Berwick Bank Windfarm

Technical Appendix 11.2: Drainage Strategy Report

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01	2022-03-04	S.Donnan	Z.Ritchie	Z.Ritchie	Draft Issue
02	2022-03-24	S.Donnan	Z.Ritchie	Z.Ritchie	Draft Issue following internal review

Contents

Document References

Tables

Figures

Drawings

Drawing DRA-001: Drainage Overview

Drawing DRA-002: Drainage Design

Drawing DRA-003: Drainage Details

Drawing TDW-000: Temporary Drainage Works – Overview

Drawings TDW-001-TDW-009: Temporary Drainage Works – Sheets 1 to 9

Appendices

Appendix A: Innerwick Burn Catchment Assessment

Appendix B: MicroDrainage SourceControl Modelling Extracts

1. Introduction

1.1 Context

ITPEnergised (ITP) has been appointed by SSE Renewables (The Client) to provide support and input to the onshore component of the Environmental Impact Assessment Report (EIAR) submission to support a planning application for Berwick Bank Windfarm.

This Drainage Strategy Report has been prepared as Technical Appendix 11.2 to Chapter 11: Geology, Hydrology, Soils & Flood Risk within the onshore EIAR.

This report summarises the proposed permanent and temporary drainage strategy for both surface water and foul water and the assessment of increased surface water runoff in accordance with sustainable drainage principles. Underlying this assessment is the need to ensure there are no material impacts to offsite receptors and no deterioration of the water environment.

This report takes due cognisance of local / national drainage design guidance, CIRIA Report C753[1], East Lothian SuDS guidance[2] and various SEPA technical guidance documents where appropriate.

The Site has been visited by an experienced ITP Hydrologist and Civil Engineer on several occasions between 2020 and 2022 to inform this assessment.

1.2 Site Location

The site is situated near Torness and the village of Innerwick, south-east of Dunbar located in East Lothian. The centre of the site is OSGB36, British National Grid (BNG) 373977, 674114 and is approximately 598 ha in size.

The extent of the site runs from the settlement of Branxton in the south, Bilsdean in the south-east, the coastline at Skateraw and Torness in the north, Oxwell Mains Cement Works and Quarry in the north-west and Fouracres in the west. The land on which the site is located is predominantly agricultural land with sparse settlements spread throughout, connected by small local roads and tracks. The A1 trunk road and East Coast Main Line (ECML) railway cut through the site in a north-west to south-east direction running parallel to the coast. Torness Power Station (Nuclear) is located to the south-east of the proposed landfall at Skateraw.

1.3 Proposed Onshore Development

The Onshore Transmission Works (OnTW) shall include the following:

- a new onshore substation;
- one landfall location;
- onshore cables within a cable corridor between the landfall and the new onshore substation, and between the new onshore substation and the SPEN Branxton substation; and
- associated ancillary infrastructure.

The Branxton substation is being developed by SPEN and is subject to a separate planning application.

[1] CIRIA (2015) The SuDS Manual, Report C753
[2] East Lothian Council (2018) LDP 2018, Sustainable Drainage Systems, Supplementary Planning Guidance

1.4 Topography

Ground levels within the site vary due to the scale of the site and the sloping topography towards the coastline. The highest elevations within the site are approximately 120mAOD around the location of the proposed SPEN Branxton substation whilst the lowest elevations are at sea level along the coastline. The topography across the site generally falls in a north-easterly direction.

2. Proposed Surface Water Drainage Strategy

2.1 Sustainable Drainage Systems (SuDS)

To satisfy the requirements of current best national / local flood risk and surface water management guidance, SuDS are required to be incorporated into the design proposals to manage, attenuate and treat surface water runoff before discharging from the site.

Current best practice guidance relating to sustainable surface water management is outlined in the SuDS Manual (CIRIA Report C753) which provides details on the use of SuDS for managing surface water runoff.

There are four main categories of SuDS which are referred to as the 'four pillars of SuDS design' as depicted in Figure 1 below.

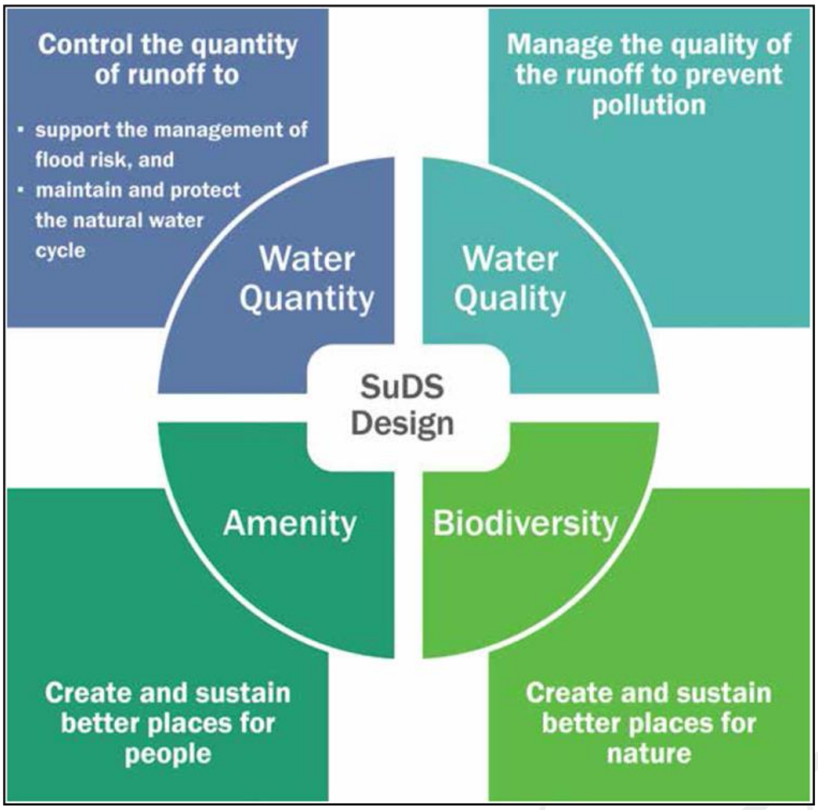


Figure 1 Four Pillars of SuDS (CIRIA Report C753)

The SuDS Manual identifies a hierarchy of SuDS for managing runoff, which is commonly referred to as a ‘management train’ as depicted in **Error! Reference source not found.**.

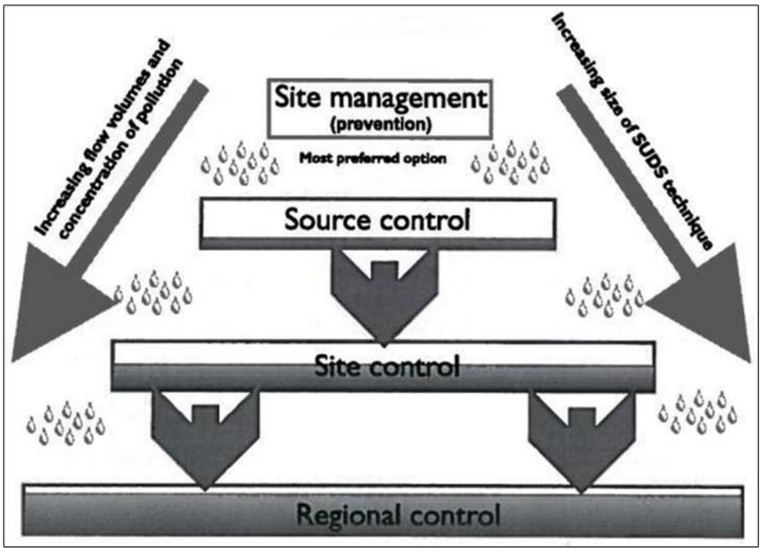


Figure 2 SuDS Management Train

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

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 providing biodiversity and wildlife habitat enhancements; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

2.2 Proposed Permanent Surface Water Drainage Strategy

2.2.1 Overview

The proposed permanent surface water drainage strategy for the Proposed Development will comprise the management of surface water runoff from the onshore substation platform and associated cut embankments and intercepted surface water from the catchment upgradient of the substation via underground pipework and cut-off ditches. These drained areas will be routed to a SuDS pond that will provide adequate treatment and attenuation of the runoff prior to discharge. The proposed discharge is via a piped outfall to the unnamed watercourse (referred to as the Innerwick Burn) directly upstream from a culvert passing under the A1. Drawings DRA-001, DRA-002, DRA-003 enclosed provide further details on the proposed permanent drainage strategy.

Normally, upgradient undeveloped areas would not be collected and attenuated within the SuDS system but instead by routed around the development and discharged in a similar fashion to the pre-development regime. The purpose of routing these upgradient areas through proposed SuDS pond and providing attenuation is to mitigate a known pre-existing localised flooding issue to the northeast of the substation location. This north eastern corner is low lying, does not drain to the Innerwick Burn and is bounded by to the north by the A1 and railways, preventing any natural runoff towards the coastline. An existing drainage system is present near to the Railway Cottage property which drains this low lying area and conveys the flows to east. The drainage system is unsuitably sized to manage the overland runoff from the fields to the south and thus the low lying area regularly floods. The proposed drainage strategy shall reduce the total catchment area draining to this location and thus reduce the existing flood risk.

It is noted that the drained areas attenuated through the SuDS pond and discharged to the Innerwick Burn does not all currently drain to the watercourse. A separate assessment was prepared for East Lothian Council to demonstrate that this increase in catchment area to the watercourse will not increase the risk of downstream flooding, and this assessment is included as Appendix A.

The remaining onshore infrastructure comprises the landfall location and onshore cable route. Once constructed and in operation, this infrastructure will be buried and therefore does not require permanent drainage.

2.2.2 Design Criteria

2.2.2.1 Proposed Surface Water Discharge Location(s)

In accordance with CIRIA Report C753, the hierarchy for favoured disposal options of permanent surface water runoff from development sites is as follows:

1. Infiltration to Ground;
2. Discharge to Surface Waters; or
3. Discharge to Sewer.

Table 1 below discusses the disposal method suitability in the context of the site and proposed development.

Table 1 Suitability of Surface Water Disposal Methods

Surface Water Disposal Method	Suitability Description	Method Suitable? (Y/N)
Infiltration to Ground	The results of the Ground Investigation indicates the substation site is underlain by superficial material comprising clays and silts, indicating infiltration would not	N

Surface Water Disposal Method	Suitability Description	Method Suitable? (Y/N)
	be a viable option. Soakaway testing undertaken during the GI campaign confirmed that discharge to ground is not viable (soakaway tests were abandoned due to negligible infiltration)	
Surface Water Discharge	The Innerwick Burn flows from west to east immediately to the north of the proposed substation location.	Y
Sewer Discharge	There are no public sewers with the vicinity of the site due to its rural setting	N

Taking the above into account it is proposed that surface water runoff from the developed site is disposed of via the Innerwick Burn through attenuated discharge. This mimics the existing hydrological regime at site albeit in a more formalised manner.

2.2.1 Water Quantity

2.2.1.1 Pre-Development Greenfield Runoff Rates

Greenfield runoff rates have been estimated through application of methodology outline in IH R124[3] (1994) as set out within the Interim Code of Practice (ICP) for catchment areas of 50ha or less.

The IH R124 method can be used to estimate Greenfield runoff release rates for a range of Annual Exceedance Probability (AEP) events, or return periods, by applying regional growth curve factors to the mean annual peak runoff (i.e. Qbar). The UK hydrological region for the East Lothian area is Region 2, therefore the appropriate growth curve factors for this region have been incorporated into the analysis undertaken in the MicroDrainage (2020) software suite[4].

Greenfield runoff modelling results are presented below in Table 2 for a range of AEP storm events.

Table 2 Estimation of the Greenfield (Pre-Development) Rate of Runoff

AEP (%)	Return Period (1 in X Years)	Unit Greenfield Runoff Rate (l/s/ha)
50	2	2.97
QBAR		3.25
3.3	30	6.16
1	100	8.55
0.5	200	9.68
0.1	1000	12.51

2.2.1.2 Post-Development Discharge Rates

Current best practice for surface water management and SuDS Design (CIRIA Report C753) states the following with respect to the control of post development 'Peak Runoff Rates' and 'Runoff Volume' from 'greenfield' sites:

[3] Institute of Hydrology Report No.124 (1994) (IH R124), Flood estimation for small catchments, June 1994
[4] MicroDrainage (2020), Innovyze Drainage Design and Modelling Software (Version 2020.1)

SuDS Manual (CIRIA Report C753) – Section 24.10.1:

"Additional runoff volumes from developments can cause increases in flood risk downstream of the site, even where peak flows from the site are controlled to greenfield rates.

Therefore, for extreme events, in addition to the standard for controlling the peak rate of runoff, there is also a standard that requires runoff volume control for the 1:200 year, 6 hour event. This is particularly critical for catchments that are susceptible to flooding downstream of the proposed development.

The difference in runoff volume between the development state and the equivalent greenfield (or possibly pre-development state where this is considered to be acceptable) is termed the Long-Term Storage Volume. It is this volume that should be prevented from leaving the site (via rainwater harvesting and/or infiltration) or, where this is not possible, controlled so that it discharges at very low rates that will have negligible impact on downstream flood risk. Only the greenfield (or pre-developed) runoff volume should be allowed to discharge at greenfield (or pre-developed) rates.

Where there is extra volume generated by the development that has to be discharged (because there are no opportunities for it to be infiltrated and/or used on site), this volume should be released at a very low rate (e.g. <2/l/s/ha or as agreed with the local drainage approving body and/or environmental regulator) and the 1:200 year greenfield allowable runoff rate reduced to take account of this extra discharge (Kellagher, 2002).

An alternative approach to managing the extra runoff volumes from extreme events separately from the main drainage system is to release all runoff (above the 1 year event) from the site at a maximum rate of 2 l/s/ha or Q_{BAR}, whichever is the higher value (or as agreed with the drainage approving body and/or environmental regulator). This avoids the need to undertake more detailed calculations and modelling.

Kellagher (2002) demonstrates that if discharges are not limited to less than 3 l/s/ha, the drainage system will generally not be effective at retaining sufficient water on the site to prevent an increase in flood risk in the receiving catchment. A discharge limit of 2 l/s/ha (or Q_{BAR}, which allows for higher discharge rates for specific soil types) has generally been accepted as an appropriate industry standard in the UK, unless alternative site or catchment specific limits are agreed based on local risk evaluation."

Note: as per SPP and surface water management design in Scotland, reference to the 1:100-year event in the above extract is replaced with 1:200-year event.

Therefore, taking the above into account it is proposed to limit surface water discharge from the Proposed Development area to the mean annual peak flood (i.e. Qbar) rate of runoff thus controlling the 'peak' discharge and discharge volume for all storm events up to and including the design 1:200-year plus climate change event.

The above design criteria adopted from CIRIA Report C753 is considered to be robust and satisfies all regulatory requirements in terms of sustainable water management and ensuring there is no increase in flood risk offsite as a result of the Proposed Development.

Determination of the contributing post-development drained areas to be managed by the SuDS system prior to discharge is detailed in Table 3 below.

Table 3 Post-Development Drained Areas Summary

Catchment	Area (ha)	Runoff Coefficient	Effective Impermeable Area (ha)	Notes
Substation Platform and Cut Embankments	12.72	0.75	9.54	• Area measured from 3D design of substation earthworks platform • Runoff Coefficient determined from reference to industry best practice
Upgradient Catchment	11.26	0.47	5.29	• Area determined from catchment analysis of upgradient areas using site-specific topographic survey information • Runoff Coefficient determined from reference to industry best practice and assessment of average slopes and assumption the upgradient land (within SSE-R ownership) will be grass-seeded post construction
Total	**23.98**	-	**14.83**	-

With reference to Table 2 the Qbar 'Unit Greenfield Runoff Rate' has been estimated to be **3.25 l/s/ha**. Multiplying this unit value by the total drained catchment area (**23.98 ha**) provides the limiting post development peak runoff rate of **77.9 l/s** for all storm events up to and including the design 0.5% AEP plus a 35% climate change allowance.

2.2.2 Water Quality Design Criteria

In accordance with CIRIA Report C753 it is necessary to undertake a 'Water Quality Risk Management' assessment to determine the suitability of SuDS methods from a water quality perspective. The approach outlined below is based on the 'Simple Index Approach' for groundwater and surface water as detailed in the SuDS Manual (Section 26.7).

Table 4 below compares the SuDS Mitigation Indices against the Pollution Hazard Indices for the Proposed Development. This is based on the application of a SuDS pond as the proposed strategy to treat post-development runoff.

Table 4 SuDS Water Quality Design Criteria: Index Approach Review

Land Use	Pollution Hazard and SuDS Mitigation Indices Comparison					
	Total Suspended Solids (TSS)		Metals		Hydro-Carbons	
	Pollution Index	Mitigation Index	Pollution Index	Mitigation Index	Pollution Index	Mitigation Index
Substation[1]	0.7	**0.7**	0.6	**0.7**	0.7	**0.5**

Note: [1] Pollution Hazard Level 'Medium' based on Table 26.2 (C753)

The SuDS Mitigation Index offered by the proposed SuDS is ≥ Pollution Hazard Index for both Total Suspended Solids and Metals. The internal substation drainage will include fuel interceptors prior to discharge from the substation (upstream of the SuDS pond) thus ensuring the Mitigation for Hydro-Carbons is satisfied.

Therefore, the water quality assessment criteria are considered to be satisfied.

2.2.3 SuDS Outline Performance Analysis

The proposed SuDS pond has been modelled within the industry standard MicroDrainage Source Control software to demonstrate the layout and provisional design details are sufficiently sized and that a viable SuDS scheme is feasible within the proposed site layout. The key design parameters for the proposed SuDS pond are detailed in Table 5 5 below.

Table 5 SuDS Pond Summary Design Details

Parameter	Unit	Value	*Notes*
Total pond depth	m	2.0	*From base to functional crest*
Permanent water depth	m	0.5	*From base to permanent water level*
Functional pond depth	m	1.5	*From permanent water level to crest*
Crest level	mAOD	36.0	*From AutoCad 3D Design*
Base level	mAOD	34.0	*From AutoCad 3D Design*
Outlet level	mAOD	34.5	*From AutoCad 3D Design*
Limiting discharge rate	l/s	77.9	*To be provided by Hydrobrake Optimum unit or similar approved*
Crest area	m^2	9303	*From AutoCad 3D Design*
Area at functional base	m^2	7570	*From AutoCad 3D Design*

Using the above design details the SuDS Pond has been modelled using the MicroDrainage software suite and the results are presented in Table 6 below and full modelling extracts are included as Appendix B.

Table 6 Hydraulic Modelling Performance of Provisional SuDS Pond Design

Annual Probability (%)	Max. Water Depth (above perm. water level) (m)	Freeboard Allowance (mm)	Max Outflow Rate (l/s)	Maximum Stored Volume (m^3)
100	0.348	1152	40.9	2572.3
50	0.418	1082	41.6	3103.7
20	0.501	999	45.4	3746.8
10	0.574	926	48.4	4319.0
3.3	0.712	788	53.7	5403.4
1	0.897	603	60.0	6898.5
0.5	1.022	478	64.0	7936.1
0.5 +35%CC	1.410	90	74.7	11248.0

2.2.4 Exceedance Flow Considerations

The SuDS pond will be designed to provide an exceedance flow route for storm events larger than the design event of 0.5% AEP plus a 35% climate change allowance. The SuDS pond will include a downgradient notch within the functional crest and fill embankment to enable any overflow from exceedance events do not simply overtop the structure. Overflows will be conveyed to the Innerwick Burn via a preferential flow route in the form of a discrete, shallow grassed overflow channel that will follow the alignment of the outlet pipe.

2.3 Proposed Temporary Surface Water Drainage Strategy

2.3.1 Overview

Temporary construction drainage has been proposed for all elements of the Proposed Development and associated ancillary infrastructure.

In the vicinity of the onshore substation, it is proposed that an arrangement similar to the permanent drainage solution is implemented at as early a stage of the construction programme as possible, to enable what will eventually be the permanent SuDS pond to be used for temporary drainage and to control silt-laden runoff. Silt fencing and cut-off ditches (fitted with check dams) are proposed at the toe of the platform fill embankments, with flows collected and routed to appropriately sized settlement ponds.

A similar approach is proposed at the various construction and HDD compounds, with runoff intercepted using subsurface herringbone systems discharging to construction drainage ditches (fitted with check dams) and routed to settlement ponds. Should additional areas be used for laydown or material storage / stockpiles, further silt fences downstream of these areas are proposed, with cut-off ditches to direct flows to settlement ponds.

The outflows of settlement lagoons will be discharged to watercourses where available in the vicinity or to level spreaders to disperse the flow overland as per the pre-development hydrological regime where a watercourse is not located nearby.

Typical temporary drainage details have also been provided for managing runoff from stockpiles, haul roads, access and the general cable corridor. Construction drainage for the areas will include silt fencing, cut-off ditches (fitted with checks dams) and settlement ponds.

Full details of the proposed temporary drainage strategy are shown in drawings TDW-000 to TDW-009.

The temporary drainage mitigation measures proposed are not final nor exhaustive. Other alternative measures may be implemented to achieve similar objectives and this would be at the discretion of the appointed Principal Designer / Contractor at the post planning stages.

2.3.2 Design Criteria

The temporary drainage design outlined in the subsequent section and relevant drawings have been prepared to an outline detail for the full Proposed Development. Detailed design will be undertaken at the post planning stage and should be designed in accordance with the following key guidance documents:

- SEPA (2021) Water run-off from construction sites (WAT-SG-75)
- CIRIA (2001) Control of water pollution from construction sites (C532)
- CIRIA (2006) Control of water pollution from linear construction projects (C648/C649)

The outline designs provided at this stage have been undertaken in reference to the above documents.

3. Foul Water Drainage Scheme

With reference SEPA's Regulatory Method for Indirect Sewage Discharges to Groundwater[5], SEPA's order of preference for means of discharge are:

- Connect to public sewer
- Discharge to land
- Discharge to watercourse

Connection to a public sewer is not viable due to the distance and elevation difference between the wastewater generation facilities within the site (i.e. the substation) and the closest sewer. Discharge to land generally requires a percolation value (V_p) between 15 and 100 secs/mm. The results of the ground investigation indicated poor infiltration capacity of the underlying material, suggesting that V_P values are likely to be >140 secs/mm; therefore, the following SEPA guidance applies:

> ***"If the Vp value is:***
> - ***>140 secs/mm Consider other disposal options including appropriately treated effluent to surface waters (normally via a partial soakaway) or for a discharge to land, a filtration system or construction of a mound soakawa in accordance with the aforementioned Technical Handbook."***

Discharge to land is therefore viable ensuring the above guidance is adhered to and the proposed secondary treatment to meet the above guidance is discussed below.

The Proposed Development will likely accommodate 1-2 persons visiting per day. However, in the event of maintenance being undertaken there may be up to 20 visitors in total. In order to provide a conservative design, the foul drainage design has been sized to accommodate a P.E. of 15.

Primary treatment of the foul flows is to be provided by a private packaged sewage treatment plant (Klargester Biodisc or similar approved).

In order to provide secondary treatment of the foul flows, a filter mound is proposed. This has been designed in accordance with BRE 478[6] and a summary of the filter mound parameters is included in Table 7 below.

