Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Outline Operational Drainage Strategy (Revision C) (Tracked)

Revision C
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Approved by:	Date:
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Glossary of Acronyms

AOD	Above Ordnance Datum
BS	British Standard
DCO	Development Consent Order
DEL	Dudgeon Extension Limited
DEP	Dudgeon Offshore Wind Farm Extension Project
EIA	Environmental Impact Assessment
ES	Environmental Statement
FoS	Factor of Safety
HDD	Horizontal Directional Drill
HVAC	High-Voltage Alternating Current
Km	Kilometre
NG	National Grid
ODS	Outline Drainage Strategy
SEL	Scira Extension Limited
SEP	Sheringham Shoal Offshore Wind Farm Extension Project

Glossary of Terms

Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
Onshore export cables	The cables which would bring electricity from the landfall to the onshore substation. 220 – 230kV.
Onshore Substation	Compound containing electrical equipment to enable connection to the National Grid.
Outline ODP	Outline Operational Drainage Plan
Order limits	The area subject to the application for development consent, including all permanent and temporary works for SEP and DEP.
Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
The Applicant	Equinor New Energy Limited

1 OUTLINE OPERATIONAL DRAINANGE STRATEGY (ONSHORE SUBSTATION)

1.1 Background

1. Equinor New Energy Limited ('the Applicant') is seeking a Development Consent Order (DCO) for the Sheringham Shoal Offshore Wind Farm Extension Project (SEP) and Dudgeon Offshore Wind Farm Extension Project (DEP) (hereafter collectively referred to as 'the Project' or 'SEP and DEP').
2. As the owners of SEP and DEP, Scira Extension Limited (SEL) and Dudgeon Extension Limited (DEL) are the named undertakers that have the benefit of the DCO. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of SEL and DEL as the undertakers of SEP and DEP.
3. The SEP and DEP wind farm sites are located in the southern North Sea, 15.8 kilometres (km) and 26.5km from the coast respectively at their closest point. SEP and DEP will be connected to the shore by offshore export cables to a landfall point at Weybourne, on the North Norfolk coast. From there onshore export cables will transport power over approximately 60km to a new high voltage alternating current (HVAC) onshore substation near the existing Norwich Main substation. The onshore substation will be constructed to accommodate the connection of both SEP and DEP to the transmission grid. A full project description is given in the Environmental Statement (ES), **Chapter 4 Project Description**~~ (document reference 6.4)~~**(Revision B)** [document reference 6.1.4].

1.2 Introduction

4. This Outline Operational Drainage Strategy (ODS) forms part of a set of documents that support the DCO application submitted by the Applicant to the Planning Inspectorate for consent to construct and operate the Project.
5. This Outline ODS is provided as part of the DCO application to define the basis of design for the operational drainage required at the onshore substation site associated with SEP and DEP.
6. A final ODS will be produced prior to construction of SEP and DEP and will be in accordance with the content of this Outline ODS and the final design of the Project. The ODS is secured by Requirement 17 of the **Draft DCO** (document reference 3.1), which states:

> *"In the event of scenario 1 or scenario 2, each of Work Nos. [15A and 15B] must not commence until a written plan for drainage during operation of the relevant work, has been submitted to and approved by the relevant planning authority, following consultation with the relevant sewerage and drainage authorities, lead local flood authority and the Environment Agency.*
>
> *In the event of scenario 3 or scenario 4, Work No. [15C] must not commence until a written plan for drainage during operation of the relevant work, has been submitted to and approved by the relevant planning authority, following consultation with the relevant sewerage and drainage authorities, lead local flood authority and the Environment Agency.*

Each operational drainage plan must accord with the principles for the relevant work set out in the outline operational drainage plan, and must include a timetable for implementation.

Each operational drainage plan must be implemented as approved"

7. This Outline ODS should be read in conjunction with the other following documents:

- Flood Risk Assessment (Appendix 18.2 to **ES Chapter 18 Water Resources and Flood Risk** (document reference 6.18)); and
- Onshore Substation Drainage Strategy (Annex 1 to the Flood Risk Assessment described above).

8. The Onshore Substation Drainage Strategy (Rev B) concluded that drainage at the onshore substation site would be managed with attenuation combined with infiltration.

9. To determine the areas where surface water can be captured and collected in the drainage system ~~I~~it has been conservatively assumed that half of the ~~total~~61,000m^2 (6.1Ha) onshore substation platform will be finished with impermeable surfacing,~~.~~ ~~A~~an area of 30,500m^2 has therefore been adopted within the calculations. Preliminary onshore substation layouts indicate the actual impermeable areas from which surface water can be collected in a drainage system will be less than 50%.

10. To provide a worst-case the longest potential access road that could be accommodated at the onshore substation site has been adopted. The impermeable area from the access road ~~surface~~ has been taken as the full length of the 6.0m wide bitumen bound running surface ~~over the full length of the road~~ from where it ties into the existing National Grid (NG) access road to the proposed onshore substation platform, on this basis an area of 4,500m^2 has been adopted within the calculations.

