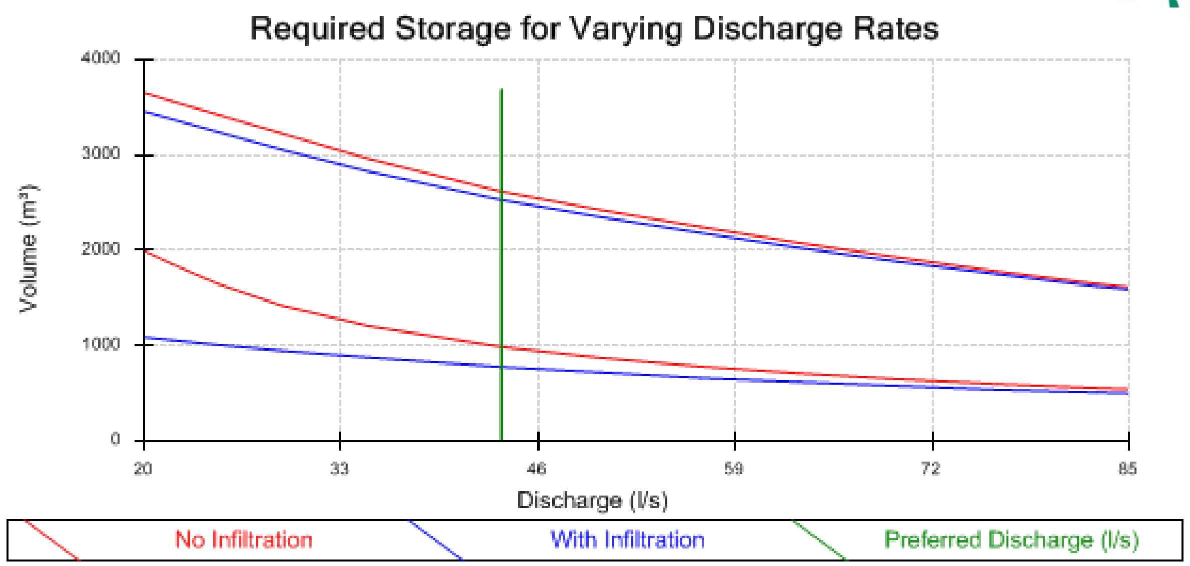


Figure 3: Required Storage for Varying Discharge Rates

As illustrated in Figure 3, the technical feasibility of employing storage with (or without) infiltration can be easily determined using the QSE function as the software generates a range of storage volumes represented in graphical format. The figure shows a minimum and maximum storage volume requirement that is based on the parameters listed in the Introduction to this appendix. The red line shows the storage requirement based on no infiltration losses and the blue line shows the storage requirement with infiltration losses. The green line shows the minimum and maximum storage volumes based on the allowable discharge rate (Greenfield runoff rate).

The figure shows that for a 30 year return period, with an allowable discharge of 43.6l/s the storage requirements will be between 990m^3 – 2620m^3 with no infiltration losses and 781m^3 – 2532m^3 with infiltration losses. These values are based on the infiltration coefficient of 0.005m/hr, and show that there are no significant differences between these values. These values also suggest that the implementation of infiltration measures does not significantly reduce the total storage volume required. The percolation value of 0.005m/hr is a conservative value that has been derived from desktop information and not from the results of percolation tests. Such tests will be carried out prior to construction and will yield a representative figure that can be used to determine the suitability of infiltration drainage measures.

Due to the dominance of peat and peaty soils, an assessment has therefore been made of the required attenuation storage volume assuming no infiltration losses. A pond or similar storage structure would be recommended to attenuate the development runoff to Greenfield levels.

It is recommended that detailed investigations are carried out post consent to determine the total volume of runoff storage structures (ponds) required. It is also recommended that the storage structures are designed to help minimise the effects of the substation construction and operation on the SAC as well overall hydrology.

The size of the pond was considered during the modelling exercise and its depth and area can be found in the WinDes calculation sheets provided in Appendix 3. The attenuation volume required to throttle the development from the whole site to the 30year Greenfield runoff level was calculated as **1393.5m^3** which is between the 990m^3 and 2620m^3 provided by the QSE. This value included a 20% climate change addition to the rainfall values provided in the calculations. The pond was modelled using an Md4 Hydro-Brake.