Table 7 Summary of Filter Mound Parameters

Parameter	Units	Value	*Notes*
Population Equivalent (p.e.)	No. persons	15	*Calculated based on data provided by SSE and reference to SEPA's guidelines*
Filter Material Percolation Rate (Vf)	s/mm	45	*Taken from BRE 478: Filter Mound Design*
Native Soil Percolation Rate (Vp)	s/mm	>140	*Approximated, given material encountered during GI and negligible infiltration during soakaway testing*
Minimum Distribution Area	m^2	168	*= p.e. x Vf x 0.25*

[5] SEPA, Regulatory Method (WAT-RM-04): Indirect Sewage Discharges to Groundwater (2017)
[6] *BRE 478: Mound Filter Systems for the Treatment of Domestic Wastewater (2008)*

Parameter	Units	Value	*Notes*
No. Infiltration Pipes	-	5	-
Infiltration Pipe Diameter	mm	100	*80mm is the minimum diameter for gravity fed system*
Infiltration Pipe Spacing	m	1.50	
Distribution Layer Width [A]	m	7	*Includes 100mm cover at each end pipe*
Distribution Layer Length [B]	m	24	-
Gravel Depth [F]	mm	300	*Depth of gravel in the distribution layer*
Depth of Filter Material [D]	mm	700	*Minimum depth for level base application*
Cap Depth at Edge of Distribution Layer [G]	mm	300	*Minimum allowable depth*
Cap Depth at Centre of Distribution Layer [H]	mm	450	*Minimum allowable depth for raised top*
Upslope Taper [J]	m	3.90	*= (D+F+G) x 3:1 slope*
Downslope Taper [C]	m	3.90	*Same calculation as [J] for level application*
Sideslope Taper [K]	m	4.35	*= (D+F+H) x 3:1 slope*
Mound Length [L]	m	32.7	*= B + 2K*
Mound Width [W]	m	14.8	*= J + A + C*
Mound Base Area	m^2	484.0	*= L x W*

It is noted that BR478 design methodology is for domestic applications. As such the population equivalent used within the design calculations and to inform filter mound sizing assumes a larger daily loading per person than would be expected for maintenance workers on a substation site. Therefore the proposed filter mound dimensions calculated provides a conservative design.

Details of the proposed foul drainage strategy and filter mound details are presented as Drawing DRA-002 and Drawing DRA-003 respectively.

4. Conclusions

ITPEnergised (ITP) has been appointed by SSE Renewables (The Client) to provide support and input to the onshore component of the Environmental Impact Assessment Report (EIAR) submission to support a planning application for Berwick Bank Offshore Windfarm.

This report provides the relevant design information relating to the permanent surface water and foul water drainage of the proposed substation including details of the proposed Sustainable Drainage Systems (SuDS) and also includes details of temporary construction drainage for the full Proposed Development.

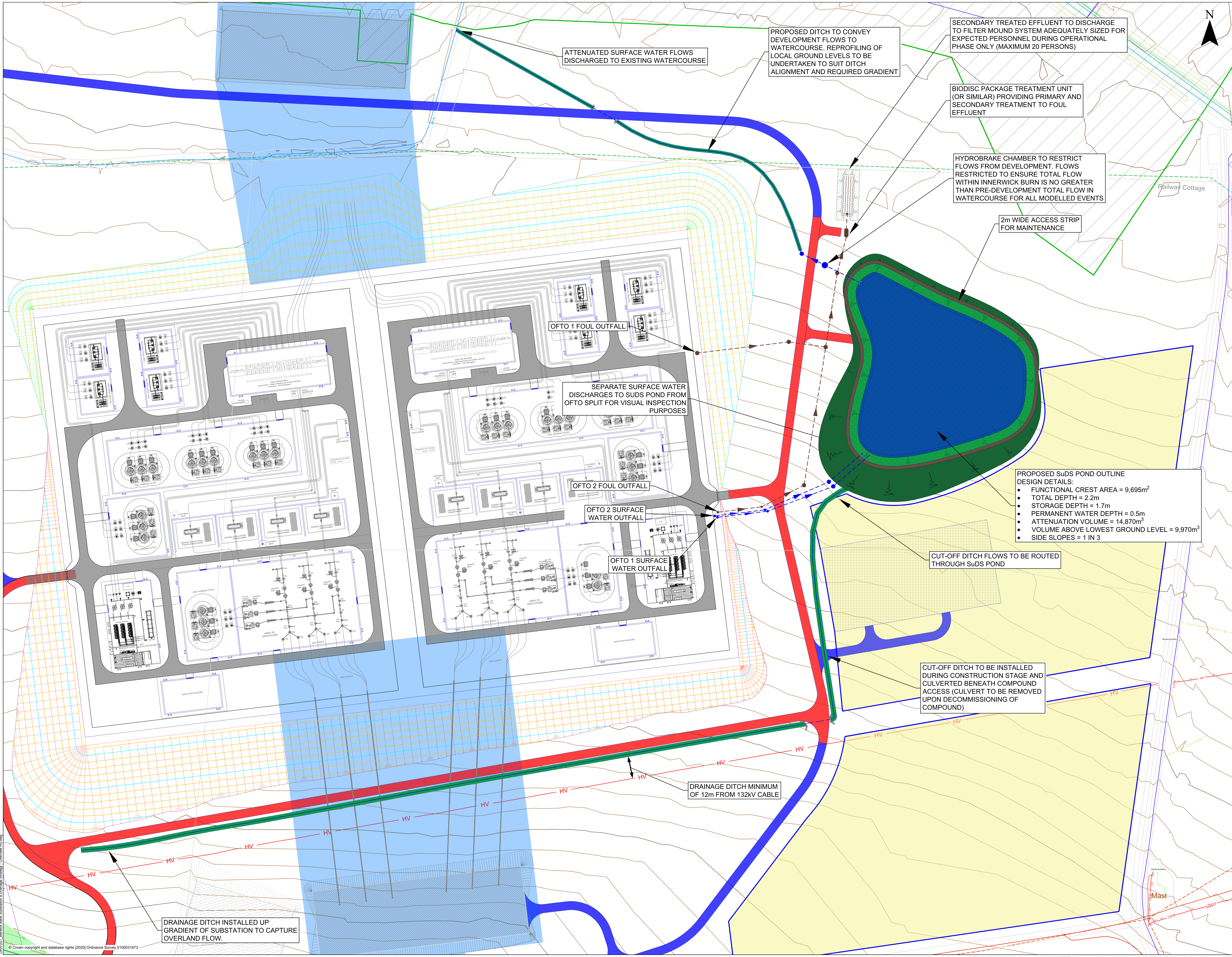
The proposed permanent surface water drainage strategy presented within this report demonstrates that adequate SuDS space provision is afforded within the design and the scheme is feasible and compliant to appropriate best practice and regulatory requirements.

Outline temporary drainage mitigation measures for the construction phase have been presented within the report and associated supporting drawings.

The proposed foul water drainage strategy presented indicates that foul water arisings from the Proposed Development can be discharged safely to ground via a mound soakaway and secondary treatment provision.

Taking all of the above into account it is considered there is no impediment to the development being granted planning permission on the grounds of surface water and foul water drainage provision.

Drawings



NOTES

1. DRAWINGS PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.
2. SuDS POND DESIGNED IN ACCORDANCE WITH CIRIA SuDS MANUAL C753.
3. REFER TO DRAWING 002 FOR SUBSTATION 8 DRAINAGE STRATEGY DESIGN AND DRAWING 003 FOR TYPICAL DRAINAGE DETAILS.
4. SuDS POND SLOPES DESIGNED AT 1 IN 3.
5. PERIMETER ACCESS STRIP OF 2m WIDTH PROVIDED AROUND SuDS TO ALLOW FOR MAINTENANCE ACCESS.
6. DRAINAGE DETAILS SHOWN ARE OUTLINE DETAIL AND SUBJECT TO REFINEMENT.
7. SEPARATE INTERNAL DRAINAGE OUTFALLS FOR BOTH SURFACE AND FOUL WATER HAVE BEEN PROPOSED FOR INDIVIDUAL OFFSHORE TRANSMISSIONS OWNERS OF THE SUBSTATION (OFTO 1 AND OFTO 2).

LEGEND

- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- PROPOSED SURFACE WATER PIPE
- PROPOSED SURFACE WATER MANHOLE
- PROPOSED SURFACE WATER HYDROBRAKE CHAMBER
- PROPOSED SURFACE WATER CUT-OFF DITCH
- PROPOSED SURFACE WATER HEADWALL
- PROPOSED FOUL WATER PIPE
- PROPOSED FOUL WATER MANHOLE
- PROPOSED FOUL WATER PACKAGE TREATMENT SYSTEM
- PROPOSED FOUL WATER FILTER MOUND
- PERMANENT ACCESS ROAD
- TEMPORARY ACCESS ROAD
- CABLE CORRIDOR
- 132kV CABLE

REV	DATE	DESCRIPTION	BY	CHK
05	06/22	UPDATED SUDS POND DESIGN	SD	ZR
04	02/22	SUBSTATION EXTENSION AMENDMENTS	SD	ZR
03	02/22	UPDATES TO INTERNAL DRAINAGE	SD	ZR
02	11/21	SUBSTATION EXTENSION	SD	KI
01	10/21	SUBSTATION RELOCATION	SD	KI
00	03/21	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
SUBSTATION 8 DRAINAGE STRATEGY OVERVIEW

SCALE: 1:1,000 (PLAN) @ A1

DATE: JUNE 2022

DRAWING NUMBER: **DRA-001**

REV: **05**

DRAWING STATUS: DRAFT ISSUE

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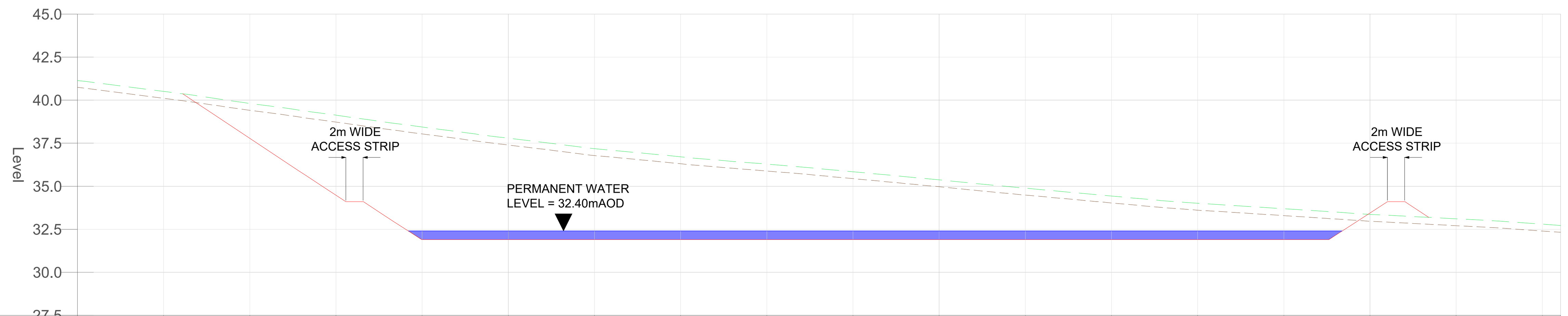
Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
SuDS Pond	1.000	1.000	13909.434sq.m	33144.622 Cu. M.	1325.258 Cu. M.	31819.365 Cu. M.<Cut>
Topsoil Strip Volume	1.000	1.000	13909.434sq.m	5563.773 Cu. M.	0.000 Cu. M.	5563.773 Cu. M.<Cut>

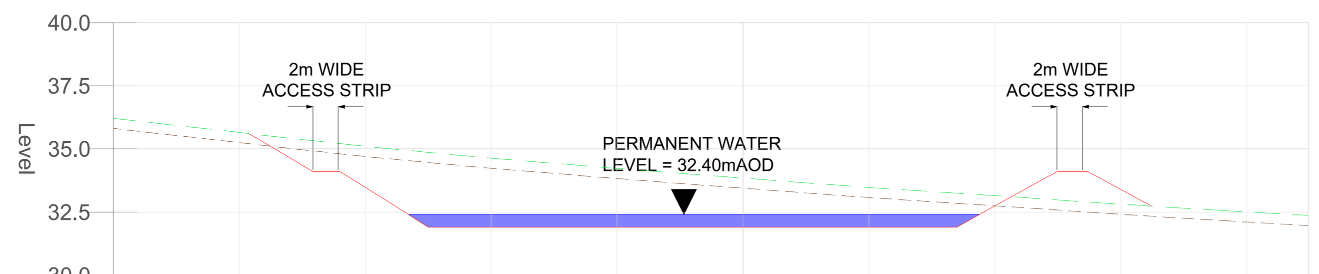
Chainage	00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	167.85
Existing Ground Levels	38.689	38.261	37.823	37.381	36.923	36.431	35.935	35.435	35.041	34.718	34.455	34.189	33.942	33.716	33.508	33.288	33.086	32.952
Topsoil Stripped Levels	38.289	37.861	37.423	36.981	36.523	36.031	35.535	35.035	34.641	34.318	34.055	33.789	33.542	33.316	33.108	32.888	32.686	32.552
Proposed Levels		38.269	34.998	32.462	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	33.637	33.154	

SUBSTATION 8 SUDS POND - SECTION A-A' - LONGSECTION
Scale: H 1:500,V 1:250. Datum: 27.500



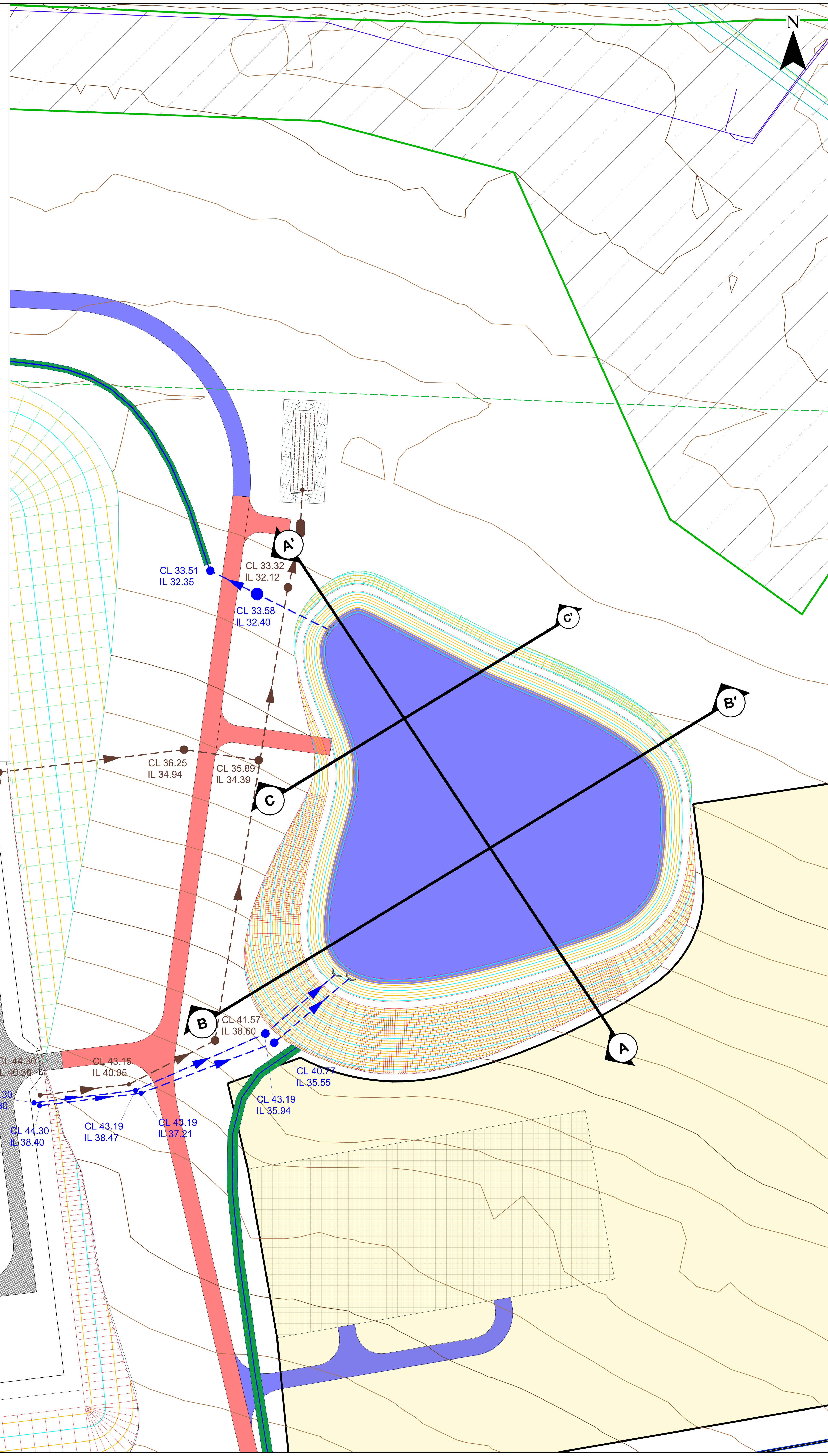
Chainage	00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	172.11
Existing Ground Levels	41.141	40.510	39.814	39.129	38.442	37.794	37.185	36.709	36.285	35.842	35.371	34.889	34.432	34.011	33.695	33.367	33.110	32.798	32.723
Topsoil Stripped Levels	40.741	40.110	39.414	38.729	38.042	37.394	36.785	36.309	35.885	35.442	34.971	34.489	34.032	33.611	33.295	32.967	32.710	32.398	32.323
Proposed Levels		40.370	37.783	34.479	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	31.900	33.447	33.193		

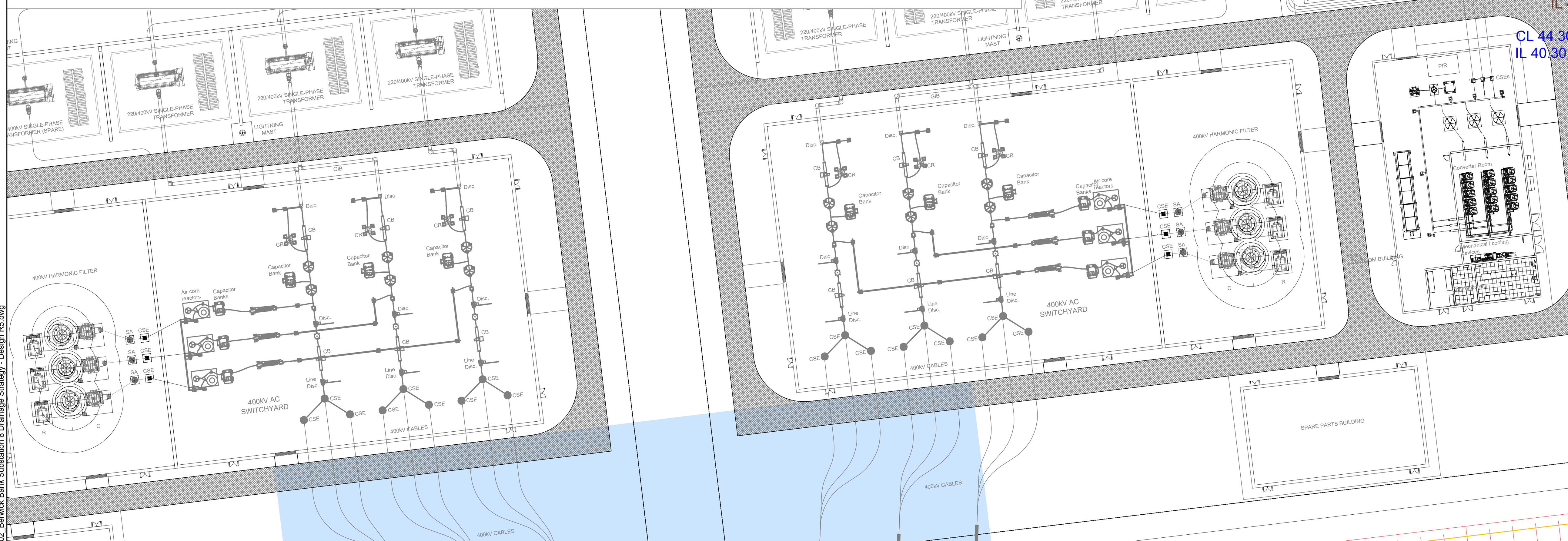
SUBSTATION 8 - SECTION B-B' - LONGSECTION
Scale: H 1:500,V 1:250. Datum: 27.500



Chainage	00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	94.86
Existing Ground Levels	36.220	35.654	35.104	34.636	34.230	33.847	33.475	33.149	32.813	32.508	32.368
Topsoil Stripped Levels	35.820	35.254	34.704	34.236	33.830	33.447	33.075	32.749	32.413	32.108	31.968
Proposed Levels			33.483	31.900	31.900	31.900	31.900	32.742	33.396		

SUBSTATION 8 - SECTION C-C' - LONGSECTION
Scale: H 1:500,V 1:250. Datum: 30.000





DRA-002_Berwick Bank Substation 8 Drainage Strategy - Design R5.dwg

NOTES

1. DRAWINGS PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.
2. SuDS POND DESIGNED IN ACCORDANCE WITH CIRIA SuDS MANUAL C753.
3. REFER TO DRAWING 001 FOR SUBSTATION 8 DRAINAGE STRATEGY OVERVIEW AND DRAWING 003 FOR DRAINAGE DETAILS.
4. SuDS POND SLOPES DESIGNED AT 1 IN 3.
5. PERIMETER ACCESS STRIP OF 2m WIDTH PROVIDED AROUND SuDS TO ALLOW FOR MAINTENANCE ACCESS.
6. DRAINAGE DETAILS SHOWN ARE OUTLINE DETAIL AND SUBJECT TO REFINEMENT.
7. TOPSOIL STRIP STORAGE AREA REQUIREMENTS TO BE APPROXIMATELY 1,500m^2 (ASSUMING A STOCKPILE HEIGHT OF 3-4m).
8. DRAINAGE DESIGN INVERT LEVELS ARE PROVISIONAL AND SUBJECT TO REFINEMENT AT DETAILED DESIGN STAGE.