~~10.~~11. The total area of impermeable surfacing from 50% of the onshore substation platform (30,500m^2) and 100% of the bitumen bound road surfacing (4,500m^2) where water can be collected and discharged into a drainage system has been taken as 35,000m^2.

~~11. The bridleway midway along the access road is the highest elevation. It is anticipated water from the access road south of the bridleway will be collected in a filter drain running south along the road verge and tie into a catch pit immediately upstream of the oil separator.~~

~~12. North of the bridleway two options are possible. Option 1 collects water from the access road in a filter drain, running north along the road verge, connecting into an oil separator before passing under the existing NG access road and connecting into the existing NG substation site drainage for discharge through their outfall. Alternatively, Option 1 could have an independent outfall, which discharges into the same location as NG's existing outfall but does not require any connection into NG's existing drainage system.~~

~~13. NG's drainage system (or outfall location) would need to accommodate water drained from approximately 2,340m^2 of access road that runs north of the bridleway. As a worst-case scenario, if a 1 in 5 year storm is considered for a 5 minute period then the NG system would need to accommodate an additional 78.6 l/s and 23.5m^3 over a 5 minute period. Paved areas under 4,000m^2 can be designed using a flat rate of rainfall method to BS EN 16933-2. Refer to **Appendix B** for calculations associated with anticipated surface water run off flows/volumes for the section of access road north of the bridleway.~~

~~14. Option 2 collects water from the access road in a filter drain which runs to the south towards to the new substation drainage system; to accommodate the changes in elevation the drain will need to be laid at a deeper elevation.~~

1.3 Infiltration

1.3.1 Basis of outline design

~~15.~~12. Soakaway testing undertaken in trial pits during the Phase 1 ground investigations reported very low permeability rates which suggested an infiltration solution may not be possible.

~~16.~~13. To explore the full potential of a drainage solution by infiltration a Geophysical survey was undertaken in the onshore substation field and in surrounding fields as shown in Figure 1~~Figure 1Figure 1~~:

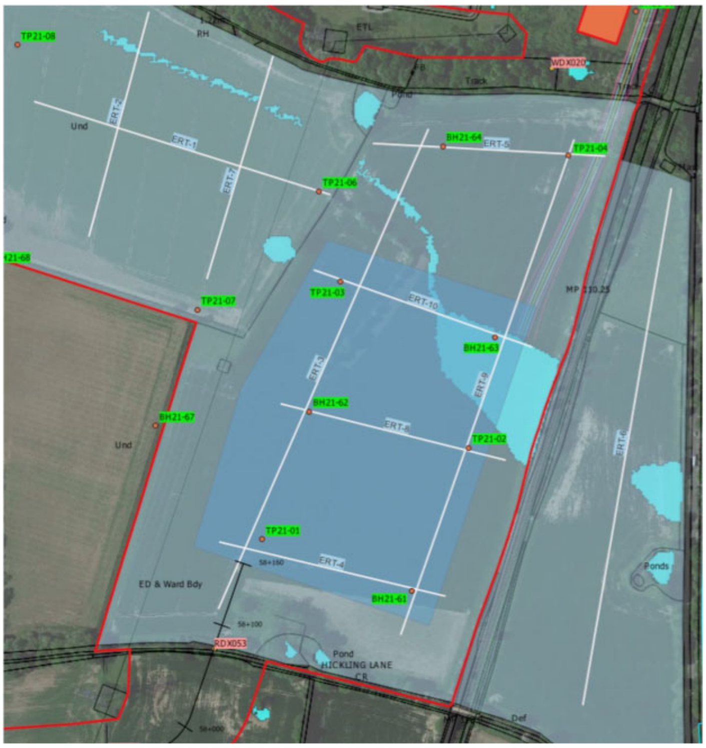

Figure 1 – Extent of Geophysical Survey

Key to Figure 1: Transparent Light Blue Shade = Electromagnetic Survey Area

White Lines = Electrical Resistivity Survey

~~17.~~14. The results of the survey identified a historic river channel that had been infilled with granular deposits to a depth of approximately 10m as shown by the brown polygon in Figure 2~~Figure 2Figure 2~~ below:

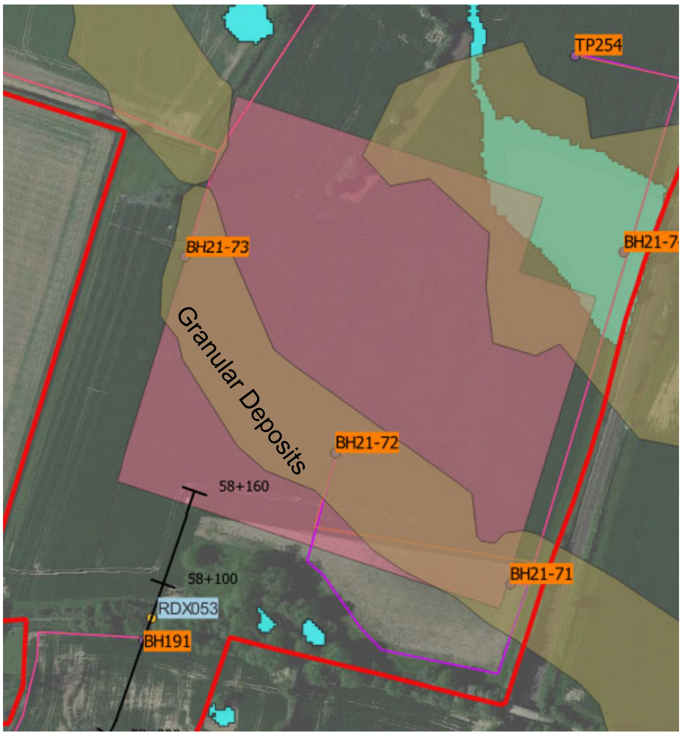

Figure 2 – Area Indicating Granular Deposits (Brown)

~~18.~~15. As part of Phase 2 ground investigation, three boreholes BH21-71, BH21-72 & BH21-73 shown in Figure 2~~Figure 2Figure 2~~ were bored to ground truth the geophysical surveys. Each borehole had a groundwater monitoring installation which monitors the granular horizon. In each borehole falling head permeability tests along with ~~-~~borehole soakaway tests in groundwater monitoring installations were undertaken to determine ground permeability and infiltration rates. The results from these tests will be used to calculate the soakaway storage volumes for the onshore substation platform.

~~19.~~16. The footprint of the onshore substation platform will be approximately 6.1Ha. Figure 3~~Figure 3Figure 3~~ below shows the footprint. It is important to note that this a conservative assessment as t~~T~~his footprint accommodates an onshore substation layout which can be orientated either north-south or east-west, as described in **Annex 18.2.2: Onshore Substation Hydraulic Modelling Report (Revision B)** [document reference 14.34].

Figure 3 – Substation Footprint

~~20.~~17. The anticipated volume of water to be managed during the 1 in 100 year storm ~~flood~~ event over the onshore substation and access road surface area has been calculated ~~using Tekla® Tedds software which is based on the methods outlined in BRE Digest 365 and the Wallingford Procedure (Volume 4). Rainfall parameters in Tedds are based on those stated in the Wallingford Procedure.~~ using FEH13 (2013) rainfall data from the FEH Web service.

~~21.~~18. A 45% allowance for climate change has been allowed and a conservative soil infiltration rate of $1x10^{-4}$ m/s has been used. ~~Actual permeability rates recorded during soakaway tests ranged from $4.84x10^{-4}$ m/s to $5.4x10^{-4}$ m/s.~~

~~22.~~19. It has been assumed that ~~50% of~~ 100% of the bitumen bound surface of the substation access road and 50% of the onshore substation platform surface area is impermeable and will accumulate water for discharge through the surface water drainage system during the storm event.

20. A soakaway design has been developed which indicates two 60m long x 15m wide x 1.6m deep soakaways with a total storage volume per soakaway of 1,368m^3 assuming 95% porosity. A t~~T~~otal storage volume 2,736m^3 at 95% porosity has been provided, as depicted on drawing C282-MU-Z-XD-00118-01_F04 included in **Appendix B**.

21. Verification calculations have been undertaken using MicroDrainage to determine if the proposed storage volume is sufficient for the worst case storm event.

22. Calculations have been undertaken in accordance with the CIRIA SuDs M~~m~~anual C753 with a factor of safety (FoS) of 5.0 adopted, which is in accordance with Table 25.2 of the CIRIA SuDS Manual C753.

23. A FoS of 5.0 has been adopted as the size of the area to be drained is in excess of 1,000m^3 and the critical infrastructure on the onshore substation platform will have additional protection measures included as standard within the design. Critical elements will either be bunded or be positioned on raised upstands ensuring any effects from a flood event will be minimal and only result in minor damage to external areas or inconvenience.

24. It is also noted that CIRIA SuDS Manual C753 suggests that care should be taken when allowing for base infiltration, especially where the infiltration rates of the surrounding strata is greater than 1 x 10^{-5} m/s as in this situation. Therefore ~~Equinor~~the Applicant commits to the inclusion and maintenance of catch pits / silt traps within the drainage system to minimise the silting of the soakaway bases. The sizing and locations of silt traps will be developed during the detailed design process.

25. ~~and a required storage volume calculated to manage surface water from the substation and access road.~~ In preparing the verification calculations it has been assumed that half of the total impermeable area (17,500m^2) will be directed to each soakaway.