APPENDIX 3: WINDES CALCULATION SHEETS

Natural Power Consultants		Page 1
McKinven House George Street Falkirk FK2 7EY		Micro Drainage
Date 06/08/2012 10:43 File Neart_na_Gaoithe_...	Designed By kellyw Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 30 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	100.411	0.411	36.5	328.6	O K
30 min Summer	100.556	0.556	36.6	445.2	O K
60 min Summer	100.748	0.748	36.6	598.5	O K
120 min Summer	100.972	0.972	36.6	777.2	O K
180 min Summer	101.102	1.102	36.6	881.3	O K
240 min Summer	101.190	1.190	36.6	951.7	O K
360 min Summer	101.315	1.315	36.6	1051.8	O K
480 min Summer	101.399	1.399	37.6	1119.4	O K
600 min Summer	101.459	1.459	38.4	1167.2	O K
720 min Summer	101.502	1.502	39.0	1201.7	O K
960 min Summer	101.561	1.561	39.7	1249.0	O K
1440 min Summer	101.612	1.612	40.4	1289.9	O K
2160 min Summer	101.614	1.614	40.4	1290.8	O K
2880 min Summer	101.577	1.577	39.9	1261.2	O K
4320 min Summer	101.140	1.140	36.6	911.8	O K
5760 min Summer	100.765	0.765	36.6	612.0	O K
7200 min Summer	100.432	0.432	36.6	345.9	O K
8640 min Summer	100.346	0.346	34.3	277.1	O K
10080 min Summer	100.305	0.305	30.9	244.1	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	56.524	25
30 min Summer	39.108	39
60 min Summer	27.059	68
120 min Summer	18.722	126
180 min Summer	15.093	184
240 min Summer	12.953	216
360 min Summer	10.443	284
480 min Summer	8.962	352
600 min Summer	7.960	422
720 min Summer	7.225	494
960 min Summer	6.215	634
1440 min Summer	5.027	916
2160 min Summer	4.066	1324
2880 min Summer	3.497	1736
4320 min Summer	2.454	2512
5760 min Summer	1.909	3248
7200 min Summer	1.571	3752
8640 min Summer	1.340	4416
10080 min Summer	1.171	5144

Summary of Results for 30 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	100.462	0.462	36.6	369.7	O K
30 min Winter	100.630	0.630	36.6	503.8	O K
60 min Winter	100.846	0.846	36.6	676.8	O K
120 min Winter	101.101	1.101	36.6	880.7	O K
180 min Winter	101.255	1.255	36.6	1004.0	O K
240 min Winter	101.359	1.359	37.1	1086.8	O K
360 min Winter	101.493	1.493	38.9	1194.1	O K
480 min Winter	101.586	1.586	40.1	1268.9	O K
600 min Winter	101.648	1.648	40.8	1318.1	O K
720 min Winter	101.688	1.688	41.3	1350.4	O K
960 min Winter	101.734	1.734	41.9	1387.1	O K
1440 min Winter	101.742	1.742	42.0	1393.5	O K
2160 min Winter	101.671	1.671	41.1	1336.5	O K
2880 min Winter	101.566	1.566	39.8	1252.8	O K
4320 min Winter	100.953	0.953	36.6	762.3	O K
5760 min Winter	100.378	0.378	35.8	302.2	O K
7200 min Winter	100.300	0.300	30.4	240.1	O K
8640 min Winter	100.264	0.264	26.1	211.2	O K
10080 min Winter	100.240	0.240	22.9	192.1	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	56.524	25
30 min Winter	39.108	39
60 min Winter	27.059	68
120 min Winter	18.722	124
180 min Winter	15.093	180
240 min Winter	12.953	234
360 min Winter	10.443	296
480 min Winter	8.962	374
600 min Winter	7.960	454
720 min Winter	7.225	532
960 min Winter	6.215	688
1440 min Winter	5.027	986
2160 min Winter	4.066	1416
2880 min Winter	3.497	1848
4320 min Winter	2.454	2684
5760 min Winter	1.909	3056
7200 min Winter	1.571	3688
8640 min Winter	1.340	4408
10080 min Winter	1.171	5144

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
Site Location	GB 366550 669400 NT 66550 69400
C (1km)	-0.014
D1 (1km)	0.516
D2 (1km)	0.524
D3 (1km)	0.174
E (1km)	0.236
F (1km)	2.317
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time / Area Diagram

Total Area (ha) 3.320

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.000	4-8	1.660	8-12	1.660

Model Details

Storage is Online Cover Level (m) 102.000

Tank or Pond Structure

Invert Level (m) 100.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	800.0	0.700	800.0	1.400	800.0	2.100	0.0
0.100	800.0	0.800	800.0	1.500	800.0	2.200	0.0
0.200	800.0	0.900	800.0	1.600	800.0	2.300	0.0
0.300	800.0	1.000	800.0	1.700	800.0	2.400	0.0
0.400	800.0	1.100	800.0	1.800	800.0	2.500	0.0
0.500	800.0	1.200	800.0	1.900	800.0		
0.600	800.0	1.300	800.0	2.000	800.0		

Hydro-Brake® Outflow Control

Design Head (m) 1.900 Hydro-Brake® Type Md4 Invert Level (m) 100.000
Design Flow (l/s) 43.6 Diameter (mm) 202

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.4	1.200	34.8	3.000	54.8	7.000	83.8
0.200	17.0	1.400	37.5	3.500	59.2	7.500	86.7
0.300	30.3	1.600	40.1	4.000	63.3	8.000	89.6
0.400	36.2	1.800	42.5	4.500	67.2	8.500	92.3
0.500	35.0	2.000	44.8	5.000	70.8	9.000	95.0
0.600	31.9	2.200	47.0	5.500	74.3	9.500	97.6
0.800	30.1	2.400	49.1	6.000	77.6		
1.000	32.0	2.600	51.1	6.500	80.7		