LEGEND - PLAN VIEW

- EXISTING MAJOR CONTOURS (5m INTERVALS)
- EXISTING MINOR CONTOURS (1m INTERVALS)
- PROPOSED MAJOR CONTOURS (1m INTERVALS)
- PROPOSED MINOR CONTOURS (0.25m INTERVALS)
- FILL EMBANKMENT
- CUT EMBANKMENT
- PROPOSED SURFACE WATER PIPE
- PROPOSED SURFACE WATER MANHOLE
- PROPOSED SURFACE WATER HYDROBRAKE CHAMBER
- PROPOSED SURFACE WATER HEADWALL
- PROPOSED SURFACE WATER CUT-OFF DITCH
- PROPOSED FOUL WATER PIPE
- PROPOSED FOUL WATER MANHOLE
- PROPOSED FOUL WATER FILTER MOUND

LEGEND - SECTION VIEW

- EXISTING GROUND LEVEL
- EXISTING SUPERFICIAL LEVEL (TOPSOIL STRIPPED)
- PROPOSED SuDS POND LEVEL

REV	DATE	DESCRIPTION	BY	CHK
05	06/22	UPDATED SUDS POND DESIGN	SD	ZR
04	02/22	SUBSTATION EXTENSION AMENDMENTS	SD	ZR
03	02/22	UPDATES TO INTERNAL DRAINAGE	SD	ZR
02	11/21	SUBSTATION EXTENSION	SD	KI
01	10/21	SUBSTATION RELOCATION	SD	KI
00	03/21	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
SUBSTATION 8 DRAINAGE STRATEGY DESIGN

SCALE: 1:750 (PLAN) @ A1
DATE: JUNE 2022

DRAWING NUMBER: DRA-002
REV: 05

DRAWING STATUS: DRAFT ISSUE

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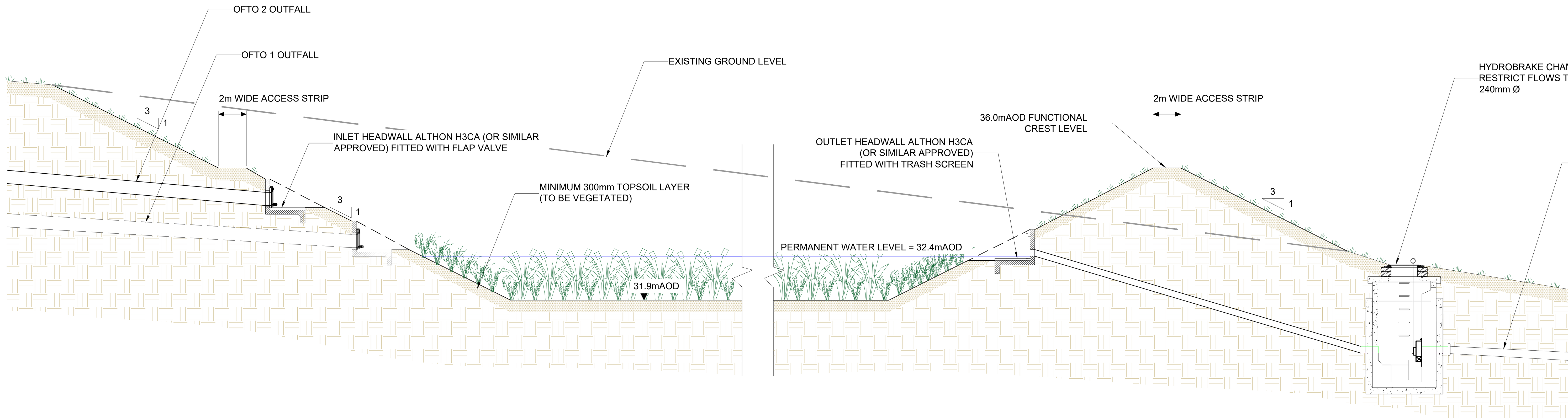
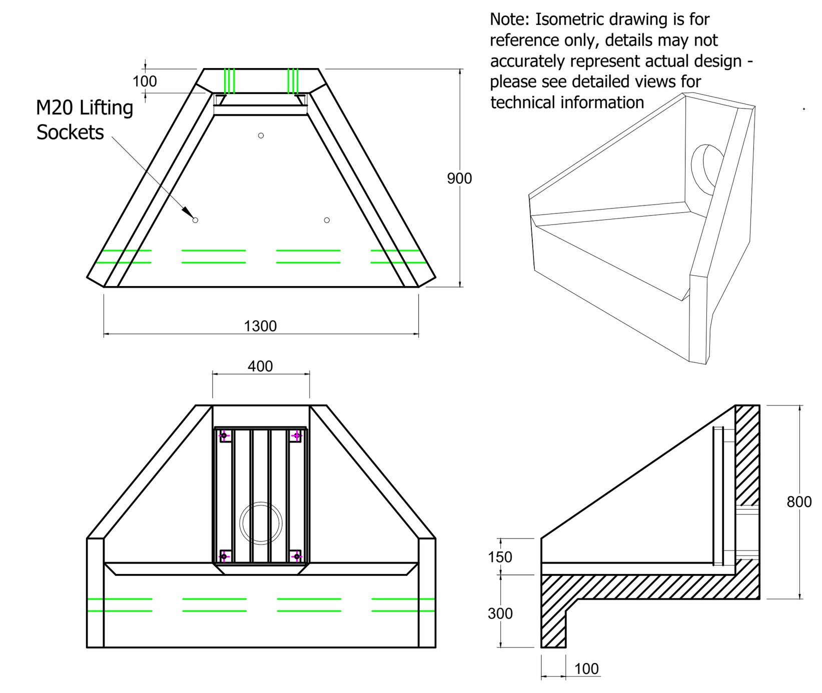
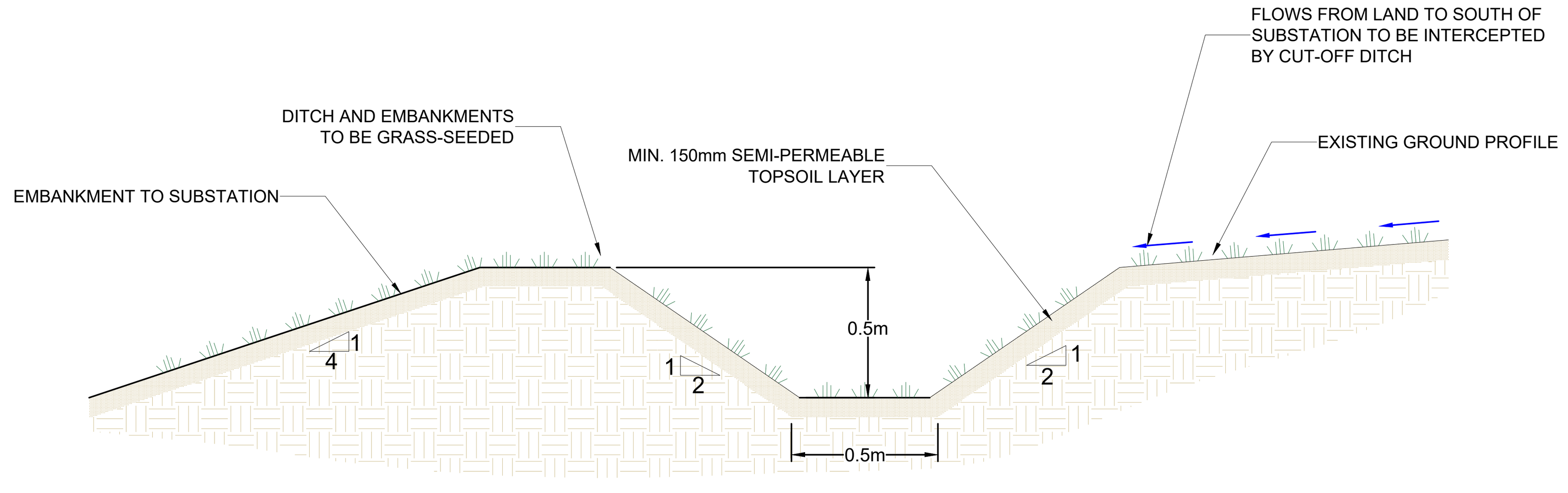


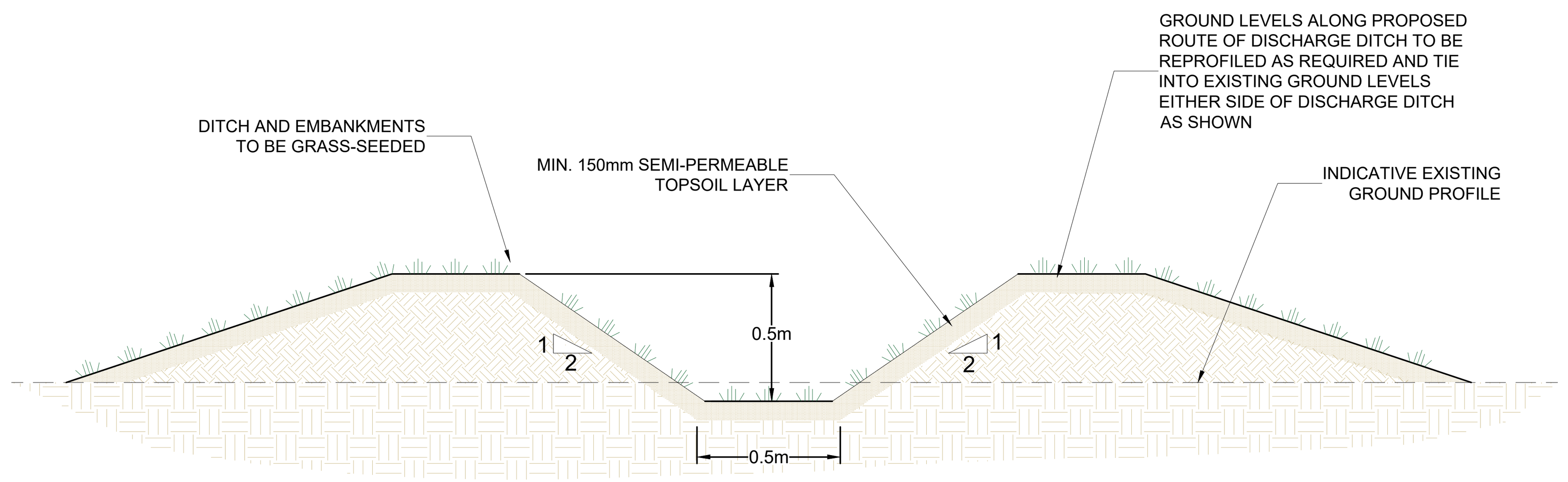
TYPICAL SECTION THROUGH SuDS POND



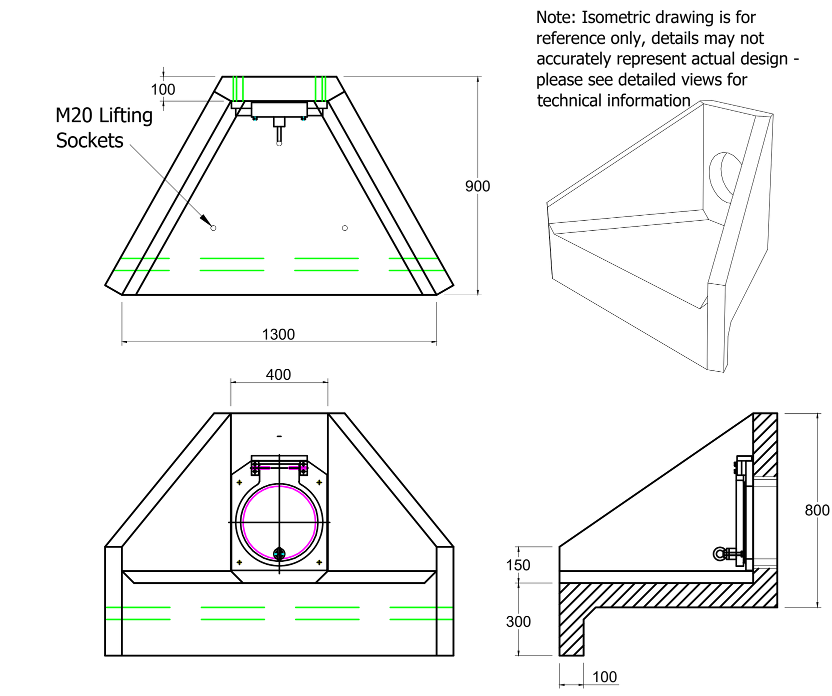
PRECAST CONCRETE OUTLET HEADWALL WITH TRASH SCREEN (ATHLON H3CA OR SIMILAR) - FITTED TO SUDS POND OUTFLOW



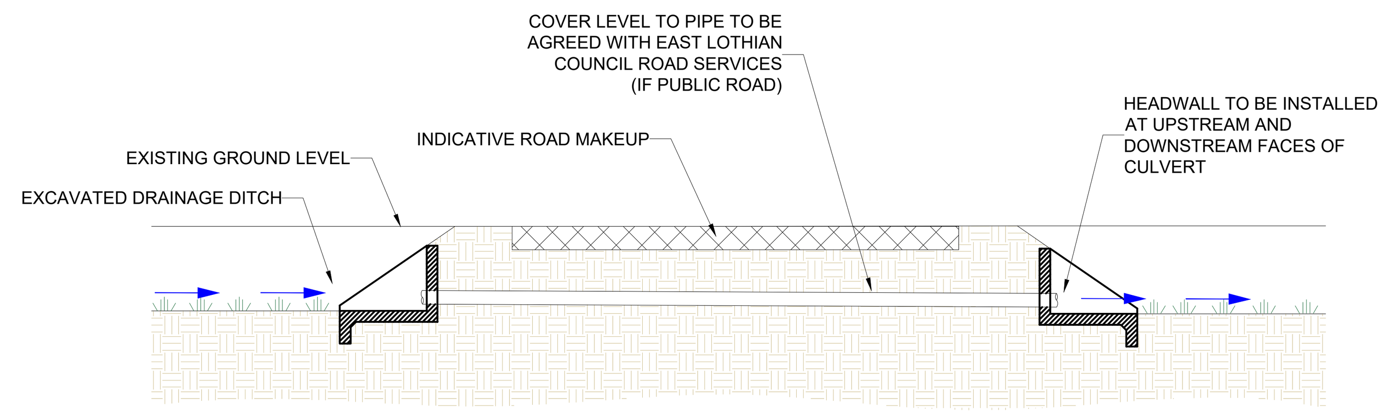
TYPICAL SECTION THROUGH CUT-OFF DITCH



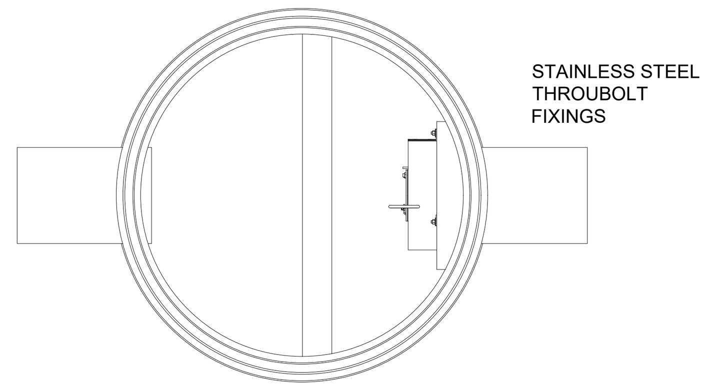
TYPICAL SECTION THROUGH DISCHARGE DITCH



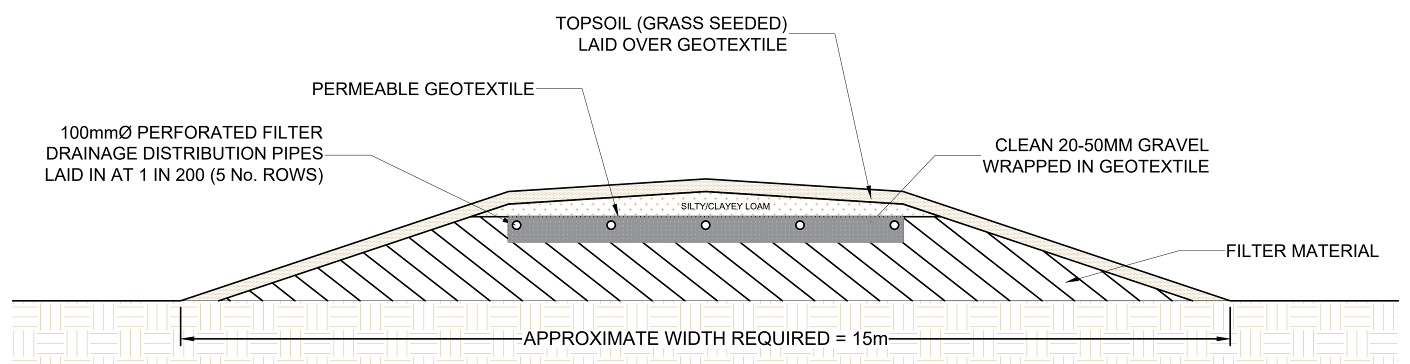
PRECAST CONCRETE INLET HEADWALL WITH FLAP VALVE (ATHLON H3CA OR SIMILAR) - FITTED TO SUDS POND INFLOWS



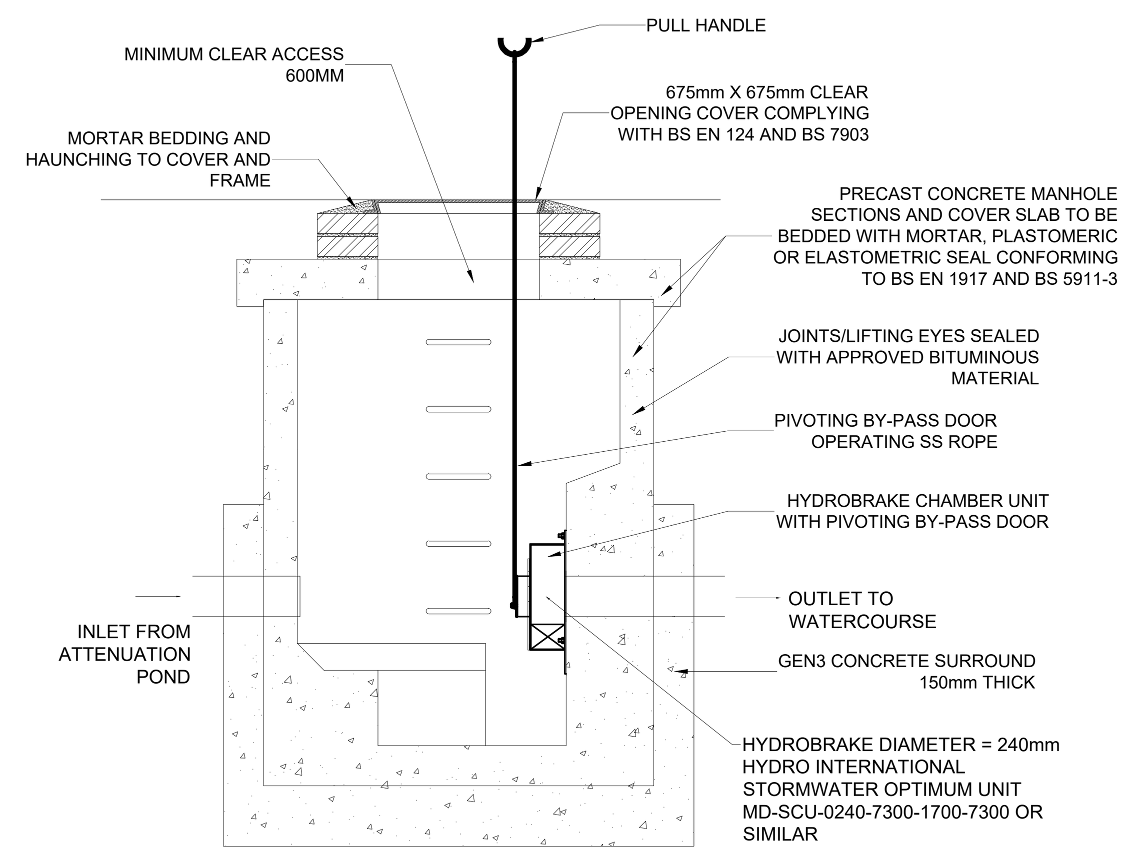
TYPICAL SECTION THROUGH ROAD CULVERT CROSSING



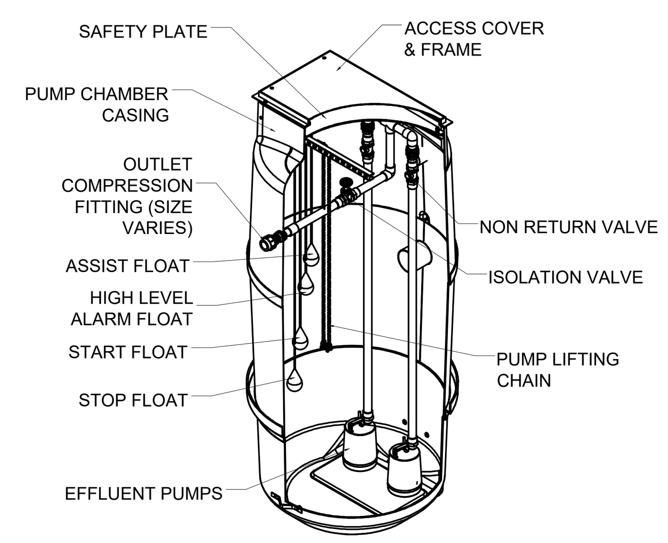
PLAN



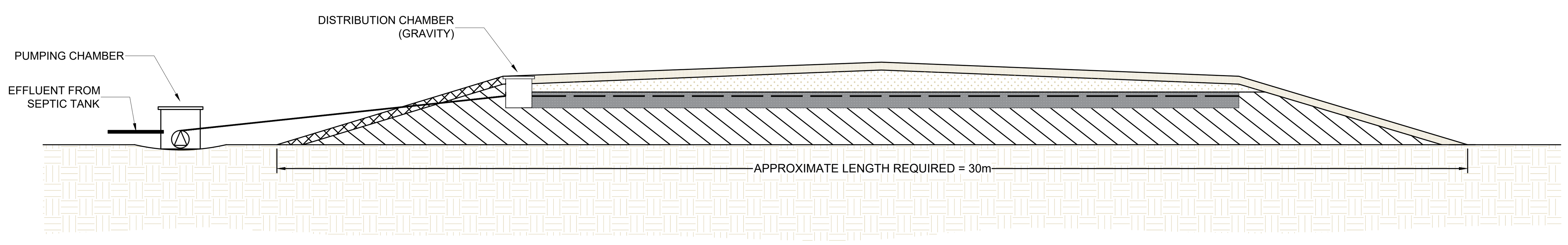
TYPICAL CROSS-SECTION THROUGH FILTER MOUND



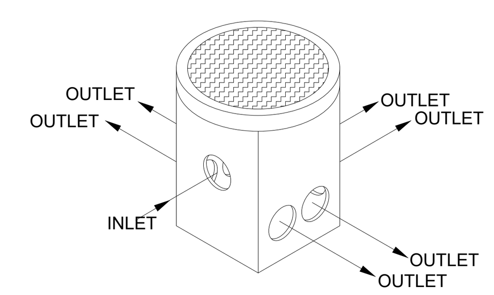
HYDROBRAKE OPTIMUM CHAMBER



TWIN EFFLUENT PUMP CHAMBER



TYPICAL LONG-SECTION THROUGH FILTER MOUND



TYPICAL GRAVITY FED DISTRIBUTION CHAMBER

NOTES

1. REFER TO DRAWING 001 FOR SUBSTATION 8 DRAINAGE STRATEGY OVERVIEW AND DRAWING 002 FOR DRAINAGE STRATEGY DESIGN.
2. DRAINAGE DETAILS SHOWN ARE OUTLINE DETAIL AND SUBJECT TO REFINEMENT.
3. POND LINER MAY BE REQUIRED (AND SUPPORTING GEOTEXTILE) DEPENDENT ON GROUND CONDITIONS ENCOUNTERED DURING EXCAVATION. TO BE CONFIRMED AT DETAILED DESIGN STAGE.
4. FILTER MOUND TO BE CONSTRUCTED IN ACCORDANCE WITH BRE 427 GUIDANCE DOCUMENT.
5. ADEQUATE FALL PROTECTION TO BE INSTALLED AROUND SUDS POND AND DITCHES / HEADWALLS WHERE APPLICABLE.