26. For the worst case 480min winter storm a soakaway storage volume of 1,192.7m^3 per soakaway is indicated to be required which confirms that each soakaway shown on drawing C282-MU-Z-XD-00118-01_F04 included in **Appendix B** is oversized by 175m^3 giving a total site storage 350m^3 greater than required. ~~-~~Please refer to **Appendix A** for the MicroDrainage verification calculations~~soakaway volume calculation~~

~~23.~~27. ~~and drawing C282-MU-Z-XD-00118-01_F03 for the soakaway layout and cross section included in **Appendix C**.~~

~~24. Secondary verification of the calculations undertaken in Tekla® Tedds has been undertaken by RHDHV using MicroDrainage. Two verification scenarios have been analysed as follows:~~

~~25. Option 1 is in accordance with BRE 365 and NCC LLFA Statutory Consultee for Planning Guidance Document, Version 6.1. The results from this option are in general agreement with the Tekla® Tedds output with slight differences in the rainfall parameters. An additional total storage volume of 320m^3 above the total volume indicated by Tekla® Tedds is indicated to be required. This larger volume has been included in the design and is shown on drawing C282-MU-Z-XD-00118-01_F03.~~

~~26. Option 2 is not in compliance with BRE365 and proposes a 50% reduction in the base infiltration coefficient and a global factor of safety of 2, the results of this analysis indicate that the storage volume could be reduced to 1073m^3, an overall reduction of 352.5m^3. Following development of the substation layout and drainage maintenance plan this option will be given greater consideration at detailed design.~~

~~27. The results of the RHDHV analysis are included as **Appendix C.**~~

1.3.2 Description of solution

28. The soakaway solution works by collecting the surface water drainage in a modular crate system, buried under the onshore substation platform. The outfall drainage pipe is connected to the inlet of the soakaway crates and water is allowed to accumulate in the voids that exist within the crates. At the same time as water accumulates, it is also infiltrated into the surrounding ground as all sides of the crates are open. The crates are sized to ensure the open voids that exist within them have sufficient volume to accommodate the water that will accumulate during a 1 in 100 year storm event whilst taking consideration of infiltration rates.

29. Initial sizing of the soakaway volume is based on an assumed soil infiltration rate of $1x10^{-4}$ m/s however initial results from the site tests indicate actual permeability rates recorded during soakaway tests ranged from $4.84x10^{-4}$ m/s to $5.4x10^{-4}$m/s,~~the expected infiltration rate will be higher at a value closer to 5x10^-4 m/s,~~ which means the soakaway crate volume will be on the conservative side.~~.~~

30. Soakaway testing to BRE Digest 365 will be required once the onshore substation platform is constructed to confirm the initial results and assumptions used in the design are acceptable.

31. Pollution control will be managed by incorporating a class 1 oil separator upstream of the soakaway crate inlet. Class one separators are designed to achieve a concentration of less than 5mg/l of oil under standard test conditions and are suitable for discharging to the environment. Any water collected from car parks, access roads and hard standing areas with potential for oil contamination will be required to connect into the oil separator before flowing into the soakaway.

32. In a storm event, water collected from roof tops may bypass the oil separator and connect downstream into the next catch pit before flowing into the soakaway.

33. The platform level is 28.23m Above Ordnance Datum (AOD). The finished ground level (formation level) following any earthworks is 475mm lower at 27.775m AOD. It is anticipated that the soakaway crates will be buried with a minimum cover of 1.2m to platform level to ensure any vehicles/equipment located above do not adversely impact the structure.

34. To ensure heavy loads (from transformers etc) are not directly located above the soakaway units, they will be positioned adjacent to (and within) the site boundary limits where there is higher potential for an access road to be located once the final site layout is confirmed. To maintain the required soakaway volume and keep to the site boundary limits, the soakaway crates have been positioned on the east and west sides of the site. The drainage design within the onshore substation will ensure 50% of water collected is routed to the east soakaway and 50% to the west. A single soakaway may be possible once the onshore substation layout has ~~s have~~ been confirmed later in the Project.

35. Access will be maintained to all catch pits and silt traps located upstream of the soakaway to ensure any silt/deposits can be removed as part of a maintenance programme. Access will be maintained to the oil separator unit so routine maintenance can be performed. A detailed maintenance plan will be developed during detailed design once the drainage design is finalised. An indicative layout of the soakaway design and upstream treatment is indicated on drawing C282-MU-Z-XD-00118-01_F034, which is i. Included in **Appendix BD**.

Appendix A – MicroDrainage Onshore Drainage Solution – Hydraulic Verification Calculations ~~Soakaway Volume Calculations~~

REPORT

Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Onshore Substation Drainage Solution - Hydraulic Verification Calculations

Client: Equinor New Energy Limited

Reference: PC4239-ZZ-XX-RP-D-0001

Status: S0/P04.01

Date: 25 April 2023

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Document title:	Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects
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Reference:	PC4239-ZZ-XX-RP-D-0001
Status:	P04.01/S0
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Project name:	Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects
Project number:	PC4239
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Date / initials:	25/04/2023
Approved by:	Dean Johnson
Date / initials:	25/04/2023

Classification
Project related

Royal HaskoningDHV has undertaken a hydraulic design verification of the proposed Onshore Substation (OnSS) surface water drainage design calculations in support of Equinor New Energy Limited who are seeking a Development Consent Order (DCO) for the Sheringham Shoal (SEP) and Dudgeon (DEP) Offshore Wind Farm Extension Projects.