REV	DATE	DESCRIPTION	BY	CHK
03	07/22	UPDATED SUDS POND DESIGN	SD	ZR
02	04/22	SSE-R REVIEW ISSUE	SD	ZR
01	02/22	GENERAL UPDATES	SD	ZR
00	10/21	INITIAL ISSUE	SD	KI

CLIENT: SSE RENEWABLES

PROJECT: BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
SUBSTATION 8
DRAINAGE STRATEGY
DRAINAGE DETAILS

SCALE: NOT TO SCALE
DATE: JULY 2022

DRAWING NUMBER: **DRA-003**
REV: **03**

DRAWING STATUS: DRAFT ISSUE

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DRA-003_Substation 8 Drainage Strategy - Drainage Details R3.dwg

NOTES

1. DRAWINGS PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.
2. FOR TEMPORARY DRAINAGE OF CABLE ROUTE, HAUL ROADS AND STOCKPILES PLEASE REFER TO TYPICAL DETAIL DRAWING (TDW-009).
3. FOR SUBSTATION EARTHWORKS AND PERMANENT DRAINAGE DESIGN, PLEASE REFER TO RELEVANT DRAWINGS.
4. EXTENTS OF CUT AND FILL OF ANY COMPOUNDS AND ROADS HAVE BEEN DESIGNED BY OTHERS AND ARE ASSUMED TO BE CORRECT WHERE PRESENT. FINAL EARTHWORKS OF WORKING AREAS MAY BE SUBJECT TO REFINEMENT AT A LATER STAGE AND WILL REQUIRE ADJUSTMENTS TO TEMPORARY DRAINAGE TO SUIT.
5. SETTLEMENT PONDS HAVE BEEN INDICATIVELY SIZED. PRIOR TO CONSTRUCTION, SETTLEMENT PONDS ARE TO BE DESIGNED AND SIZED IN ACCORDANCE WITH CIRIA C648 AND C532.
6. WHERE SPACE PERMITS, USE OF A MULTI SETTLEMENT POND ARRANGEMENT SHOULD BE CONSIDERED.
7. CONSTRUCTION DRAINAGE DITCHES SHOULD BE CONSTRUCTED WITH CHECK DAMS AT REGULAR INTERVALS (20 - 40M).
8. ALL CONSTRUCTION DRAINAGE ELEMENTS SHOULD BE DESIGNED AND SIZED TO MANAGE THE 1IN10 YEAR STORM EVENT.
9. USE OF SILT FENCING SHOULD BE INFORMED BY GROUND CONDITIONS. SILT FENCING TO BE USED IN AREAS WHERE HIGH SEDIMENT LOADING IS LIKELY TO INCREASE MAINTENANCE REQUIREMENTS OF DITCHES AND SETTLEMENT PONDS.
11. ADEQUATE FALL PROTECTION TO BE INSTALLED AROUND SETTLEMENT PONDS AND / OR DITCHES WHERE APPLICABLE.
12. TEMPORARY DRAINAGE MEASURES PROPOSED FOR CONSTRUCTION PHASE ARE NOT FINAL OR EXHAUSTIVE. ALTERNATIVE MEASURES MAY BE AVAILABLE AND WOULD BE AT THE DISCRETION OF THE PRINCIPAL CONTRACTOR DURING CONSTRUCTION PHASE.

LEGEND

- SITE BOUNDARY
- INDICATIVE MICROSITING BOUNDARY
- LANDFALL HDD CABLE
- HDD COMPOUND
- CABLE
- JOINT BAY
- CABLE CORRIDOR
- PERMANENT ACCESS ROAD
- TEMPORARY HAUL ROAD / ACCESS ROAD
- POSSIBLE TRACK (TO BE AGREED)
- CONTRACTOR COMPOUND
- LANDFALL COMPOUND
- HDD CABLE DUCT
- EXCESS MATERIAL FROM CABLE CORRIDOR
- SHARED EXCESS MATERIAL (CORRIDOR AND COMPOUNDS)
- EXISTING TOPSOIL STOCKPILE
- RELOCATED TOPSOIL STOCKPILE
- POTENTIAL AREA FOR LAYDOWN SPACE / MATERIAL STORAGE
- PROPOSED SPEN INFRASTRUCTURE (VARIOUS)
- PROPOSED SPEN SUBSTATION
- CUT EMBANKMENT
- FILL EMBANKMENT
- PROPOSED CONSTRUCTION DRAINAGE DITCH
- PROPOSED UPGRADIENT CUT-OFF DITCH
- PROPOSED PERFORATED PIPEWORK
- PROPOSED OIL SEPARATOR
- PROPOSED SETTLEMENT POND
- PROPOSED LEVEL SPREADER
- PROPOSED SILT FENCING
- PROPOSED GRADING FOR RUNOFF CONTROL

REV	DATE	DESCRIPTION	BY	CHK
02	06/22	UPDATED SUDS POND DESIGN	SD	ZR
01	04/22	SSE-R REVIEW ISSUE	SD	ZR
00	02/22	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN OVERVIEW

SCALE:
1:3,000 @ A0

DATE:
JUNE 2022

DRAWING NUMBER:
TDW-000

REV:
02

DRAWING STATUS:
DRAFT ISSUE

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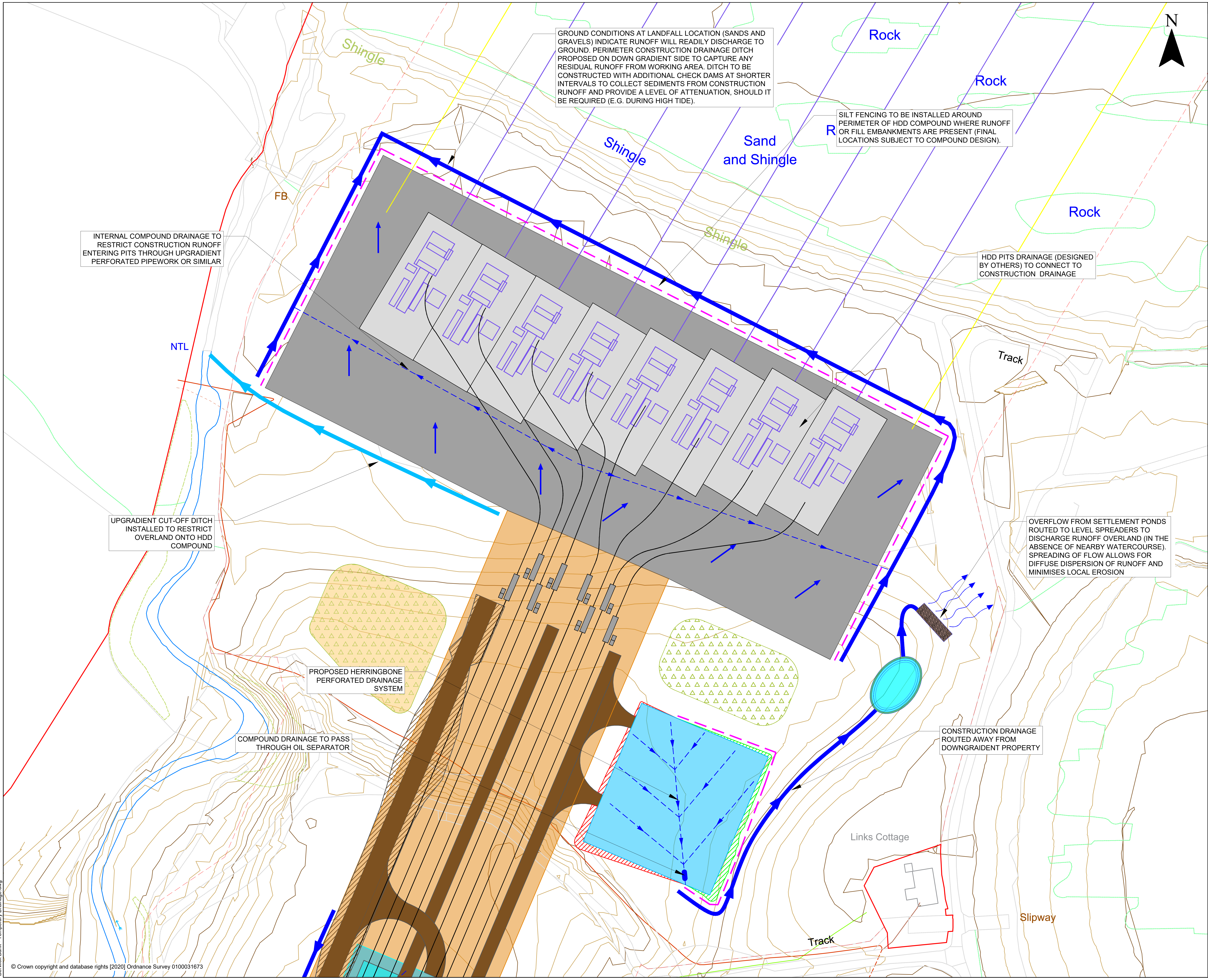

N

NOTES

1. REFER TO DRAWING 000 FOR FULL LEGEND DETAILS.
2. DRAWINGS PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.
3. FOR TEMPORARY DRAINAGE OF CABLE ROUTE, HAUL ROADS AND STOCKPILES PLEASE REFER TO TYPICAL DETAIL DRAWING (TDW-009).
4. FOR SUBSTATION EARTHWORKS AND PERMANENT DRAINAGE DESIGN, PLEASE REFER TO RELEVANT DRAWINGS.
5. EXTENTS OF CUT AND FILL OF ANY COMPOUNDS AND ROADS HAVE BEEN DESIGNED BY OTHERS AND ARE ASSUMED TO BE CORRECT WHERE PRESENT. FINAL EARTHWORKS OF WORKING AREAS MAY BE SUBJECT TO REFINEMENT AT A LATER STAGE AND WILL REQUIRE ADJUSTMENTS TO TEMPORARY DRAINAGE TO SUIT.
6. SETTLEMENT PONDS HAVE BEEN INDICATIVELY SIZED. PRIOR TO CONSTRUCTION, SETTLEMENT PONDS ARE TO BE DESIGNED AND SIZED IN ACCORDANCE WITH CIRIA C648 AND C532.
7. WHERE SPACE PERMITS, USE OF A MULTI SETTLEMENT POND ARRANGEMENT SHOULD BE CONSIDERED.
8. CONSTRUCTION DRAINAGE DITCHES SHOULD BE CONSTRUCTED WITH CHECK DAMS AT REGULAR INTERVALS (20 - 40M).
9. ALL CONSTRUCTION DRAINAGE ELEMENTS SHOULD BE DESIGNED AND SIZED TO MANAGE THE 1IN10 YEAR STORM EVENT.
10. USE OF SILT FENCING SHOULD BE INFORMED BY GROUND CONDITIONS. SILT FENCING TO BE USED IN AREAS WHERE HIGH SEDIMENT LOADING IS LIKELY TO INCREASE MAINTENANCE REQUIREMENTS OF DITCHES AND SETTLEMENT PONDS.
11. ADEQUATE FALL PROTECTION TO BE INSTALLED AROUND SETTLEMENT PONDS AND / OR DITCHES WHERE APPLICABLE.

LEGEND

EXISTING MAJOR CONTOURS (5m INTERVALS)

EXISTING MINOR CONTOURS (1m INTERVALS)

REV	DATE	DESCRIPTION	BY	CHK
01	04/22	SSE-R REVIEW ISSUE	SD	ZR
00	02/22	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 1

SCALE: 1:1,000 @ A2
DATE: APRIL 2022

DRAWING NUMBER: **TDW-001**
REV: **01**

DRAWING STATUS:
DRAFT ISSUE

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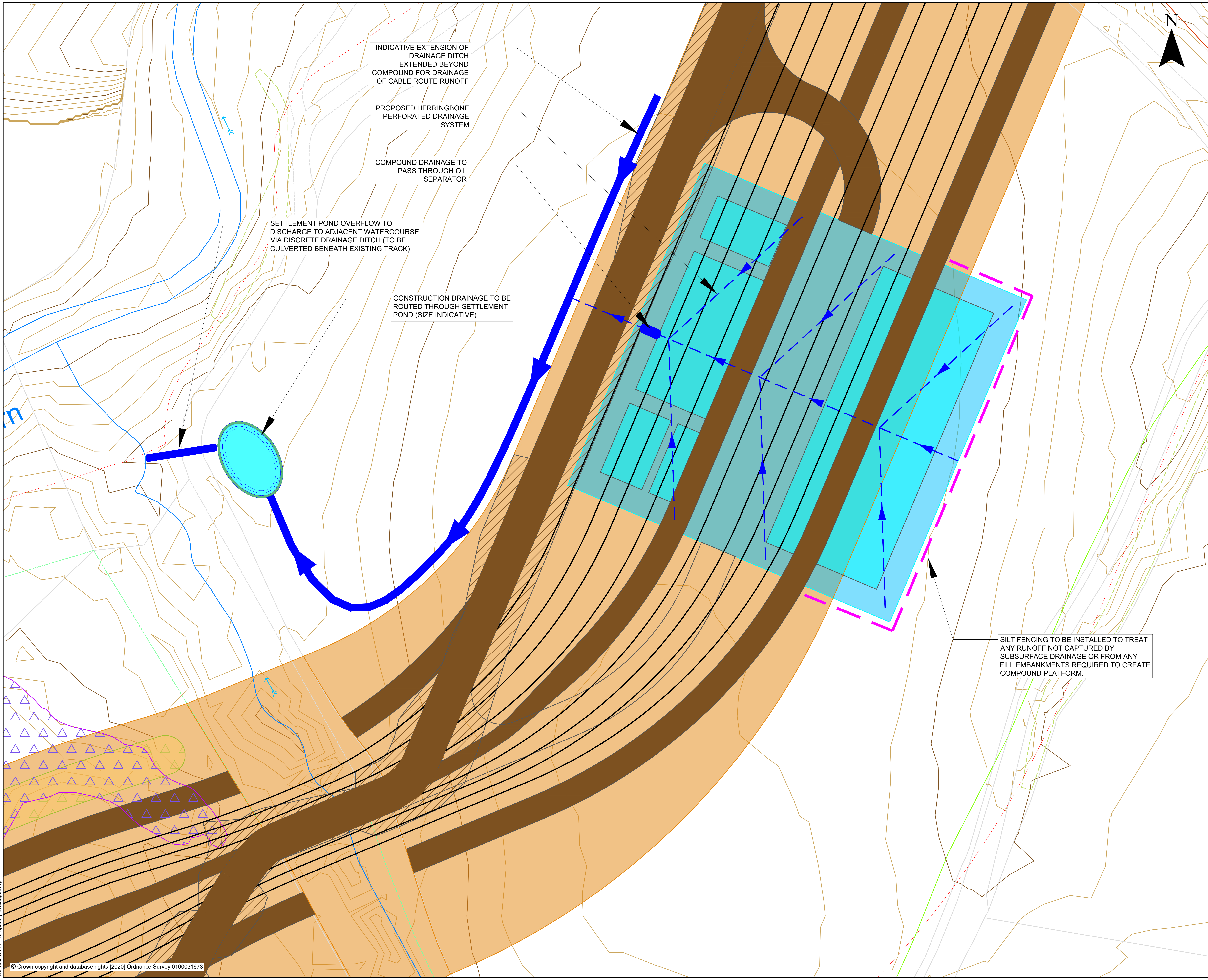

Berwick Bank - Temporary Drainage.dwg

NOTES

1. REFER TO DRAWING 000 FOR FULL LEGEND DETAILS.
2. DRAWINGS PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.
3. FOR TEMPORARY DRAINAGE OF CABLE ROUTE, HAUL ROADS AND STOCKPILES PLEASE REFER TO TYPICAL DETAIL DRAWING (TDW-009).
4. FOR SUBSTATION EARTHWORKS AND PERMANENT DRAINAGE DESIGN, PLEASE REFER TO RELEVANT DRAWINGS.
5. EXTENTS OF CUT AND FILL OF ANY COMPOUNDS AND ROADS HAVE BEEN DESIGNED BY OTHERS AND ARE ASSUMED TO BE CORRECT WHERE PRESENT. FINAL EARTHWORKS OF WORKING AREAS MAY BE SUBJECT TO REFINEMENT AT A LATER STAGE AND WILL REQUIRE ADJUSTMENTS TO TEMPORARY DRAINAGE TO SUIT.
6. SETTLEMENT PONDS HAVE BEEN INDICATIVELY SIZED. PRIOR TO CONSTRUCTION, SETTLEMENT PONDS ARE TO BE DESIGNED AND SIZED IN ACCORDANCE WITH CIRIA C648 AND C532.
7. WHERE SPACE PERMITS, USE OF A MULTI SETTLEMENT POND ARRANGEMENT SHOULD BE CONSIDERED.
8. CONSTRUCTION DRAINAGE DITCHES SHOULD BE CONSTRUCTED WITH CHECK DAMS AT REGULAR INTERVALS (20 - 40M).
9. ALL CONSTRUCTION DRAINAGE ELEMENTS SHOULD BE DESIGNED AND SIZED TO MANAGE THE 1IN10 YEAR STORM EVENT.
10. USE OF SILT FENCING SHOULD BE INFORMED BY GROUND CONDITIONS. SILT FENCING TO BE USED IN AREAS WHERE HIGH SEDIMENT LOADING IS LIKELY TO INCREASE MAINTENANCE REQUIREMENTS OF DITCHES AND SETTLEMENT PONDS.
11. ADEQUATE FALL PROTECTION TO BE INSTALLED AROUND SETTLEMENT PONDS AND / OR DITCHES WHERE APPLICABLE.

LEGEND

EXISTING MAJOR CONTOURS (5m INTERVALS)

EXISTING MINOR CONTOURS (1m INTERVALS)

REV	DATE	DESCRIPTION	BY	CHK
01	04/22	SSE-R REVIEW ISSUE	SD	ZR
00	02/22	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 2

SCALE: 1:500 @ A2

DATE: APRIL 2022

DRAWING NUMBER: **TDW-002**

REV: 01

DRAWING STATUS: DRAFT ISSUE

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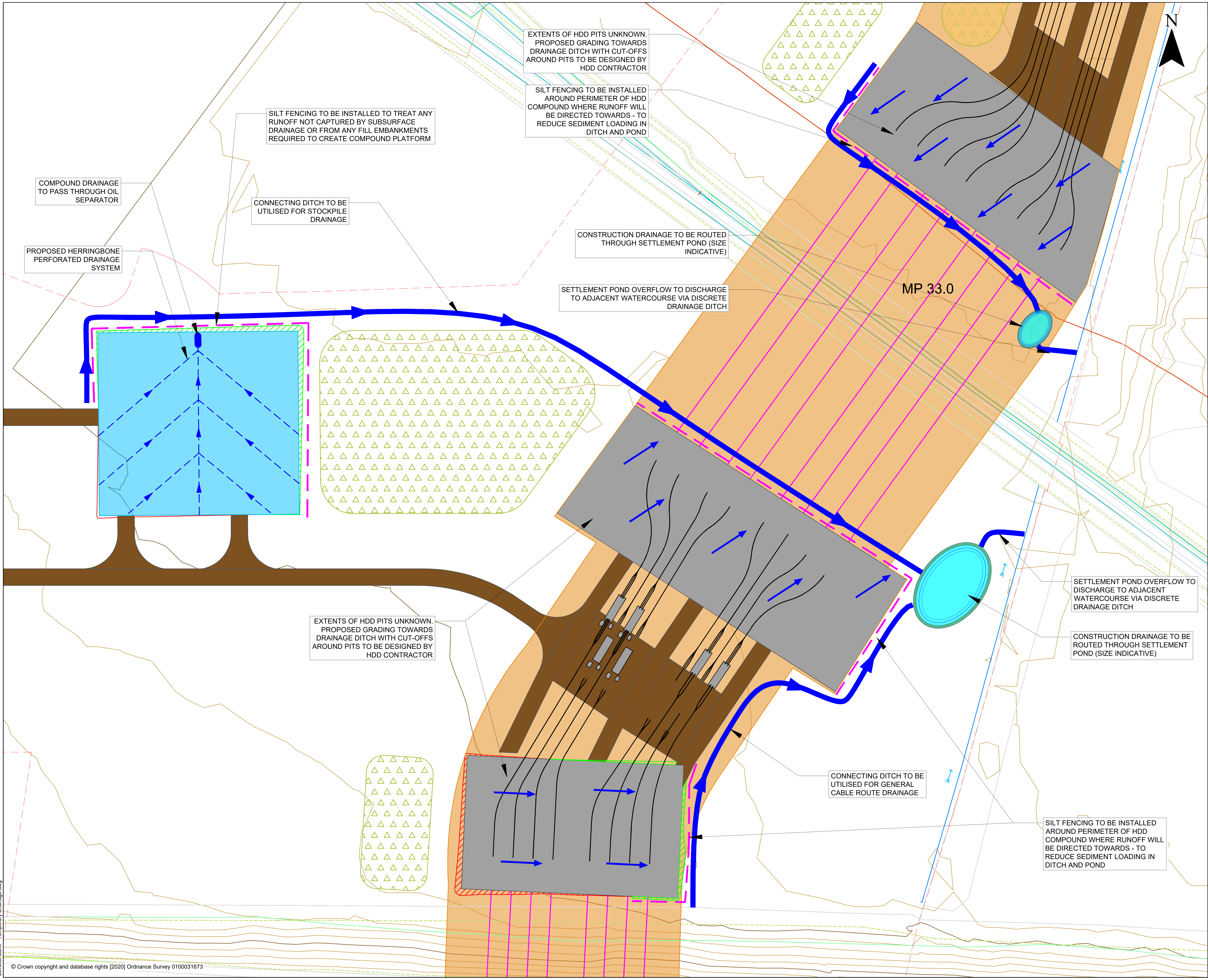

NOTES

1. REFER TO DRAWING 000 FOR FULL LEGEND DETAILS.
2. DRAWINGS PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.
3. FOR TEMPORARY DRAINAGE OF CABLE ROUTE, HAUL ROADS AND STOCKPILES PLEASE REFER TO TYPICAL DETAIL DRAWING (TDW-009).
4. FOR SUBSTATION EARTHWORKS AND PERMANENT DRAINAGE DESIGN, PLEASE REFER TO RELEVANT DRAWINGS.
5. EXTENTS OF CUT AND FILL OF ANY COMPOUNDS AND ROADS HAVE BEEN DESIGNED BY OTHERS AND ARE ASSUMED TO BE CORRECT WHERE PRESENT. FINAL EARTHWORKS OF WORKING AREAS MAY BE SUBJECT TO REFINEMENT AT A LATER STAGE AND WILL REQUIRE ADJUSTMENTS TO TEMPORARY DRAINAGE TO SUIT.
6. SETTLEMENT PONDS HAVE BEEN INDICATIVELY SIZED. PRIOR TO CONSTRUCTION, SETTLEMENT PONDS ARE TO BE DESIGNED AND SIZED IN ACCORDANCE WITH CIRIA C648 AND C532.
7. WHERE SPACE PERMITS, USE OF A MULTI SETTLEMENT POND ARRANGEMENT SHOULD BE CONSIDERED.
8. CONSTRUCTION DRAINAGE DITCHES SHOULD BE CONSTRUCTED WITH CHECK DAMS AT REGULAR INTERVALS (20 - 40M).
9. ALL CONSTRUCTION DRAINAGE ELEMENTS SHOULD BE DESIGNED AND SIZED TO MANAGE THE 1IN10 YEAR STORM EVENT.
10. USE OF SILT FENCING SHOULD BE INFORMED BY GROUND CONDITIONS. SILT FENCING TO BE USED IN AREAS WHERE HIGH SEDIMENT LOADING IS LIKELY TO INCREASE MAINTENANCE REQUIREMENTS OF DITCHES AND SETTLEMENT PONDS.
11. ADEQUATE FALL PROTECTION TO BE INSTALLED AROUND SETTLEMENT PONDS AND / OR DITCHES WHERE APPLICABLE.