The design verification sought to carry out a review of the third party (J Murphy & Sons Ltd) proposed surface water drainage strategy, specifically by checking the adequacy of the proposed geocellular soakaway (infiltration) units intended for infiltrating the site surface water runoff into the underlying ground strata.

The proposed surface water drainage strategy as contained on **Drawing No. C282-MU-Z-XD-00118-01-Substation Outline Drainage Plan Infiltration Method** [APP-307] consists of a soakaway solution which involves collecting the surface water drainage in a modular crate system, to be located under the proposed OnSS platform.

The proposed surface water drainage design indicates that the outfall drainage pipe connects into the inlet of the soakaway crates and water is allowed to accumulate in the voids that exist within the crates. As water accumulates, it is infiltrated into the surrounding ground through the sides and base.

Royal HaskoningDHV, took the approach of applying 50% of the effective catchment area to the proposed geometry of each of the geocellular tanks. The effective catchment area for each of the geocellular tank is 1.75Ha. (Overall area is 3.5Ha). This provides a more accurate means of determining the actual wetted area (internal area) of the soakaway. The design verification applies to one tank, the result is exactly applicable to the second tank.

The proposed volume of each geocellular tank as proposed by **Drawing No. C282-MU-Z-XD-00118-01-Substation Outline Drainage Plan Infiltration Method** [APP-307] is approximately 1,368m^3 (i.e. total storage volume of approximately 2,736m^3). This represents the actual geometry of the tank factoring in a porosity ratio of 95%.

Norfolk County Council (NCC) LLFA Statutory Consultee for Planning Guidance Document Version 6.1, dated October 2022 has been consulted in the preparation of the design verification exercise. Section 13 Infiltration Constraints states:

'*One uncertainty for the design of infiltration systems is the infiltration rate, which may reduce over time, particularly if there is no pre-treatment or there is poor maintenance. To account for this, we expect a safety factor to be incorporated into the design, where the factor used is a judgement based on the consequence of failure of the drainage system. Table 25.2 of CIRIA SuDS Manual (C753) should be consulted and used. If the drainage system within a new development is to be offered to NCC Highways Authority to be considered for adoption, the calculations should use at least the middle column of Table 25.2. The safety factors can only be discounted if the infiltration feature is designed in accordance with BRE365 design procedure. For the avoidance of doubt, BRE365 design does not allow infiltration through the base, only the sides of the feature. This must be demonstrated in the supporting information submitted. Design of infiltration features via the SuDS Manual does allow infiltration through the base and sides of the feature and hence the extra factor of safety must be incorporated into the designs*'.

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Table 25.2 of CIRIA SuDS Manual 2015 (C753) is captured below for reference:

TABLE 25.2 Suggested factors of safety, F, for use in hydraulic design of infiltration systems (designed using Bettess (1996). Note: not relevant for BRE method)

Size of area to be drained	Consequences of failure		
	No damage or inconvenience	Minor damage to external areas or inconvenience (eg surface water on car parking)	Damage to buildings or structures, or major inconvenience (eg flooding of roads)
< 100 m^2	1.5	2	10
100–1000 m^2	1.5	3	10
> 1000 m^2	1.5	5	10

The design verification considered the storage capacity of the geocellular structure prescribed in the CIRIA SuDs Manual C753 when designing an infiltration system. This was evaluated using the MicroDrainage Source Control module. The MicroDrainage simulations check the adequacy of the proposed geometry of the tank to attenuate surface water flow during the critical rain fall period of the 1 in 100-year storm event plus 45% climate change allowance.

The MicroDrainage simulation was modified to mimic the requirements of the CIRIA methodology, specifically changing the default Source Control Factor of Safety from 2 to 5. This simulation allows infiltration over the full depth of the proposed geometry of the tank and the base, with the Factor of Safety applied to the infiltration coefficient over the internal surface area of the tank.

The factor of safety in Table 25.2 of the CIRIA C753 safeguards against the long-term performance of the base infiltration coefficient in the design of infiltration systems. The method prescribed in CIRIA C753 considers that the base area of the geocellular system contributes to the infiltration when disposing surface water runoff. It however recognises that the effect of siltation is more pronounced when the infiltration rate of the soil is high when compared with that of the silt.

This highlights the clogging effect and the negative impact on the void ratio of the surrounding strata. CIRIA C753 suggest that care should be taken when allowing for base infiltration especially in cases where infiltration rates of the surrounding strata is greater than 1 x 10^{-5} m/s, as above this the impact of silt on the performance of the infiltration system becomes more significant. This can be mitigated where silt traps/catch pits and other sedimentation structures are situated upstream of the geocellular structure. The maintenance requirement of both the geocellular structure and the silt traps can be detailed in a maintenance management schedule as prescribed by CIRIA C753.