LEGEND

EXISTING MAJOR CONTOURS (5m INTERVALS)

EXISTING MINOR CONTOURS (1m INTERVALS)

REV	DATE	DESCRIPTION	BY	CHK
01	04/22	SSE-R REVIEW ISSUE	SD	ZR
00	02/22	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 3

SCALE: 1:750 @ A2

DATE: APRIL 2022

DRAWING NUMBER: **TDW-003**

REV: **01**

DRAWING STATUS:
DRAFT ISSUE

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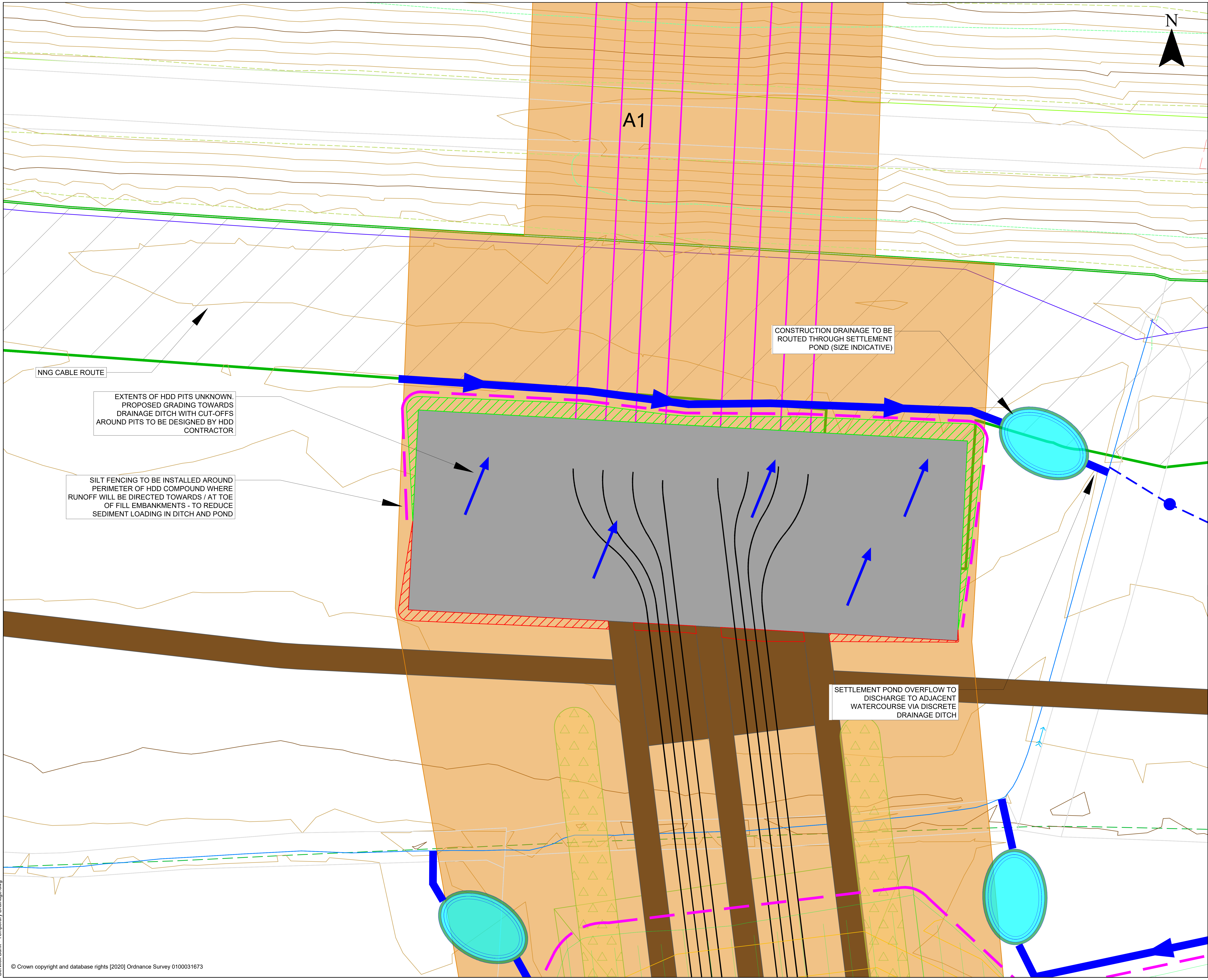

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NOTES

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EXISTING MINOR CONTOURS (1m INTERVALS)

REV	DATE	DESCRIPTION	BY	CHK
01	04/22	SSE-R REVIEW ISSUE	SD	ZR
00	02/22	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 4

SCALE: 1:500 @ A2

DATE: APRIL 2022

DRAWING NUMBER: **TDW-004**

REV: **01**

DRAWING STATUS: DRAFT ISSUE

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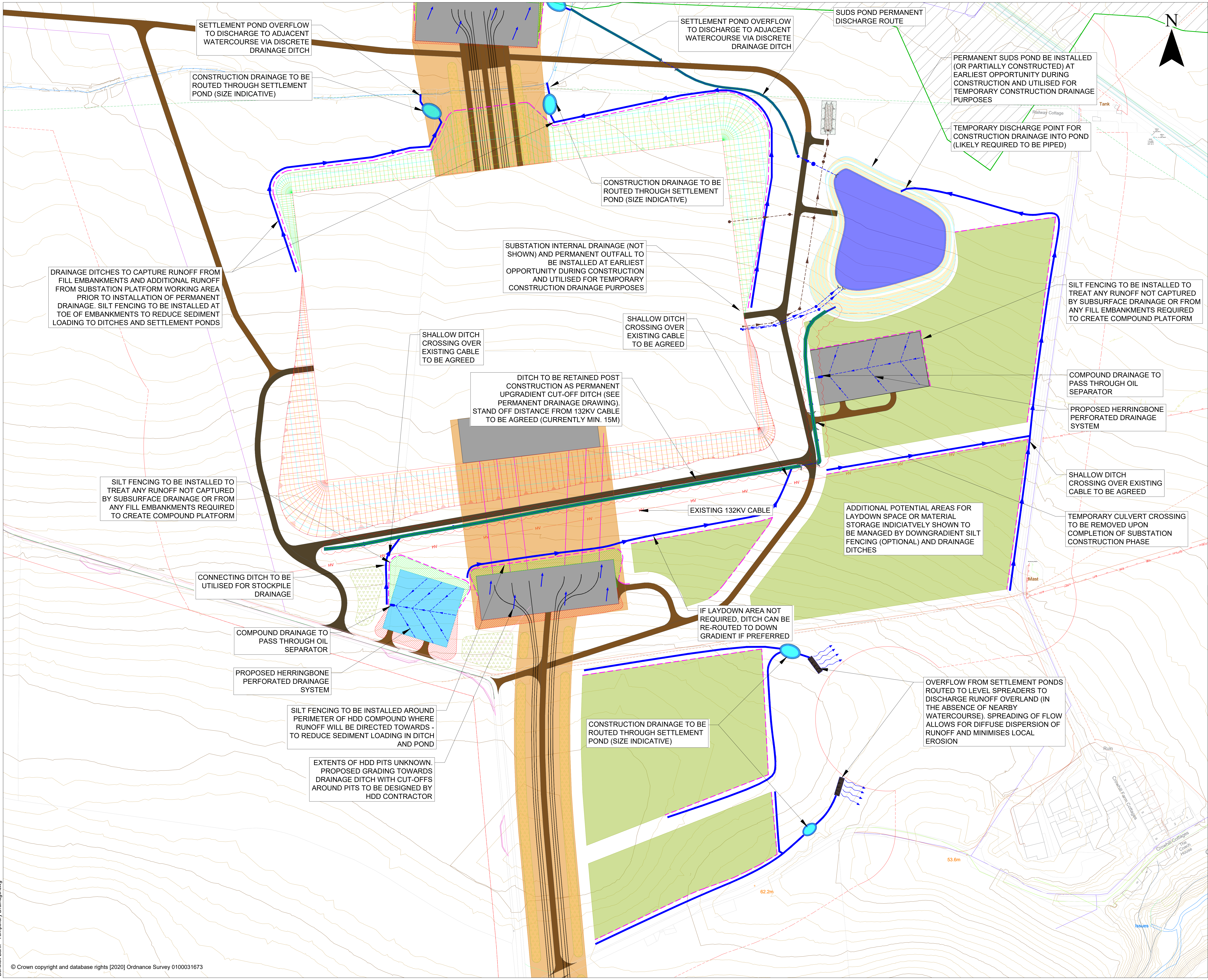

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REV	DATE	DESCRIPTION	BY	CHK
02	06/22	UPDATED SUDS POND DESIGN	SD	ZR
01	04/22	SSE-R REVIEW ISSUE	SD	ZR
00	02/22	INITIAL ISSUE	SD	ZR

CLIENT:
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PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 4

SCALE: 1:2,250 @ A2
DATE: JUNE 2022

DRAWING NUMBER: **TDW-005**
REV: **02**

DRAWING STATUS: DRAFT ISSUE

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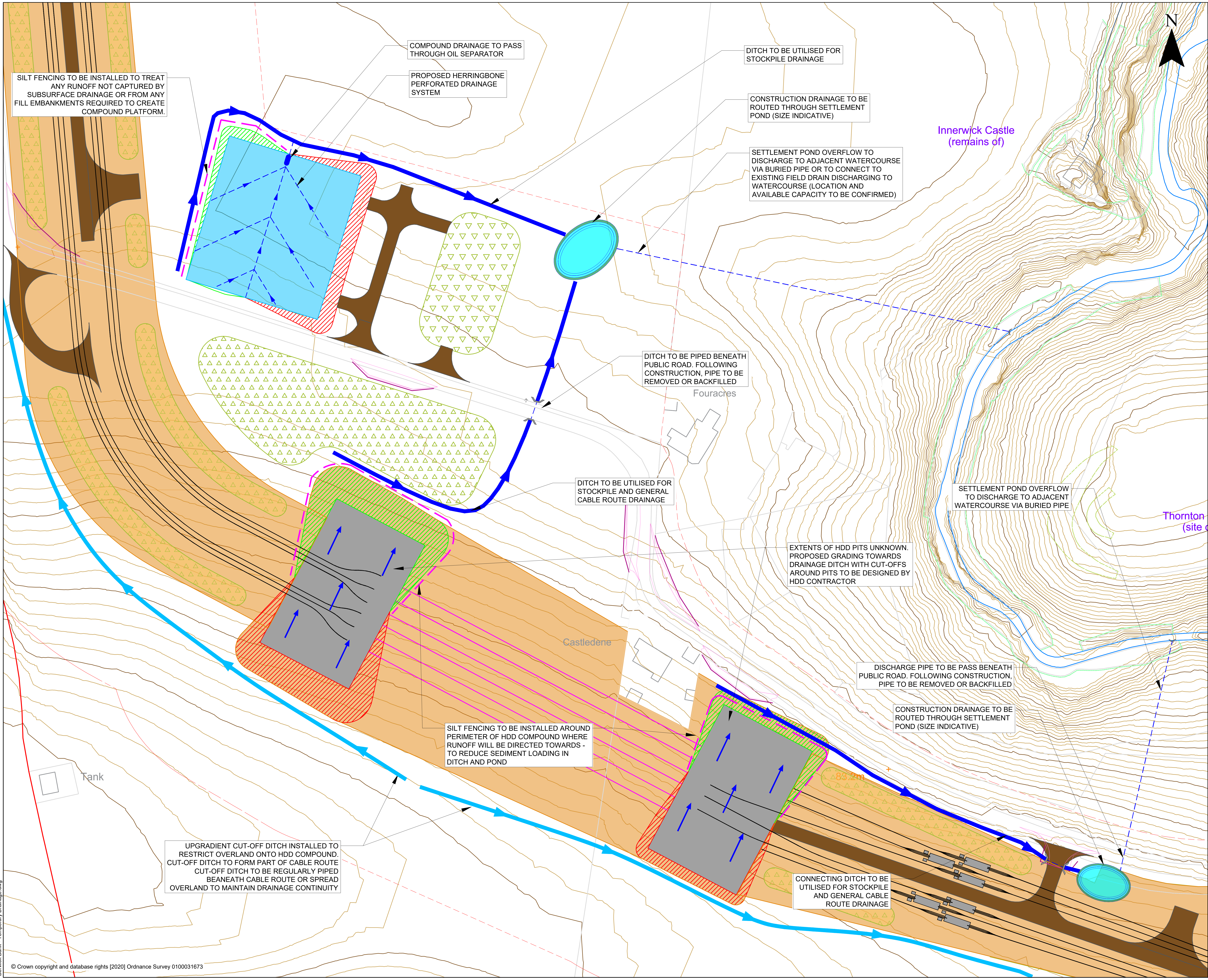

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DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 4

SCALE: 1:1,000 @ A2

DATE: APRIL 2022

DRAWING NUMBER: TDW-006

REV: 01

DRAWING STATUS: DRAFT ISSUE

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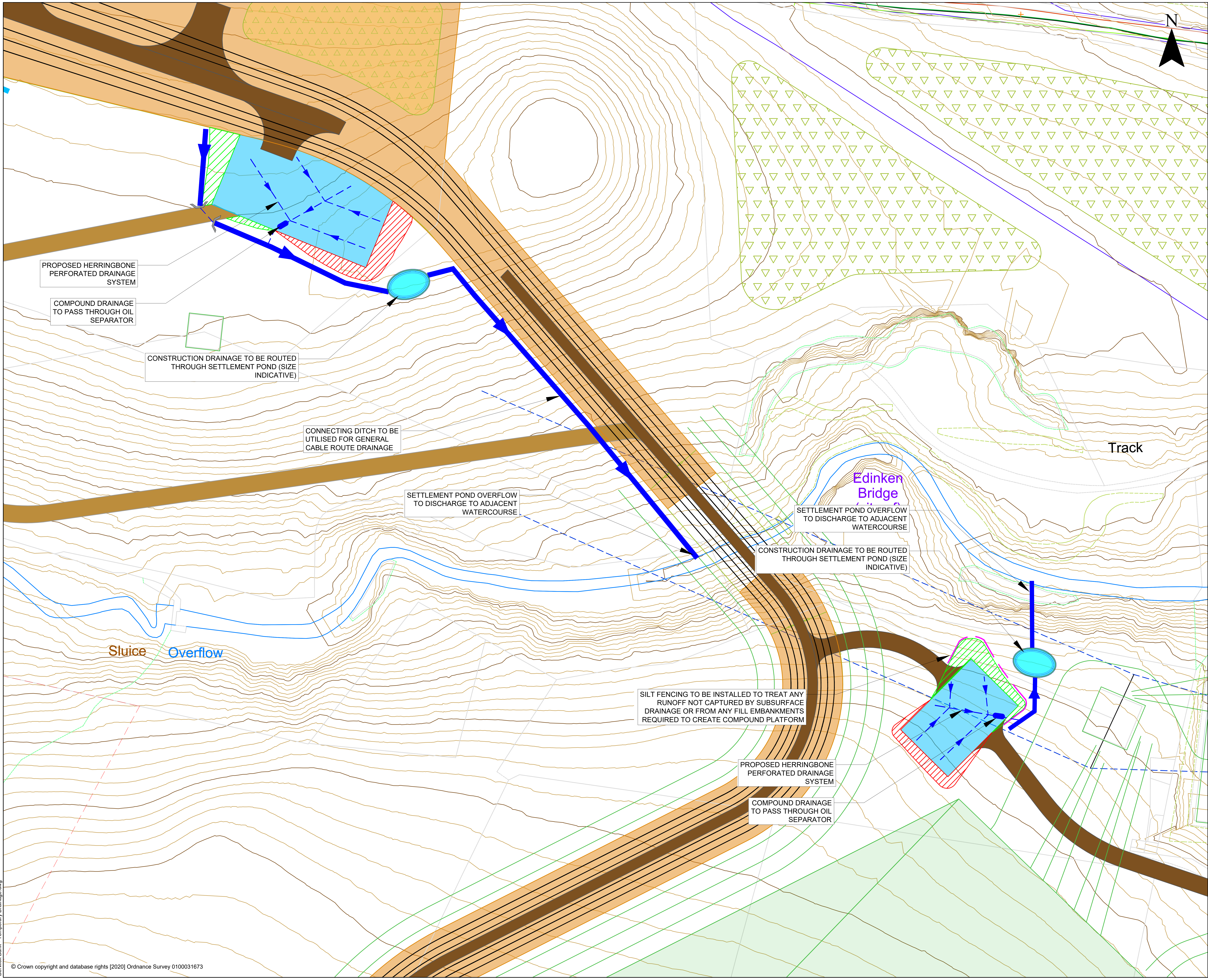

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BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 4

SCALE: 1:750 @ A2

DATE: APRIL 2022

DRAWING NUMBER: **TDW-007**

REV: **01**

DRAWING STATUS:
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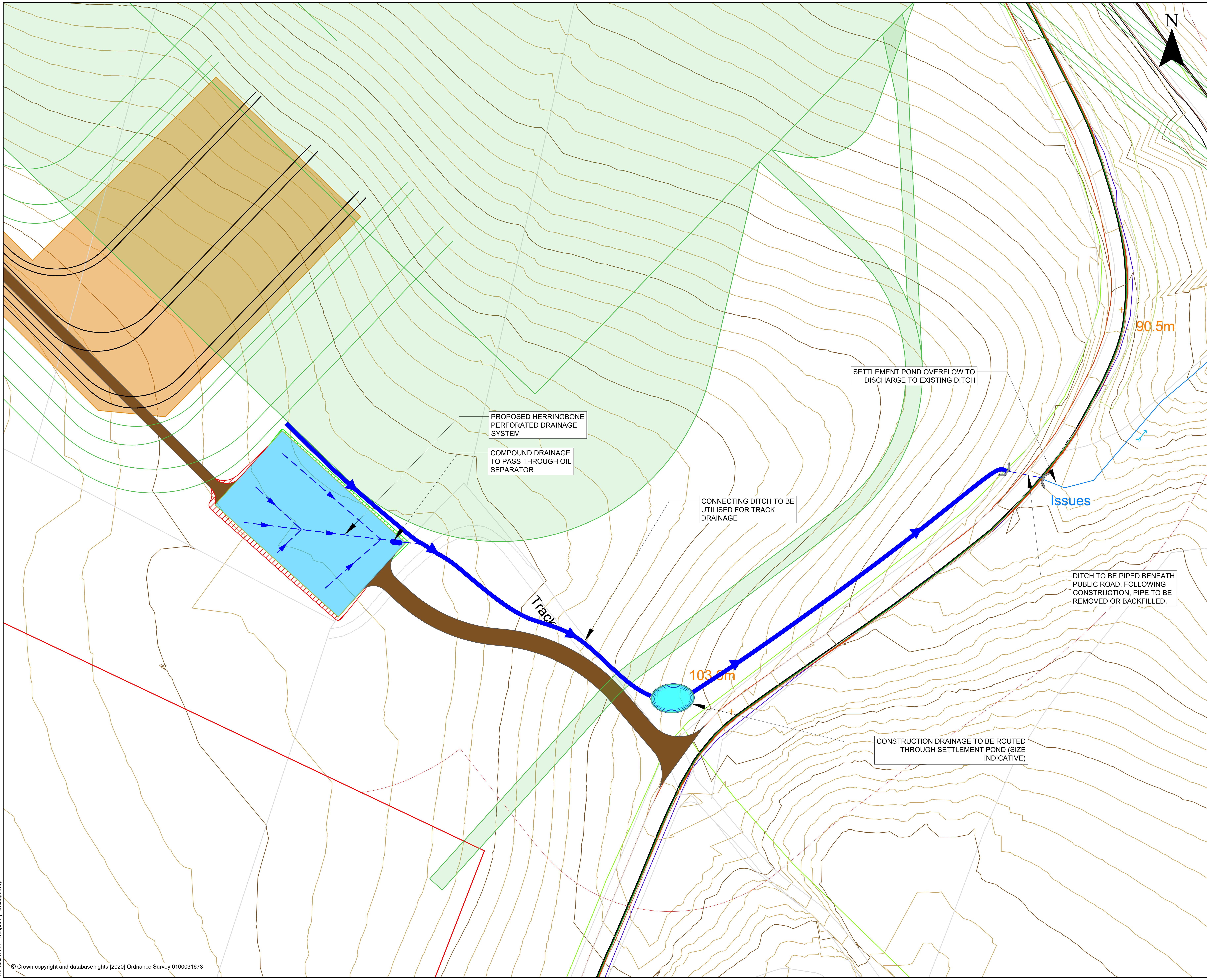

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SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
TEMPORARY DRAINAGE WORKS OUTLINE DESIGN SHEET 4