The size of the catchment area is 1.75Ha and the consequence of failure is deemed as minor damage to the external areas, therefore the factor of safety adopted in the MicroDrainage simulation is 5

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Design Parameters:

- Total impermeable catchment area = 3.5Ha, it is assumed that each of the geocellular units receives a contribution of 50% of this total impermeable area
- Climate change allowance – 45%
- Rainfall data – Utilises FEH13 (2013) from the FEH Web Service
- Porosity ratio = 95% free volume assumed in tank
- Soil Infiltration Rate = $1x10^{-4}$m/s
- Plan area of both soakaways = 15m x 60m = 900m^2
- Depth of the soakaway = 1.6m
- Minimum depth of embedment (cover) = 1.2m
- Finished ground (cover level) = 27.775mAOD
- Side infiltration Coefficient = 1 x 10^{-4} m/s (0.36m/hr)
- Base infiltration Coefficient =. 1 x 10^{-4} m/s (0.36m/hr)
- Factor of Safety = 5 (safeguard against the long-term performance of the base infiltration coefficient in the design of infiltration systems)

The results of the hydraulic verification analysis, using the parameters highlighted above, have been provided in **Appendix 1**. The MicroDrainage simulation suggests that the proposed geometric volume of the tank is sufficient. The peak volumetric rate of infiltration with this approach is approximately 22.2l/s.

The Applicant notes that the above hydraulic verification analysis has been undertaken based on the information presented in **Document No C282-RH-Z-GA-00128 Outline Operational Drainage Strategy (onshore substation) (Revision B) [REP2-029].**

The above document is to be resubmitted to the Examining Authority with a few revisions, reflecting the Applicant's confirmation of the adoption of CIRIA C753 with FoS of 5 instead of the original BRE 365 method. The document will be resubmitted as **Outline Operational Drainage Strategy (onshore substation) (Revision C)** [document reference 9.20] and this Technical Note will be included as an appendix to it.

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APPENDIX 1

Summary of Results for 100 year Return Period (+45%)

Half Drain Time : 480 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	25.509	0.534	19.6	457.0	O K
30 min Summer	25.682	0.707	20.1	604.6	O K
60 min Summer	25.843	0.868	20.6	742.1	O K
120 min Summer	25.968	0.993	21.0	848.9	O K
180 min Summer	26.040	1.065	21.2	911.0	O K
240 min Summer	26.088	1.113	21.3	951.6	O K
360 min Summer	26.141	1.166	21.5	997.3	O K
480 min Summer	26.159	1.184	21.6	1012.6	O K
600 min Summer	26.162	1.187	21.6	1014.5	O K
720 min Summer	26.155	1.180	21.5	1008.6	O K
960 min Summer	26.124	1.149	21.4	982.7	O K
1440 min Summer	26.031	1.056	21.2	902.9	O K
2160 min Summer	25.868	0.893	20.7	763.4	O K
2880 min Summer	25.708	0.733	20.2	627.1	O K
4320 min Summer	25.435	0.460	19.4	393.0	O K
5760 min Summer	25.237	0.262	18.8	224.3	O K
7200 min Summer	25.108	0.133	18.4	113.5	O K
8640 min Summer	25.039	0.064	18.2	54.5	O K
10080 min Summer	25.022	0.047	17.0	39.8	O K
15 min Winter	25.579	0.604	19.8	516.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	153.845	0.0	48
30 min Summer	101.355	0.0	61
60 min Summer	63.293	0.0	88
120 min Summer	38.008	0.0	140
180 min Summer	28.521	0.0	194
240 min Summer	23.390	0.0	250
360 min Summer	17.823	0.0	362
480 min Summer	14.689	0.0	428
600 min Summer	12.600	0.0	492
720 min Summer	11.083	0.0	558
960 min Summer	8.983	0.0	692
1440 min Summer	6.564	0.0	966
2160 min Summer	4.705	0.0	1372
2880 min Summer	3.677	0.0	1760
4320 min Summer	2.565	0.0	2504
5760 min Summer	1.978	0.0	3184
7200 min Summer	1.612	0.0	3832
8640 min Summer	1.364	0.0	4432
10080 min Summer	1.185	0.0	5112
15 min Winter	153.845	0.0	48