SCALE: 1:750 @ A2

DATE: APRIL 2022

DRAWING NUMBER: **TDW-008**

REV: **01**

DRAWING STATUS: DRAFT ISSUE

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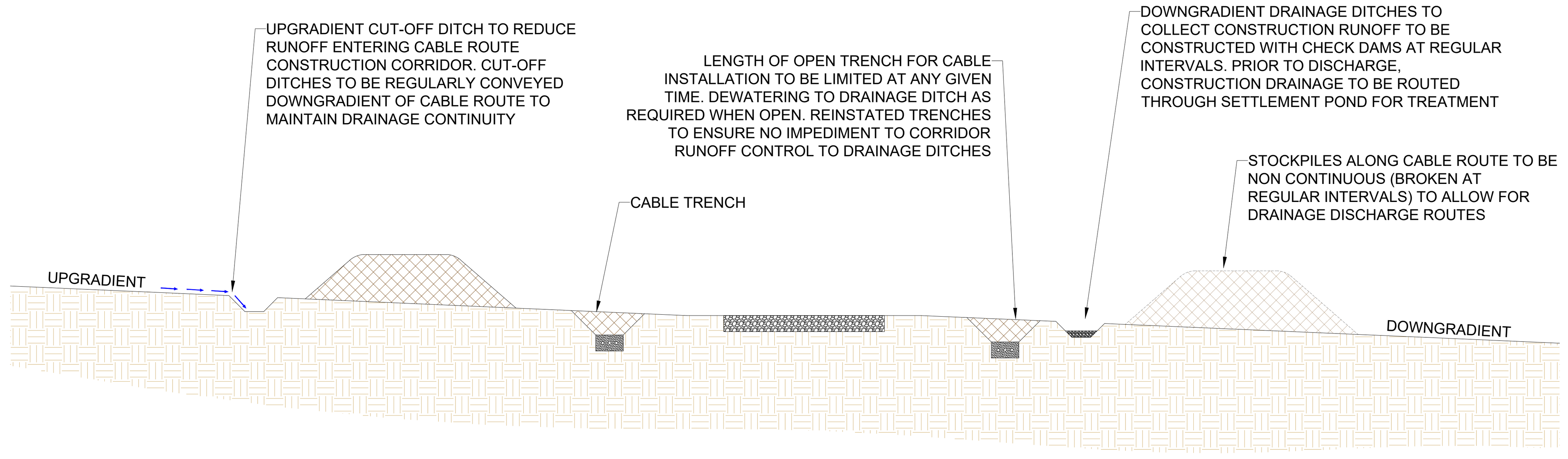
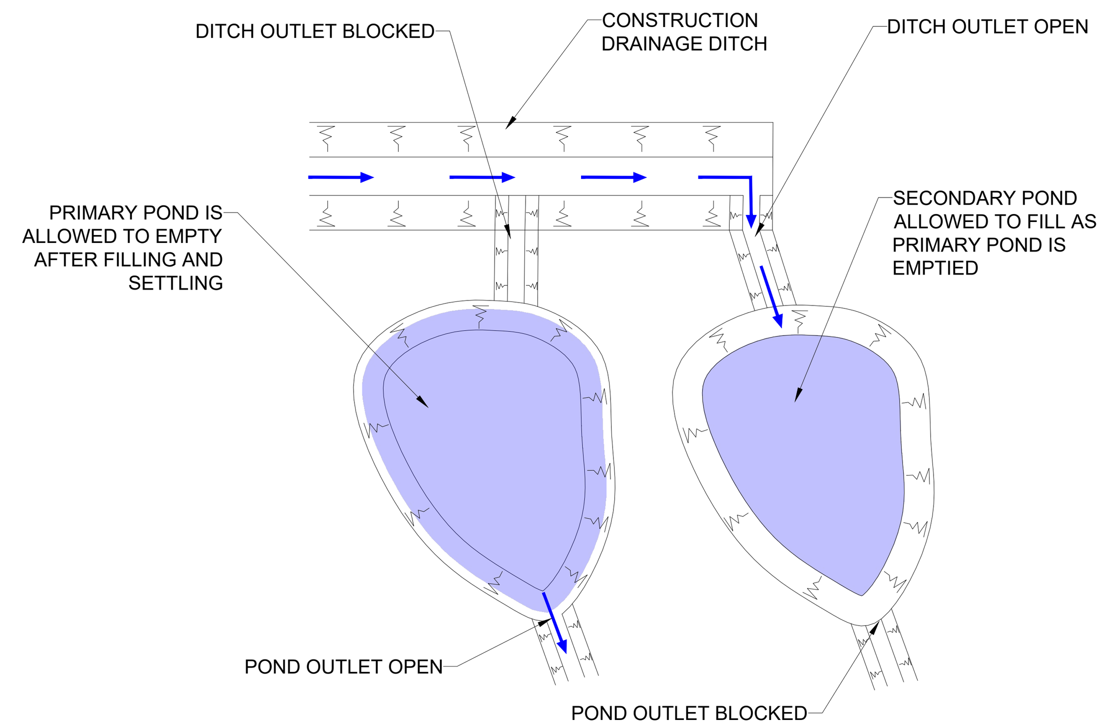
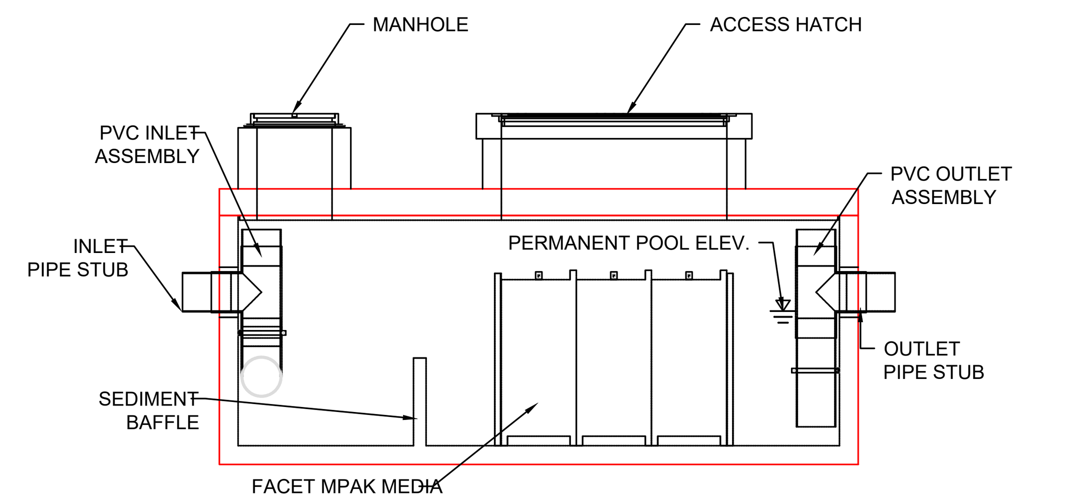


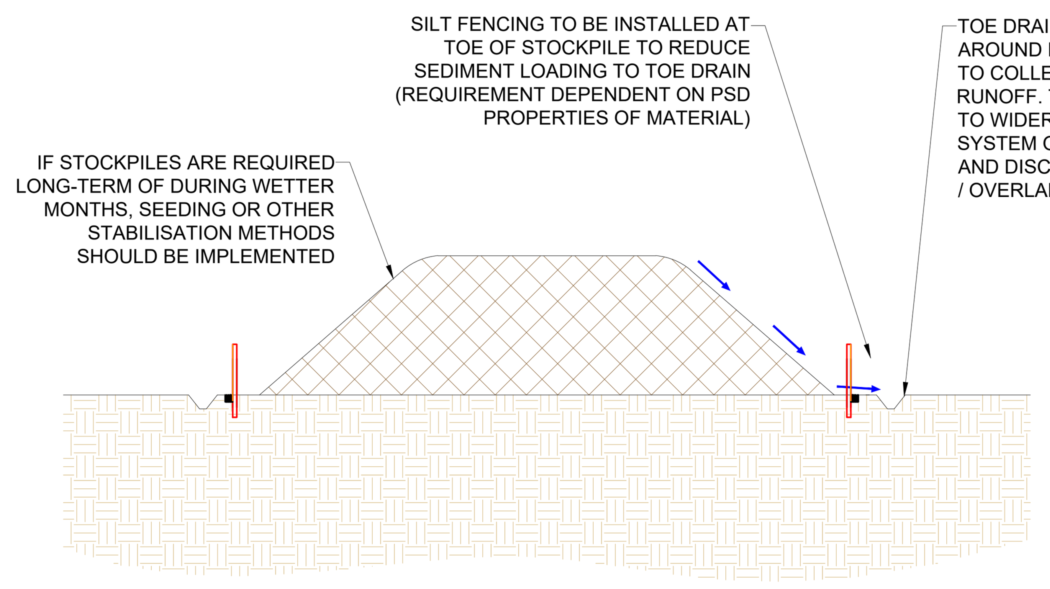
TYPICAL SECTION THROUGH CABLE CORRIDOR



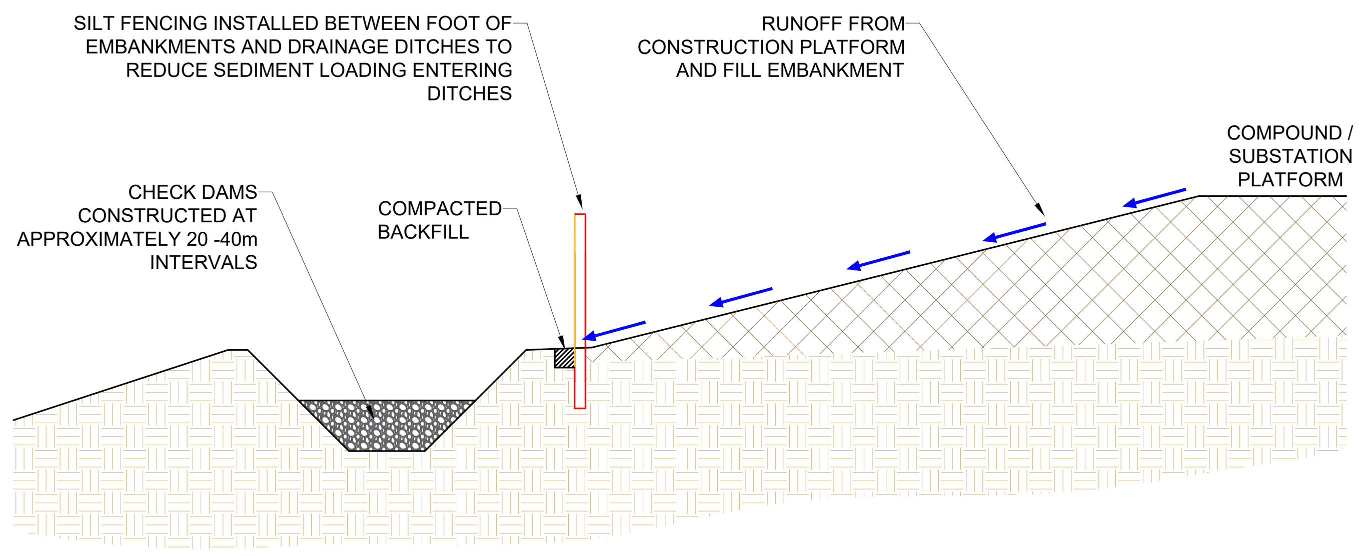
TYPICAL SETTLEMENT POND IN SERIES ARRANGEMENT



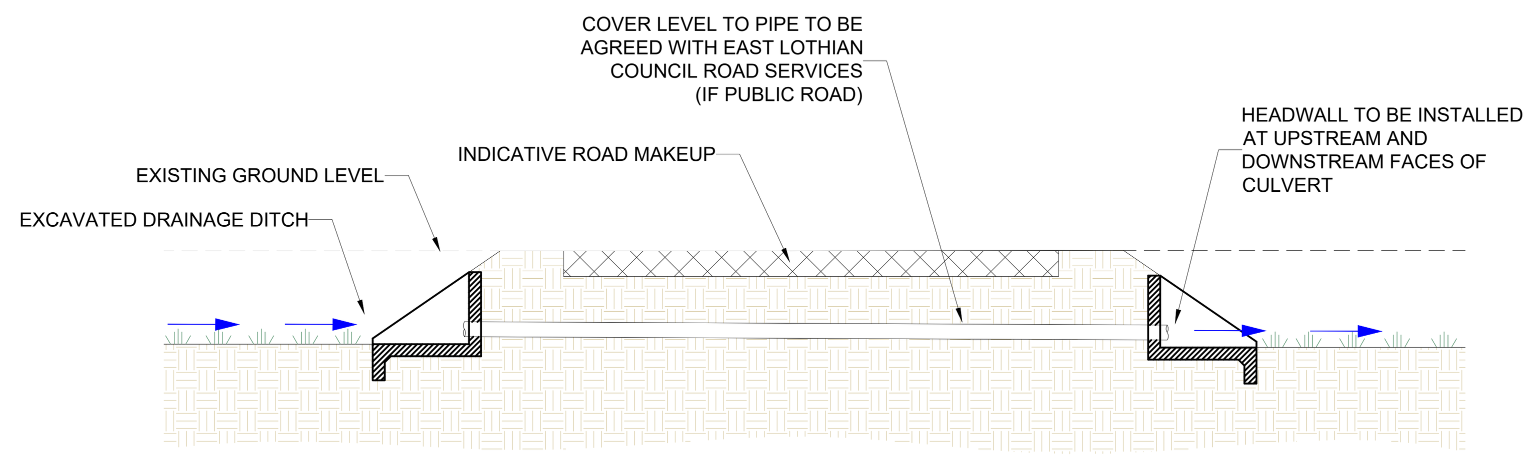
TYPICAL SECTION THROUGH OIL SEPARATOR



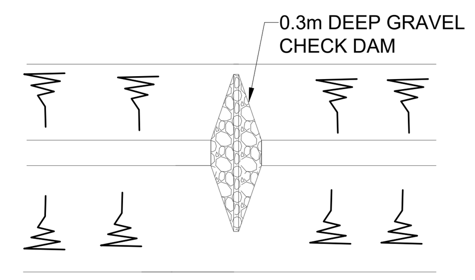
TYPICAL SECTION THROUGH STOCKPILE DRAINAGE



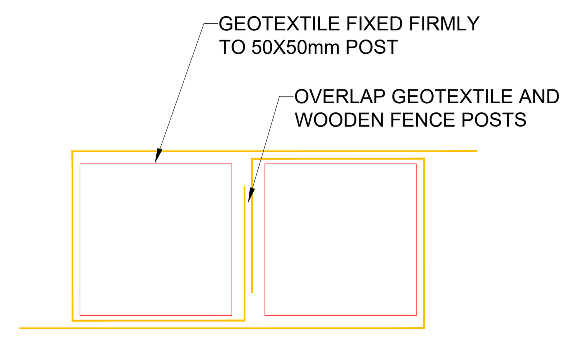
TYPICAL SECTION THROUGH DOWN GRADIENT SILT FENCING AND DRAINAGE



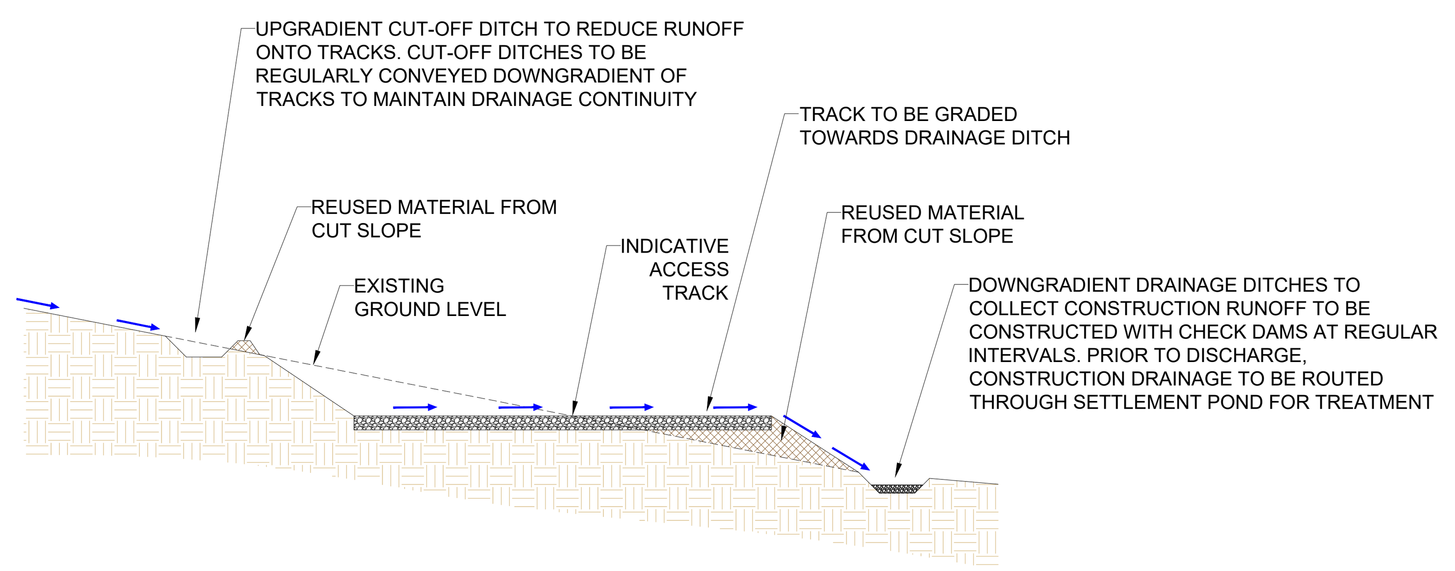
TYPICAL SECTION THROUGH ROAD CULVERT CROSSING



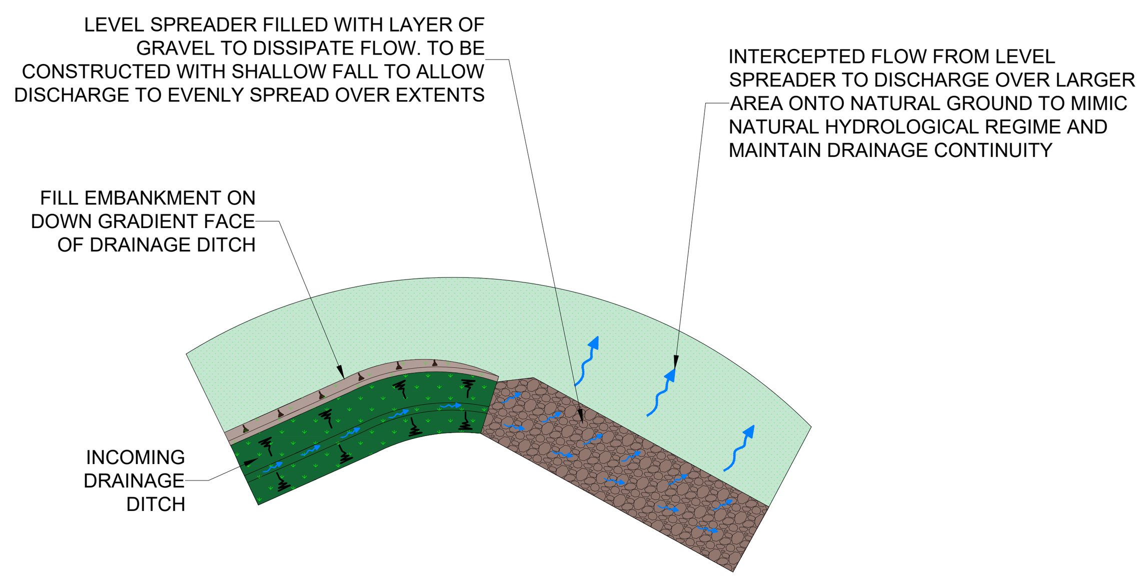
PLAN VIEW OF DRAINAGE DITCH WITH CHECK DAM



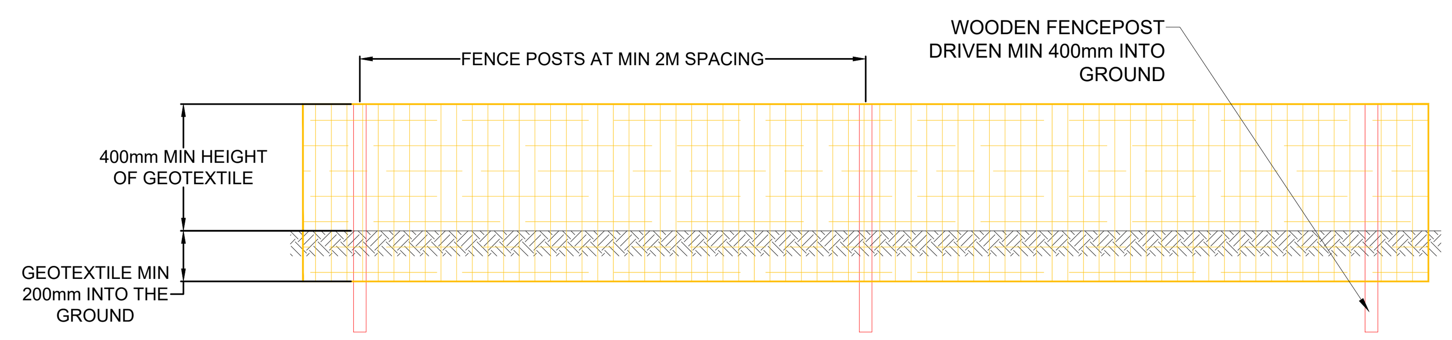
SILT FENCE STANDARD DETAILS FABRIC JOINT



TYPICAL SECTION THROUGH ACCESS TRACK



TYPICAL SECTION THROUGH DRAINAGE DITCH AND LEVEL SPREADER



SILT FENCE STANDARD DETAILS ELEVATION

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01	04/22	SSE-R REVIEW ISSUE	SD	ZR
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CLIENT: SSE RENEWABLES

PROJECT: BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE: **TEMPORARY DRAINAGE WORKS HIGH LEVEL DESIGN DETAILS SHEET 9**

SCALE: NOT TO SCALE | DATE: APRIL 2022

DRAWING NUMBER: TDW-009 | REV: 01

DRAWING STATUS: DRAFT ISSUE

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Appendix A - Innerwick Burn Catchment Assessment

BERWICK BANK OFFSHORE WINDFARM – SUBSTATION SURFACE WATER DRAINAGE DISCHARGE STRATEGY

Context

This technical memo has been prepared to provide a summary of the proposed surface water drainage discharge strategy for the proposed substation for East Lothian Council's consideration and comment on the strategy. Recent discussions with a resident local to the proposed substation location have highlighted that previous attempts to discharge to the unnamed watercourse which is culverted beneath the A1 and railway line have been unsuccessful due to existing constraints on these culverts and downstream culverts (according to the resident).

ITPEnergised and SSE-Renewables have taken this opportunity to provide evidence to show that proposed drainage strategy shall not exacerbate any existing flooding issues to culverts downstream of the proposed drainage scheme and thus the strategy should be considered viable in terms of flood risk.

Proposed Surface Water Drainage Strategy

Overview

The proposed surface water drainage strategy for the operational development will comprise the management of surface water runoff from the substation platform and associated cut embankments and intercepted surface water from the catchment upgradient of the substation. These drained areas will be routed to a SuDS pond that will provide adequate treatment and attenuation of the runoff prior to discharge. The proposed discharge is via a piped outfall to the unnamed watercourse directly upstream from the A1 culvert.

Drawings DRA-001, DRA-002, DRA-003 enclosed provide further details on the proposed drainage strategy.

Greenfield Runoff

The proposed SuDS pond has been designed to attenuate up to and including the 1:200 year event plus an allowance of 35% for climate change whilst limiting the discharge rate to the pre-development greenfield rate of QBAR.

Greenfield runoff rates have been estimated through the application of methodology outlined in IH R124 as set out within the Interim Code of Practice for SuDS for catchment areas of 50ha or less. The analysis was undertaken in the MicroDrainage software suite using hydrological characteristics of the local catchment to the unnamed watercourse. The calculated QBAR rate for the development area is **3.25 l/s/ha**.

Surface Water Drainage Strategy Catchment Analysis

A summary of the contributing catchments generating the inflow to the proposed SuDS pond is shown in Table 1 below.

Table 1 – Catchment Summary

Catchment	Area (ha)	Runoff Coefficient	Effective Impermeable Area (ha)	Notes
Substation Platform and Cut Embankments	12.72	0.75	9.54	• Area measured from 3D design of substation earthworks platform • Runoff Coefficient determined from reference to industry best practice
Upgradient Catchment	11.26	0.47	5.29	• Area determined from catchment analysis of upgradient areas using site-specific topographic survey information • Runoff Coefficient determined from reference to industry best practice and assessment of average slopes and assumption the upgradient land (within SSE-R ownership) will be grass-seeded post construction
Total	**23.98**	-	**14.83**	-

As the above summary shows, the total area drained is **23.98ha** and therefore the equivalent QBAR discharge rate is calculated to be **77.9 l/s**. Therefore, the SuDS pond has been designed to limit all discharges up to and including the 1:200 year event plus 35% climate change to this rate.

SuDS Pond Performance Analysis

The proposed SuDS pond has been designed within the industry standard MicroDrainage software suite and a copy of the modelling results are enclosed. Table 2 below provides a summary of the results with respect to the maximum discharge rate from the pond for a variety of return periods.

The outlet from the pond is proposed to be controlled using a Hydrobrake Optimum chamber designed to the specific QBAR rate and configured for a linear discharge profile (to minimise the outflow during lower return periods).

The summary shows that for the modelled return periods, the maximum outflow rate from the SuDS pond is limited to the calculated QBAR rate 77.9 l/s.

Table 2 – SuDS Pond Discharge Rate Summary

Return Period (1 in X years)	Maximum Outflow Rate (l/s)
1	41
2	42
5	45
10	48
30	54
100	60
200	64
200 (+35% climate change)	75

Watercourse Assessment

Overview

The proposed surface water drainage strategy seeks to discharge to the adjacent unnamed watercourse that originates to the west of the village of Innerwick and discharges to the Dry Burn north of the settlement of Skateraw. Along its route, the watercourse has been highly modified with the inclusion of multiple culverts. This assessment focuses on the culverts located between the proposed substation area and the discharge point to the Dry Burn.

A hydrological summary and catchment characteristics of the watercourse are shown in Table 3 below. The data shown is taken from the FEH Web Service and the and the catchment has been delineated from the culvert opening immediately downstream of the railway next to the old A1 at NGR: NT 73200 75200.

Table 3 – Catchment Characteristics

Waterbody Catchment	Area (km^2)	SAAR[1] (mm)	URBEXT2000[2]	SPRHOST[3] (%)	PROPWET[4]
Unnamed watercourse originating from near to Innerwick and discharging to the Dry Burn	1.74	671	0.0130	33.71	0.43

[1]SAAR – Standard Annual Average Rainfall

[2]URBEXT2000 – Extent of urban and suburban land cover (2000)

[3]SPRHOST – Standard Percentage Runoff using UK hydrology of Soil Types (HOST) Classification

[4]PROPWET = Proportion of time soils spend wet

From the FEH Web Service catchment data it is shown that the area has a very low SAAR value (for Scottish catchments) and that the catchment is essentially completely rural. An SPRHOST value of 33.71 indicates an FSR Soil Type of between 3 and 4 and thus a moderate runoff potential.

Culvert Assessment

Three culverts are present along the watercourse downstream of the proposed substation location and are summarised as follows (numbered upstream to downstream):

1. Culvert beneath A1: A stone lined channel routes the watercourse into a 900mm diameter concrete pipe (See Figures 1 and 2). The slope within the culvert from the upstream and downstream opening is approximately 1 in 40 as measured from the site topographic survey information.
2. Culvert beneath railway line: A concrete / brick lined arch culvert measuring 1000mm wide (see Figure 3). The slope within the culvert has been conservatively estimated based on the slope between the invert levels of upstream openings of culvert 2 and 3 (no downstream invert level was obtained during the survey due to the opening being on Network Rail land) to be approximately 1 in 400 as measured from the site topographic survey information.
3. Culvert beneath old A1 and through Skateraw settlement: An approximately 450m length of culvert in varying sections with access chambers located at direction changes. The original site topographic survey recorded the inlet to the culvert as a 900mm diameter concrete pipe (confirmed during site visit – Figure 4) and the outlet to a be a 800mm diameter concrete pipe. A culvert survey was undertaken by UTEC (see Figure 5) to gather further information along the route of the culvert. Access into the culvert was limited but the type of culvert was observed as both a concrete pipe between 800 and 900mm in diameter (location dependent) and square sections between 800 and 900mm wide (location dependent). The average slope (confirmed by both topographic survey and culvert survey) from upstream and downstream of the full culvert length is approximately 1 in 50.

The capacity of the culverts are summarised in Table 4 below based on the above information and with reference to Table for the Hydraulic Design of Pipes, Sewers and Channels[1], using conservative roughness values.

Table 4 – Culvert Capacity Summary

Culvert	Diameter (mm)	Slope (1 in X)	Roughness Value (mm)	Flow Capacity (l/s)	Notes
1	900	40	0.6	2823	Roughness assumed for precast concrete pipe in poor condition
2	1000	400	18	804	Roughness assumed for unfinished concrete channel in poor condition
3	800	50	18	1248	Roughness assumed for unfinished concrete channel in poor condition

The above results show that the culvert beneath the railway is likely to be the critical component with respect to flood risk as it has the least capacity. It is noted that the slope of this culvert is a conservative estimate and that the actual capacity may be higher.

[1] HR Wallingford and D.I.H. Barr (2006) Table for the Hydraulic Design of Pipes, Sewers and Channels, 8th Edition

Watercourse Flow Analysis

Flows within the watercourse for a range of return periods have been estimated using the industry standard Revitalised Flood Hydrograph V.2 (ReFH2) software in combination with the catchment data obtained from the FEH Web Service. Table 5 below provides a summary of the estimated peak flows in the watercourse based on the contributing catchment up to the opening of culvert 3.

Table 5 – Watercourse Peak Flow Summary

Return Period (1 in X years)	Peak Flow (l/s)
1	439
2	490
5	670
10	813
30	1103
100	1557
200	1867
200 (+35% climate change)	2640

Comparison of Tables 4 and 5 shows that the limiting capacity of Culvert 2 equates to approximately the 1 in 10 year event, at which point the culvert would be unable to convey the expected peak flow unhindered.

Pre-Development and Post-Development Comparison

Overview

The existing flow within the unnamed watercourse and its limitations in conveying higher flows due to culvert capacities have been shown in the above sections. The proposed drainage strategy seeks to alter how a small proportion of the catchment is managed in terms of its runoff rate and how it enters the watercourse.

Drawing CA-001 enclosed provides a summary of the pre and post contributing catchments to the watercourse. The proposed substation location is on the boundary of the drained catchment to the watercourse. As such, some of the substation development area and upgradient areas do not currently drain to the watercourse. The drainage strategy has shown that all captured areas will be discharged to the watercourse and therefore there is a slight increase to the overall drained catchment size (approximately 6% increase).

Given that the SuDS pond has been designed to attenuate all design flows to a maximum of the pre-development QBAR it is shown in the following section how this design criteria negates the impact on flow rates within the watercourse due to the additional catchment area proposed to drain to it.

Peak Flow Analysis

The proposed drainage strategy is designed to properly manage surface water runoff from the development but also to ensure no detrimental impact to flood risk downstream. To demonstrate that no detrimental impact to flood risk downstream, a comparison of pre and post development peak flows is shown in Table 6.

Return Period (1 in X years)	Pre-Development Peak Flow[1] (l/s)	Post-Development Peak Flow from Remaining Catchment[2] (l/s)	Post-Development Peak Flow from Drainage System[3] (l/s)	Total Post-Development Peak Flow[4] (l/s)
1	**439**	403	41	**444**
2	**490**	451	42	**493**
5	**670**	616	45	**661**
10	**813**	748	48	**796**
30	**1103**	1014	54	**1064**
100	**1557**	1432	60	**1492**
200	**1867**	1717	64	**1781**
200 (+35% climate change)	**2640**	2428	75	**2503**

[1] Taken from Table 5

[2] Calculated from ReFH2 using a revised catchment area of 160ha -*'174ha (original catchment area) – 14ha (drained area originally within watercourse catchment)'*

[3] Taken from Table 2

[4] Sum of post development flows

The above analysis shows that up to and including the 1 in 2 year event, the post-development peak flow within the watercourse is increased marginally by approximately 1%. From the 1 in 5 year event and greater, the post-development peak flow is less than the pre-development peak up to a maximum of a 5% decrease for the design climate change event. Critically the analysis shows that the proposed drainage system will not detrimentally impact flows in the watercourse during the 1 in 10 year event which has shown to be the threshold at which the capacity of the downstream culverts would be exceeded (via cross reference to Table 4).

Overall, the proposed drainage system has a negligible impact on peak flows in the watercourse for lower return periods and slight reduction in flows during higher return periods.

Conclusions

The proposed surface water drainage strategy for the substation development for Berwick Bank Offshore Windfarm seeks to drain the development area and upgradient catchment runoff via a purpose built SuDS pond discharging to the adjacent unnamed watercourse. The proposed discharge will be attenuated to the pre-development QBAR runoff rate.

This report has assessed the existing condition and capacity of the watercourse and associated culverts to quantify any potential impact the proposed drainage strategy may have on any pre-existing flooding issues. The assessment has shown that the culvert beneath the railway line to the north of the A1 is likely to be the principal constraining component of the watercourse's ability to convey flow. It has been estimated that this culvert is able to convey approximately up to the respective peak flow of the 1 in 10 year return period storm event.

An assessment of pre-development and post-development peak flows within the watercourse has been undertaken to determine if the proposed drainage strategy has a detrimental impact on flows within the watercourse and may exacerbate the existing flood risk associated with the culvert capacity. The post-development drained area includes additional catchment not currently draining to the watercourse due to the proposed substation location being situated on the catchment divide. The impact of this additional catchment area is largely negated by the design criteria limiting the discharge from the proposed drainage system to pre-development QBAR rates for all return periods.

The comparison of pre-development to post-development peak flows indicate that during low return periods, the peak flow is marginally increased, whereas for the more critical higher return periods, peak flows are marginally decreased. Critically, post-development peak flows for the 1 in 10 year return period (the estimated capacity of the critical culvert) are less than pre-development rates and thus the proposed drainage strategy does not exacerbate downstream flood risk.

Figures

Figure 1 – Stone line channel at A1 culvert entry

Figure 2 – A1 culvert entry (900mm concrete pipe)

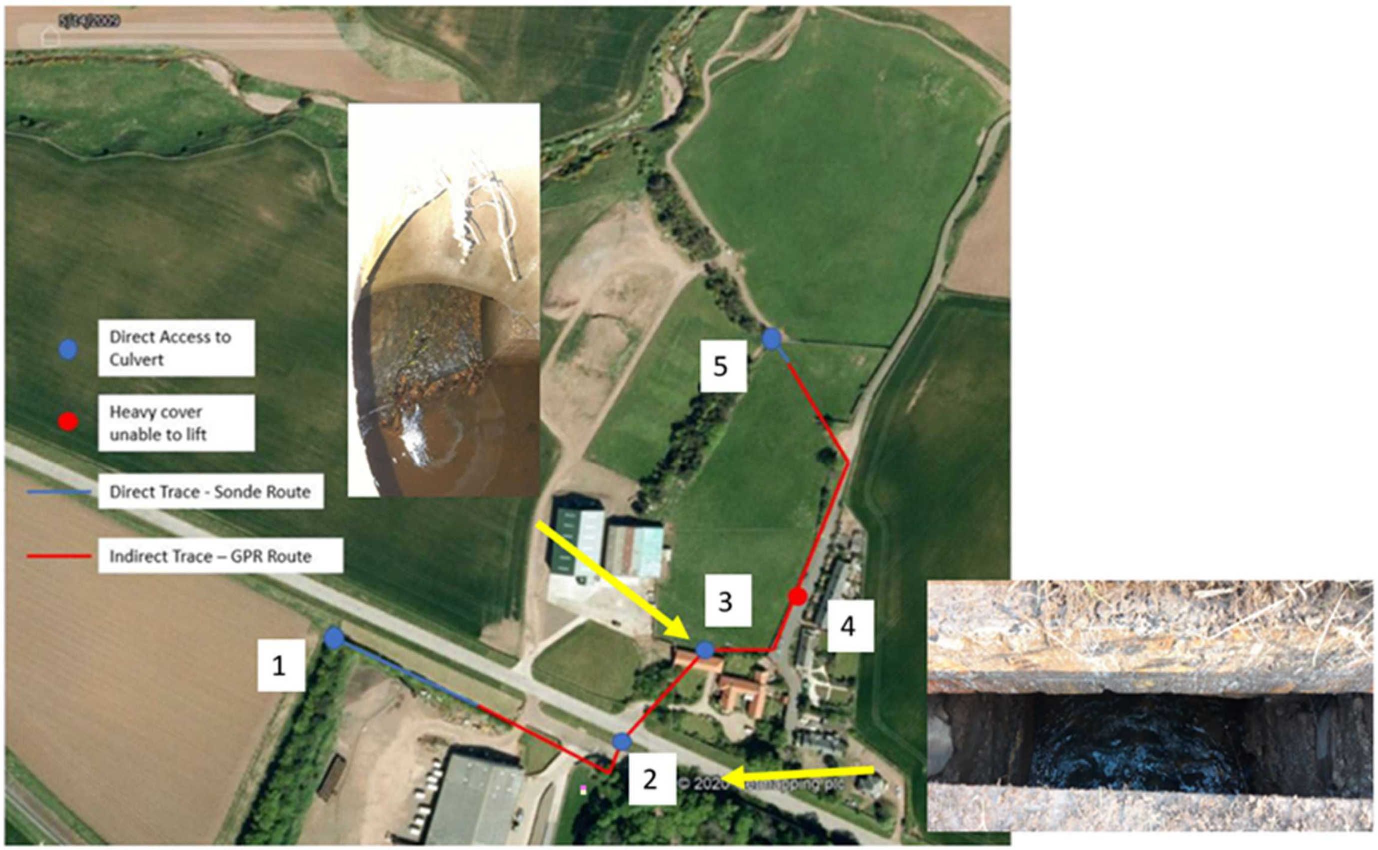
Figure 3 – Railway culvert exit (1000mm wide concrete / brick lined arch culvert)

Figure 4 – Old A1 / Skateraw culvert entry (900mm concrete pipe)

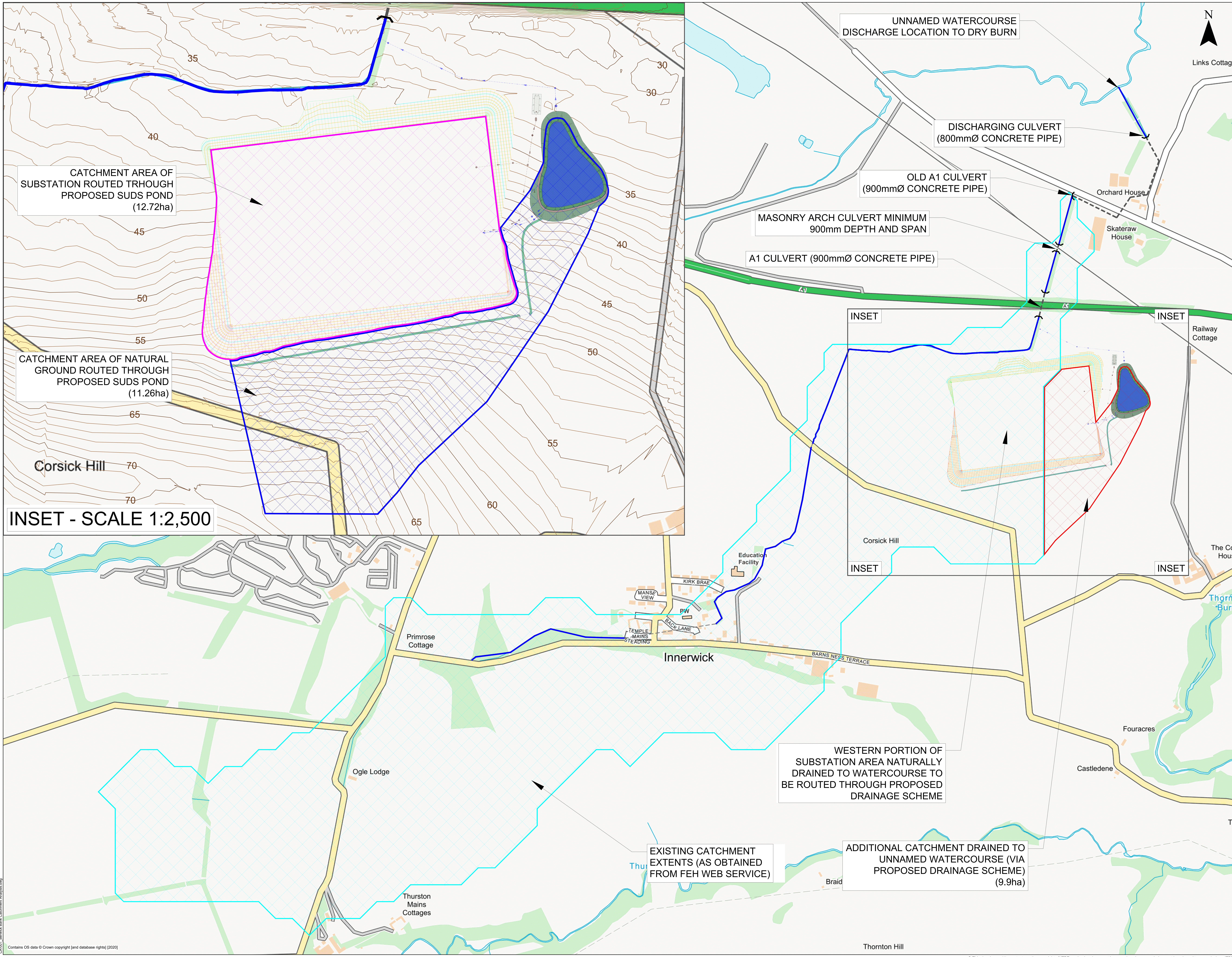
Figure 5 – Old A1 / Skateraw culvert details (from UTEC survey)

Access Point 1 – Approx. 900mm pipe Invert Level 26.96 AOD
Access Point 2 – Stone Cut and Cover Trench Construction. Approx. 900mm wide, 1.3m deep (see photo)
Access Point 3 – Concrete square section construction. Approx. 800mm wide 1.85m deep (see photo)
No access at point 4
Access Point 5 – 800mm (Assumed Concrete) Pipe outfalls into burn. Invert Level 17.85 AOD

Please note access was severely limited to the culvert and even where direct access could be gained measurement was difficult.



Drawings



NOTES

1. REFER TO PROVIDED DRAINAGE STRATEGY DRAWING FOR FURTHER DETAILS ON PROPOSED STRATEGY.
2. CULVERT DETAILS OBTAINED FROM COMBINATION OF SITE WALKOVER AND INFORMATION GATHERED FROM CCTV SURVEY UNDERTAKEN BY UTEC.

LEGEND

- SUBJECT WATERCOURSE (UNNAMED)
- EXISTING CULVERT (DOWNSTREAM)
- EXISTING CULVERT (UPSTREAM - NOT ASSESSED)
- ORIGINAL CATCHMENT TO WATERCOURSE
- ADDITIONAL CATCHMENT TO WATERCOURSE
- SUBSTATION CATCHMENT DRAINED TO SUDS POND
- NATURAL GROUND CATCHMENT DRAINED TO SUDS POND
- MAJOR CONTOURS (5m INTERVALS)
- MINOR CONTOURS (1m INTERVALS)

REV	DATE	DESCRIPTION	BY	CHK
00	03/22	INITIAL ISSUE	SD	ZR

CLIENT: SSE RENEWABLES

PROJECT: BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
SUBSTATION 8 DRAINAGE STRATEGY CATCHMENT ANALYSIS

SCALE: 1:5,000 (PLAN) @ A1

DATE: MARCH 2022

DRAWING NUMBER: **CA-001**

REV: **00**

DRAWING STATUS: FOR INFORMATION

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Appendix B - MicroDrainage SourceControl Modelling Extracts

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	13.700	Shortest Storm (mins)	15
Ratio R	0.250	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 14.830

Time From:	**(mins) To:**	**Area (ha)**
0	4	14.830

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	7210.0	0.500	7750.0	1.000	8300.0	1.500	8860.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0254-7700-1500-7700
Design Head (m)	1.500
Design Flow (l/s)	77.0
Flush-Flo™	Calculated
Objective	Linear discharge profile
Application	Surface
Sump Available	Yes
Diameter (mm)	254
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	77.0
Flush-Flo™	0.294	40.9
Kick-Flo®	0.380	39.7
Mean Flow over Head Range	-	51.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.1	1.200	69.1	3.000	107.9	7.000	163.2
0.200	28.7	1.400	74.5	3.500	116.3	7.500	168.8
0.300	40.9	1.600	79.4	4.000	124.1	8.000	174.2
0.400	40.7	1.800	84.1	4.500	131.5	8.500	179.5
0.500	45.3	2.000	88.5	5.000	138.4	9.000	184.6
0.600	49.5	2.200	92.7	5.500	145.0	9.500	189.5
0.800	56.8	2.400	96.7	6.000	151.3		
1.000	63.3	2.600	100.6	6.500	157.4		

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.077	0.077	5.5	554.8	O K
30 min Summer	0.106	0.106	10.0	767.3	O K
60 min Summer	0.140	0.140	16.5	1020.6	O K
120 min Summer	0.180	0.180	24.6	1311.9	O K
180 min Summer	0.204	0.204	29.5	1490.2	O K
240 min Summer	0.220	0.220	32.5	1613.1	O K
360 min Summer	0.241	0.241	36.0	1771.8	O K
480 min Summer	0.257	0.257	38.5	1889.4	O K
600 min Summer	0.270	0.270	40.3	1984.5	O K
720 min Summer	0.281	0.281	40.9	2065.3	O K
960 min Summer	0.298	0.298	40.9	2194.6	O K
1440 min Summer	0.317	0.317	40.9	2339.5	O K
2160 min Summer	0.328	0.328	40.9	2422.5	O K
2880 min Summer	0.328	0.328	40.9	2424.8	O K
4320 min Summer	0.316	0.316	40.9	2330.2	O K
5760 min Summer	0.298	0.298	40.9	2196.6	O K
7200 min Summer	0.280	0.280	40.9	2061.3	O K
8640 min Summer	0.266	0.266	39.8	1956.9	O K
10080 min Summer	0.255	0.255	38.1	1871.1	O K
15 min Winter	0.086	0.086	6.8	621.1	O K
30 min Winter	0.118	0.118	12.2	858.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	20.046	0.0	262.1	19
30 min Summer	13.951	0.0	422.6	34
60 min Summer	9.417	0.0	801.5	64
120 min Summer	6.255	0.0	1122.8	122
180 min Summer	4.906	0.0	1353.5	182
240 min Summer	4.127	0.0	1540.3	240
360 min Summer	3.233	0.0	1840.8	332
480 min Summer	2.719	0.0	2083.8	384
600 min Summer	2.378	0.0	2290.9	446
720 min Summer	2.132	0.0	2472.5	514
960 min Summer	1.795	0.0	2781.1	656
1440 min Summer	1.401	0.0	3230.5	938
2160 min Summer	1.093	0.0	4157.1	1360
2880 min Summer	0.915	0.0	4635.6	1760
4320 min Summer	0.714	0.0	5349.3	2548
5760 min Summer	0.599	0.0	6273.2	3288
7200 min Summer	0.522	0.0	6808.9	3968
8640 min Summer	0.466	0.0	7260.7	4680
10080 min Summer	0.423	0.0	7623.9	5448
15 min Winter	20.046	0.0	310.0	19
30 min Winter	13.951	0.0	495.3	33

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.157	0.157	19.8	1141.9	O K
120 min Winter	0.201	0.201	28.9	1467.6	O K
180 min Winter	0.228	0.228	33.8	1669.0	O K
240 min Winter	0.247	0.247	36.9	1810.7	O K
360 min Winter	0.272	0.272	40.6	1997.0	O K
480 min Winter	0.288	0.288	40.9	2122.5	O K
600 min Winter	0.302	0.302	40.9	2229.7	O K
720 min Winter	0.314	0.314	40.9	2317.4	O K
960 min Winter	0.331	0.331	40.9	2444.6	O K
1440 min Winter	0.346	0.346	40.9	2559.3	O K
2160 min Winter	0.348	0.348	40.9	2572.3	O K
2880 min Winter	0.338	0.338	40.9	2496.3	O K
4320 min Winter	0.307	0.307	40.9	2261.1	O K
5760 min Winter	0.277	0.277	40.9	2035.5	O K
7200 min Winter	0.256	0.256	38.2	1880.4	O K
8640 min Winter	0.239	0.239	35.7	1754.9	O K
10080 min Winter	0.225	0.225	33.4	1652.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	9.417	0.0	919.2	62
120 min Winter	6.255	0.0	1281.6	120
180 min Winter	4.906	0.0	1541.3	178
240 min Winter	4.127	0.0	1751.3	234
360 min Winter	3.233	0.0	2089.0	342
480 min Winter	2.719	0.0	2361.1	438
600 min Winter	2.378	0.0	2592.1	476
720 min Winter	2.132	0.0	2794.4	556
960 min Winter	1.795	0.0	3138.0	714
1440 min Winter	1.401	0.0	3636.5	1026
2160 min Winter	1.093	0.0	4674.6	1472
2880 min Winter	0.915	0.0	5213.8	1900
4320 min Winter	0.714	0.0	6025.2	2680
5760 min Winter	0.599	0.0	7040.2	3392
7200 min Winter	0.522	0.0	7643.5	4104
8640 min Winter	0.466	0.0	8155.2	4840
10080 min Winter	0.423	0.0	8573.6	5552