Summary of Results for 100 year Return Period (+45%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	25.774	0.799	20.4	683.2	O K
60 min Winter	25.958	0.983	20.9	840.4	O K
120 min Winter	26.107	1.132	21.4	967.8	O K
180 min Winter	26.198	1.223	21.7	1045.7	O K
240 min Winter	26.261	1.286	21.9	1099.4	O K
360 min Winter	26.339	1.364	22.1	1166.6	O K
480 min Winter	26.370	1.395	22.2	1192.7	O K
600 min Winter	26.369	1.394	22.2	1191.5	O K
720 min Winter	26.357	1.382	22.1	1181.7	O K
960 min Winter	26.313	1.338	22.0	1143.9	O K
1440 min Winter	26.176	1.201	21.6	1026.4	O K
2160 min Winter	25.934	0.959	20.9	820.1	O K
2880 min Winter	25.702	0.727	20.2	621.9	O K
4320 min Winter	25.322	0.347	19.0	296.9	O K
5760 min Winter	25.081	0.106	18.3	90.3	O K
7200 min Winter	25.021	0.046	16.6	38.9	O K
8640 min Winter	25.014	0.039	14.1	33.0	O K
10080 min Winter	25.009	0.034	12.3	28.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.355	0.0	61
60 min Winter	63.293	0.0	88
120 min Winter	38.008	0.0	140
180 min Winter	28.521	0.0	196
240 min Winter	23.390	0.0	250
360 min Winter	17.823	0.0	360
480 min Winter	14.689	0.0	468
600 min Winter	12.600	0.0	560
720 min Winter	11.083	0.0	592
960 min Winter	8.983	0.0	744
1440 min Winter	6.564	0.0	1050
2160 min Winter	4.705	0.0	1480
2880 min Winter	3.677	0.0	1888
4320 min Winter	2.565	0.0	2612
5760 min Winter	1.978	0.0	3192
7200 min Winter	1.612	0.0	3672
8640 min Winter	1.364	0.0	4304
10080 min Winter	1.185	0.0	5104

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 652500 307500 TG 52500 07500
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+45

Time Area Diagram

Total Area (ha) 1.747

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	6	0.292	12	18	0.291	24	30	0.291
6	12	0.291	18	24	0.291	30	36	0.291

Model Details

Storage is Online Cover Level (m) 27.775

Cellular Storage Structure

Invert Level (m) 24.975 Safety Factor 5.0
Infiltration Coefficient Base (m/hr) 0.36000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.36000

Depth (m)	**Area (m^2)**	**Inf. Area (m^2)**	**Depth (m)**	**Area (m^2)**	**Inf. Area (m^2)**
0.000	900.0	900.0	1.601	0.0	1140.0
1.600	900.0	1140.0			

Royal HaskoningDHV is an independent, international engineering and project management consultancy with over 138 years of experience. Our professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water.

Backed by expertise and experience of 6,000 colleagues across the world, we work for public and private clients in over 140 countries. We understand the local context and deliver appropriate local solutions.

We focus on delivering added value for our clients while at the same time addressing the challenges that societies are facing. These include the growing world population and the consequences for towns and cities; the demand for clean drinking water, water security and water safety; pressures on traffic and transport; resource availability and demand for energy and waste issues facing industry.

We aim to minimise our impact on the environment by leading by example in our projects, our own business operations and by the role we see in "giving back" to society. By showing leadership in sustainable development and innovation, together with our clients, we are working to become part of the solution to a more sustainable society now and into the future.

Our head office is in the Netherlands, other principal offices are in the United Kingdom, South Africa and Indonesia. We also have established offices in Thailand, India and the Americas; and we have a long standing presence in Africa and the Middle East.

ETHIC Intelligence CERTIFICATE ANTI-CORRUPTION COMPLIANCE SYSTEM

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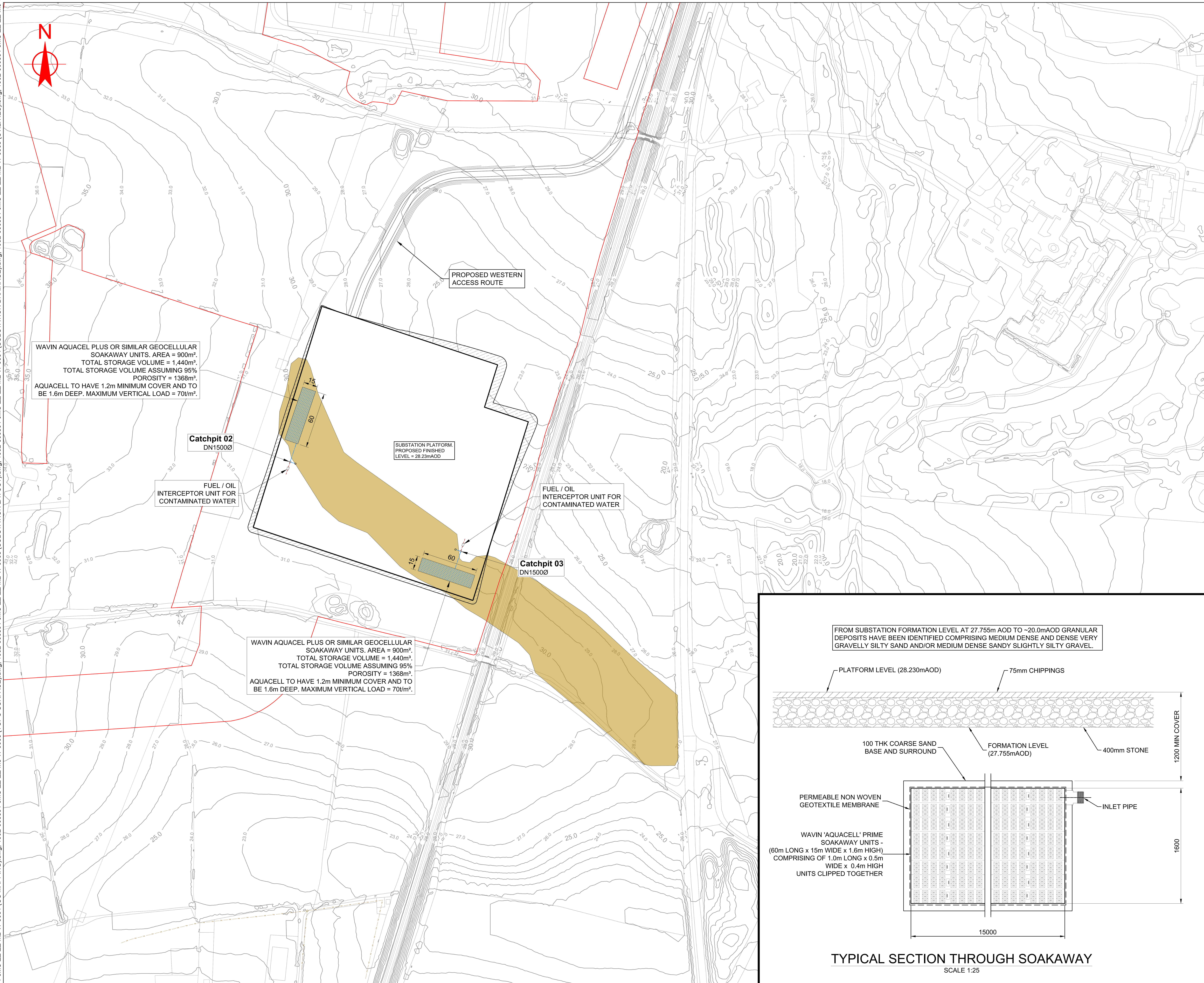
~~Appendix B – Discharge Calculations for North Section of Access Road~~

~~Appendix C – MicroDrainage Soakaway Volume Validation Calculations~~

Appendix BD – Drawings

- C282-MU-Z-XD-00118-01_F043 – Substation Outline Drainage Strategy – Infiltration Method



TYPICAL SECTION THROUGH SOAKAWAY

SCALE 1:25

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM.
3. EXISTING GROUND LEVELS ARE TAKEN FROM 2014 LiDAR SURVEY DATA.
4. RECESSED STEEL MANHOLE COVERS TO COMPLY WITH BS EN1449:1991 AND GALVANISED TO COMPLY WITH BS EN ISO 1461.
5. ALL BELOW GROUND PIPEWORK TO BE Ø225 NOMINAL SIZE POLYPIPE 'POLYSEWER' TO WIS 4-35-01. TO BE INSTALLED IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.
6. FUEL / OIL INTERCEPTOR TO BE OPERATED AND MAINTAINED IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.
7. SOAKAWAY UNIT LOCATIONS ARE INDICATIVE AND WILL BE CONFIRMED IN CONJUNCTION WITH THE FINAL SUBSTATION LAYOUTS AT DETAILED DESIGN.

LEGEND:

- PROPOSED SURFACE WATER PIPEWORK
- PROPOSED SURFACE WATER MANHOLE
- PROPOSED FUEL / OIL PIPEWORK
- PROPOSED FUEL / OIL INTERCEPTOR
- PROPOSED GEOCELLULAR SOAKAWAY UNIT
- EXISTING GRANULAR SOILS
- PROPOSED CUT
- PROPOSED FILL
- DCO BOUNDARY

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equinor

0 50 100 1:2000 200m

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
F04	A.LISIKOW	M.PERKINS	J.CURRAN	26/04/23	MINOR CHANGES TO SOAKAWAY VOLUME TEXT
F03	S.LYONS	M.PERKINS	J.CURRAN	28/02/23	SOAKAWAY AREA INCREASED IN LINE WITH MICRODRAINAGE VALIDATION
F02	L.EDGE	M.PERKINS	J.CURRAN	27/07/22	SOAKAWAY DETAILS ADDED
F01	S.LYONS	M.PERKINS	J.CURRAN	01/07/22	ISSUED FOR INFORMATION

Project:	SHERINGHAM SHOAL & DUDGEON WINDFARM ONSHORE CABLE FEED
Revision:	F04
Dwg Title:	SUBSTATION OUTLINE DRAINAGE STRATEGY INFILTRATION METHOD
Suitability:	-
Scale @ A1:	1:2000
Dwg No:	C282-MU-Z-XD-00118-01
Sheets:	1 OF 1
Purpose of Issue:	FOR INFORMATION
Internal Proj.Ref:	1002-000591
Client Ref Number:	-