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.093	0.093	7.9	673.5	O K
30 min Summer	0.127	0.127	13.8	923.5	O K
60 min Summer	0.168	0.168	22.1	1224.2	O K
120 min Summer	0.214	0.214	31.3	1567.0	O K
180 min Summer	0.242	0.242	36.1	1773.3	O K
240 min Summer	0.260	0.260	38.8	1908.4	O K
360 min Summer	0.284	0.284	40.9	2093.6	O K
480 min Summer	0.304	0.304	40.9	2243.8	O K
600 min Summer	0.320	0.320	40.9	2358.7	O K
720 min Summer	0.332	0.332	40.9	2453.0	O K
960 min Summer	0.351	0.351	40.9	2598.7	O K
1440 min Summer	0.375	0.375	40.9	2779.0	O K
2160 min Summer	0.389	0.389	40.9	2888.6	O K
2880 min Summer	0.390	0.390	40.9	2894.9	O K
4320 min Summer	0.376	0.376	40.9	2788.7	O K
5760 min Summer	0.353	0.353	40.9	2614.8	O K
7200 min Summer	0.329	0.329	40.9	2426.2	O K
8640 min Summer	0.306	0.306	40.9	2253.8	O K
10080 min Summer	0.287	0.287	40.9	2109.9	O K
15 min Winter	0.104	0.104	9.7	753.9	O K
30 min Winter	0.142	0.142	16.8	1033.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	24.357	0.0	349.0	19
30 min Summer	16.821	0.0	548.3	34
60 min Summer	11.335	0.0	1001.8	64
120 min Summer	7.514	0.0	1389.5	122
180 min Summer	5.871	0.0	1661.7	182
240 min Summer	4.905	0.0	1872.1	240
360 min Summer	3.821	0.0	2216.9	344
480 min Summer	3.209	0.0	2499.1	406
600 min Summer	2.795	0.0	2729.5	476
720 min Summer	2.497	0.0	2929.4	542
960 min Summer	2.090	0.0	3264.8	684
1440 min Summer	1.627	0.0	3762.7	968
2160 min Summer	1.266	0.0	4836.8	1384
2880 min Summer	1.057	0.0	5373.9	1792
4320 min Summer	0.820	0.0	6170.7	2596
5760 min Summer	0.685	0.0	7186.2	3352
7200 min Summer	0.594	0.0	7775.7	4104
8640 min Summer	0.529	0.0	8270.6	4760
10080 min Summer	0.480	0.0	8666.7	5456
15 min Winter	24.357	0.0	410.5	19
30 min Winter	16.821	0.0	639.4	33

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.187	0.187	26.1	1370.1	O K
120 min Winter	0.239	0.239	35.7	1755.4	O K
180 min Winter	0.271	0.271	40.4	1990.1	O K
240 min Winter	0.292	0.292	40.9	2151.6	O K
360 min Winter	0.324	0.324	40.9	2392.1	O K
480 min Winter	0.347	0.347	40.9	2563.6	O K
600 min Winter	0.362	0.362	40.9	2680.3	O K
720 min Winter	0.374	0.374	40.9	2772.9	O K
960 min Winter	0.393	0.393	40.9	2917.8	O K
1440 min Winter	0.412	0.412	41.3	3065.0	O K
2160 min Winter	0.418	0.418	41.6	3103.7	O K
2880 min Winter	0.408	0.408	41.1	3034.3	O K
4320 min Winter	0.374	0.374	40.9	2769.9	O K
5760 min Winter	0.331	0.331	40.9	2446.5	O K
7200 min Winter	0.293	0.293	40.9	2159.2	O K
8640 min Winter	0.268	0.268	40.0	1968.0	O K
10080 min Winter	0.250	0.250	37.4	1839.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	11.335	0.0	1145.1	62
120 min Winter	7.514	0.0	1581.4	120
180 min Winter	5.871	0.0	1887.2	178
240 min Winter	4.905	0.0	2123.1	234
360 min Winter	3.821	0.0	2507.8	346
480 min Winter	3.209	0.0	2822.3	456
600 min Winter	2.795	0.0	3078.7	556
720 min Winter	2.497	0.0	3300.6	588
960 min Winter	2.090	0.0	3672.1	740
1440 min Winter	1.627	0.0	4219.0	1052
2160 min Winter	1.266	0.0	5434.0	1512
2880 min Winter	1.057	0.0	6037.2	1936
4320 min Winter	0.820	0.0	6941.1	2768
5760 min Winter	0.685	0.0	8063.0	3520
7200 min Winter	0.594	0.0	8726.9	4184
8640 min Winter	0.529	0.0	9287.4	4848
10080 min Winter	0.480	0.0	9743.6	5552

Summary of Results for 5 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.115	0.115	11.7	839.5	O K
30 min Summer	0.158	0.158	20.0	1150.2	O K
60 min Summer	0.206	0.206	29.9	1510.2	O K
120 min Summer	0.260	0.260	38.9	1912.8	O K
180 min Summer	0.293	0.293	40.9	2160.5	O K
240 min Summer	0.318	0.318	40.9	2343.8	O K
360 min Summer	0.352	0.352	40.9	2601.3	O K
480 min Summer	0.374	0.374	40.9	2774.1	O K
600 min Summer	0.391	0.391	40.9	2902.5	O K
720 min Summer	0.404	0.404	40.9	3004.0	O K
960 min Summer	0.425	0.425	41.9	3157.3	O K
1440 min Summer	0.449	0.449	43.0	3342.6	O K
2160 min Summer	0.463	0.463	43.7	3452.8	O K
2880 min Summer	0.464	0.464	43.7	3463.6	O K
4320 min Summer	0.450	0.450	43.1	3355.3	O K
5760 min Summer	0.428	0.428	42.1	3181.7	O K
7200 min Summer	0.403	0.403	40.9	2992.1	O K
8640 min Summer	0.376	0.376	40.9	2790.2	O K
10080 min Summer	0.350	0.350	40.9	2585.8	O K
15 min Winter	0.129	0.129	14.3	939.7	O K
30 min Winter	0.176	0.176	23.8	1287.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	30.394	0.0	477.9	19
30 min Summer	20.996	0.0	738.7	34
60 min Summer	14.036	0.0	1287.1	64
120 min Summer	9.203	0.0	1749.5	122
180 min Summer	7.153	0.0	2071.9	182
240 min Summer	5.973	0.0	2326.7	242
360 min Summer	4.626	0.0	2726.3	360
480 min Summer	3.856	0.0	3040.0	468
600 min Summer	3.348	0.0	3301.3	522
720 min Summer	2.982	0.0	3526.2	586
960 min Summer	2.483	0.0	3898.5	714
1440 min Summer	1.918	0.0	4429.4	984
2160 min Summer	1.481	0.0	5681.2	1404
2880 min Summer	1.233	0.0	6289.2	1816
4320 min Summer	0.951	0.0	7185.0	2636
5760 min Summer	0.792	0.0	8323.8	3408
7200 min Summer	0.687	0.0	9003.3	4184
8640 min Summer	0.611	0.0	9576.4	4936
10080 min Summer	0.554	0.0	10038.0	5648
15 min Winter	30.394	0.0	558.7	19
30 min Winter	20.996	0.0	856.5	33

Summary of Results for 5 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.231	0.231	34.3	1691.4	O K
120 min Winter	0.292	0.292	40.9	2147.5	O K
180 min Winter	0.330	0.330	40.9	2441.0	O K
240 min Winter	0.359	0.359	40.9	2657.7	O K
360 min Winter	0.399	0.399	40.9	2963.3	O K
480 min Winter	0.425	0.425	41.9	3160.3	O K
600 min Winter	0.442	0.442	42.7	3295.2	O K
720 min Winter	0.455	0.455	43.3	3390.0	O K
960 min Winter	0.474	0.474	44.2	3538.4	O K
1440 min Winter	0.495	0.495	45.1	3702.0	O K
2160 min Winter	0.501	0.501	45.4	3746.8	O K
2880 min Winter	0.492	0.492	45.0	3680.0	O K
4320 min Winter	0.458	0.458	43.5	3417.0	O K
5760 min Winter	0.417	0.417	41.6	3100.1	O K
7200 min Winter	0.372	0.372	40.9	2752.9	O K
8640 min Winter	0.326	0.326	40.9	2408.8	O K
10080 min Winter	0.291	0.291	40.9	2142.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	14.036	0.0	1466.2	62
120 min Winter	9.203	0.0	1985.2	120
180 min Winter	7.153	0.0	2345.2	178
240 min Winter	5.973	0.0	2629.3	236
360 min Winter	4.626	0.0	3074.3	350
480 min Winter	3.856	0.0	3424.6	462
600 min Winter	3.348	0.0	3716.1	568
720 min Winter	2.982	0.0	3966.3	664
960 min Winter	2.483	0.0	4377.8	752
1440 min Winter	1.918	0.0	4951.8	1068
2160 min Winter	1.481	0.0	6379.9	1516
2880 min Winter	1.233	0.0	7059.6	1964
4320 min Winter	0.951	0.0	8064.8	2812
5760 min Winter	0.792	0.0	9336.5	3632
7200 min Winter	0.687	0.0	10102.1	4400
8640 min Winter	0.611	0.0	10751.1	5104
10080 min Winter	0.554	0.0	11282.5	5744

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.133	0.133	15.1	970.2	O K
30 min Summer	0.183	0.183	25.2	1336.0	O K
60 min Summer	0.239	0.239	35.7	1757.1	O K
120 min Summer	0.302	0.302	40.9	2223.9	O K
180 min Summer	0.341	0.341	40.9	2523.6	O K
240 min Summer	0.370	0.370	40.9	2743.6	O K
360 min Summer	0.410	0.410	41.2	3046.3	O K
480 min Summer	0.435	0.435	42.4	3235.1	O K
600 min Summer	0.452	0.452	43.2	3365.1	O K
720 min Summer	0.466	0.466	43.8	3472.6	O K
960 min Summer	0.487	0.487	44.7	3635.1	O K
1440 min Summer	0.512	0.512	45.9	3832.4	O K
2160 min Summer	0.527	0.527	46.5	3949.0	O K
2880 min Summer	0.528	0.528	46.5	3957.5	O K
4320 min Summer	0.512	0.512	45.9	3834.3	O K
5760 min Summer	0.487	0.487	44.8	3642.2	O K
7200 min Summer	0.460	0.460	43.6	3433.5	O K
8640 min Summer	0.434	0.434	42.3	3228.1	O K
10080 min Summer	0.408	0.408	41.1	3029.6	O K
15 min Winter	0.149	0.149	18.2	1086.0	O K
30 min Winter	0.204	0.204	29.6	1495.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	35.153	0.0	583.7	19
30 min Summer	24.424	0.0	899.4	34
60 min Summer	16.360	0.0	1534.4	64
120 min Summer	10.685	0.0	2065.8	122
180 min Summer	8.280	0.0	2430.4	182
240 min Summer	6.897	0.0	2716.0	242
360 min Summer	5.321	0.0	3160.9	360
480 min Summer	4.423	0.0	3508.8	480
600 min Summer	3.830	0.0	3796.8	548
720 min Summer	3.404	0.0	4042.7	606
960 min Summer	2.826	0.0	4444.5	732
1440 min Summer	2.172	0.0	4994.9	998
2160 min Summer	1.670	0.0	6421.3	1424
2880 min Summer	1.385	0.0	7079.7	1844
4320 min Summer	1.064	0.0	8039.5	2640
5760 min Summer	0.882	0.0	9280.6	3456
7200 min Summer	0.762	0.0	10008.7	4248
8640 min Summer	0.677	0.0	10621.1	5008
10080 min Summer	0.612	0.0	11113.1	5752
15 min Winter	35.153	0.0	679.8	19
30 min Winter	24.424	0.0	1038.9	33

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.268	0.268	40.0	1969.3	O K
120 min Winter	0.339	0.339	40.9	2505.1	O K
180 min Winter	0.384	0.384	40.9	2850.9	O K
240 min Winter	0.417	0.417	41.6	3100.6	O K
360 min Winter	0.462	0.462	43.6	3443.5	O K
480 min Winter	0.491	0.491	44.9	3668.0	O K
600 min Winter	0.511	0.511	45.8	3822.7	O K
720 min Winter	0.525	0.525	46.4	3931.1	O K
960 min Winter	0.544	0.544	47.2	4083.0	O K
1440 min Winter	0.568	0.568	48.2	4265.3	O K
2160 min Winter	0.574	0.574	48.4	4319.0	O K
2880 min Winter	0.565	0.565	48.1	4247.8	O K
4320 min Winter	0.529	0.529	46.6	3960.9	O K
5760 min Winter	0.484	0.484	44.6	3618.3	O K
7200 min Winter	0.440	0.440	42.6	3276.2	O K
8640 min Winter	0.396	0.396	40.9	2940.2	O K
10080 min Winter	0.348	0.348	40.9	2571.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	16.360	0.0	1743.9	62
120 min Winter	10.685	0.0	2338.0	120
180 min Winter	8.280	0.0	2744.4	178
240 min Winter	6.897	0.0	3063.0	236
360 min Winter	5.321	0.0	3559.7	352
480 min Winter	4.423	0.0	3947.1	464
600 min Winter	3.830	0.0	4266.7	572
720 min Winter	3.404	0.0	4538.5	674
960 min Winter	2.826	0.0	4978.4	770
1440 min Winter	2.172	0.0	5555.9	1080
2160 min Winter	1.670	0.0	7207.6	1536
2880 min Winter	1.385	0.0	7943.8	1988
4320 min Winter	1.064	0.0	9005.6	2852
5760 min Winter	0.882	0.0	10407.6	3688
7200 min Winter	0.762	0.0	11227.8	4472
8640 min Winter	0.677	0.0	11921.3	5272
10080 min Winter	0.612	0.0	12488.5	5952

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.167	0.167	22.0	1220.1	O K
30 min Summer	0.231	0.231	34.4	1694.6	O K
60 min Summer	0.304	0.304	40.9	2240.8	O K
120 min Summer	0.384	0.384	40.9	2847.0	O K
180 min Summer	0.434	0.434	42.3	3227.2	O K
240 min Summer	0.469	0.469	43.9	3496.4	O K
360 min Summer	0.516	0.516	46.0	3861.9	O K
480 min Summer	0.546	0.546	47.3	4095.3	O K
600 min Summer	0.566	0.566	48.1	4249.4	O K
720 min Summer	0.580	0.580	48.7	4365.0	O K
960 min Summer	0.603	0.603	49.6	4544.4	O K
1440 min Summer	0.631	0.631	50.7	4760.0	O K
2160 min Summer	0.647	0.647	51.3	4887.7	O K
2880 min Summer	0.647	0.647	51.3	4891.3	O K
4320 min Summer	0.628	0.628	50.6	4738.1	O K
5760 min Summer	0.598	0.598	49.4	4504.2	O K
7200 min Summer	0.566	0.566	48.1	4254.9	O K
8640 min Summer	0.535	0.535	46.8	4009.2	O K
10080 min Summer	0.505	0.505	45.5	3776.0	O K
15 min Winter	0.187	0.187	26.0	1365.8	O K
30 min Winter	0.258	0.258	38.6	1898.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	44.268	0.0	793.5	19
30 min Summer	31.039	0.0	1215.8	34
60 min Summer	20.858	0.0	2014.4	64
120 min Summer	13.539	0.0	2669.5	122
180 min Summer	10.442	0.0	3111.5	182
240 min Summer	8.663	0.0	3453.9	242
360 min Summer	6.643	0.0	3981.7	362
480 min Summer	5.495	0.0	4387.5	480
600 min Summer	4.740	0.0	4718.3	594
720 min Summer	4.200	0.0	4996.0	642
960 min Summer	3.468	0.0	5435.4	762
1440 min Summer	2.647	0.0	5963.2	1026
2160 min Summer	2.019	0.0	7789.2	1448
2880 min Summer	1.666	0.0	8533.7	1848
4320 min Summer	1.269	0.0	9571.4	2680
5760 min Summer	1.045	0.0	11023.4	3464
7200 min Summer	0.899	0.0	11833.5	4256
8640 min Summer	0.795	0.0	12511.3	5024
10080 min Summer	0.716	0.0	13053.3	5848
15 min Winter	44.268	0.0	918.8	19
30 min Winter	31.039	0.0	1395.4	33

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.341	0.341	40.9	2517.3	O K
120 min Winter	0.430	0.430	42.2	3201.0	O K
180 min Winter	0.486	0.486	44.7	3628.8	O K
240 min Winter	0.525	0.525	46.4	3935.2	O K
360 min Winter	0.579	0.579	48.6	4358.1	O K
480 min Winter	0.615	0.615	50.1	4636.0	O K
600 min Winter	0.639	0.639	51.0	4828.2	O K
720 min Winter	0.656	0.656	51.7	4963.6	O K
960 min Winter	0.677	0.677	52.4	5127.4	O K
1440 min Winter	0.703	0.703	53.4	5335.3	O K
2160 min Winter	0.712	0.712	53.7	5403.4	O K
2880 min Winter	0.702	0.702	53.3	5323.7	O K
4320 min Winter	0.659	0.659	51.8	4988.8	O K
5760 min Winter	0.608	0.608	49.8	4586.1	O K
7200 min Winter	0.558	0.558	47.8	4188.0	O K
8640 min Winter	0.509	0.509	45.7	3812.3	O K
10080 min Winter	0.464	0.464	43.7	3464.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	20.858	0.0	2280.5	62
120 min Winter	13.539	0.0	3011.1	120
180 min Winter	10.442	0.0	3504.4	180
240 min Winter	8.663	0.0	3886.0	238
360 min Winter	6.643	0.0	4472.4	352
480 min Winter	5.495	0.0	4920.9	466
600 min Winter	4.740	0.0	5283.7	576
720 min Winter	4.200	0.0	5585.2	684
960 min Winter	3.468	0.0	6050.3	874
1440 min Winter	2.647	0.0	6535.2	1096
2160 min Winter	2.019	0.0	8736.2	1560
2880 min Winter	1.666	0.0	9565.8	2016
4320 min Winter	1.269	0.0	10693.4	2896
5760 min Winter	1.045	0.0	12357.8	3744
7200 min Winter	0.899	0.0	13270.1	4536
8640 min Winter	0.795	0.0	14037.9	5352
10080 min Winter	0.716	0.0	14662.8	6144

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Summer	0.214	0.214	31.4	1568.9	O K
30 min Summer	0.299	0.299	40.9	2203.3	O K
60 min Summer	0.396	0.396	40.9	2941.9	O K
120 min Summer	0.497	0.497	45.2	3717.2	O K
180 min Summer	0.559	0.559	47.8	4196.4	O K
240 min Summer	0.602	0.602	49.5	4535.0	O K
360 min Summer	0.660	0.660	51.8	4994.8	O K
480 min Summer	0.697	0.697	53.2	5289.1	O K
600 min Summer	0.722	0.722	54.1	5486.1	O K
720 min Summer	0.738	0.738	54.7	5618.4	O K
960 min Summer	0.762	0.762	55.5	5810.8	O K
1440 min Summer	0.791	0.791	56.5	6042.7	O K
2160 min Summer	0.808	0.808	57.1	6180.0	O K
2880 min Summer	0.808	0.808	57.1	6173.9	O K
4320 min Summer	0.783	0.783	56.2	5977.9	O K
5760 min Summer	0.747	0.747	55.0	5688.8	O K
7200 min Summer	0.709	0.709	53.6	5381.8	O K
8640 min Summer	0.671	0.671	52.2	5080.1	O K
10080 min Summer	0.635	0.635	50.8	4793.2	O K
15 min Winter	0.239	0.239	35.7	1756.6	O K
30 min Winter	0.335	0.335	40.9	2471.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m^3)	Discharge Volume (m^3)	Time-Peak (mins)
15 min Summer	56.993	0.0	1095.8	19
30 min Summer	40.363	0.0	1664.5	34
60 min Summer	27.220	0.0	2688.0	64
120 min Summer	17.549	0.0	3510.0	122
180 min Summer	13.465	0.0	4054.9	182
240 min Summer	11.121	0.0	4469.2	242
360 min Summer	8.470	0.0	5095.7	362
480 min Summer	6.970	0.0	5564.7	480
600 min Summer	5.988	0.0	5935.4	600
720 min Summer	5.287	0.0	6234.8	700
960 min Summer	4.341	0.0	6668.2	808
1440 min Summer	3.286	0.0	6977.0	1066
2160 min Summer	2.487	0.0	9610.9	1472
2880 min Summer	2.040	0.0	10451.8	1900
4320 min Summer	1.540	0.0	11522.1	2724
5760 min Summer	1.260	0.0	13304.9	3520
7200 min Summer	1.078	0.0	14210.0	4328
8640 min Summer	0.949	0.0	14963.8	5104
10080 min Summer	0.852	0.0	15563.0	5856
15 min Winter	56.993	0.0	1260.5	19
30 min Winter	40.363	0.0	1892.0	33

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.443	0.443	42.8	3300.4	O K
120 min Winter	0.556	0.556	47.7	4173.5	O K
180 min Winter	0.625	0.625	50.4	4716.1	O K
240 min Winter	0.674	0.674	52.3	5101.8	O K
360 min Winter	0.740	0.740	54.7	5633.4	O K
480 min Winter	0.784	0.784	56.3	5982.9	O K
600 min Winter	0.814	0.814	57.3	6225.6	O K
720 min Winter	0.835	0.835	58.0	6397.7	O K
960 min Winter	0.861	0.861	58.9	6605.8	O K
1440 min Winter	0.886	0.886	59.7	6813.7	O K
2160 min Winter	0.897	0.897	60.0	6898.5	O K
2880 min Winter	0.885	0.885	59.7	6806.6	O K
4320 min Winter	0.836	0.836	58.0	6405.1	O K
5760 min Winter	0.776	0.776	56.0	5917.5	O K
7200 min Winter	0.715	0.715	53.8	5434.1	O K
8640 min Winter	0.658	0.658	51.7	4977.9	O K
10080 min Winter	0.605	0.605	49.7	4560.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	27.220	0.0	3031.7	62
120 min Winter	17.549	0.0	3948.3	122
180 min Winter	13.465	0.0	4553.9	180
240 min Winter	11.121	0.0	5012.6	238
360 min Winter	8.470	0.0	5701.1	354
480 min Winter	6.970	0.0	6209.1	468
600 min Winter	5.988	0.0	6601.8	580
720 min Winter	5.287	0.0	6907.8	692
960 min Winter	4.341	0.0	7308.4	902
1440 min Winter	3.286	0.0	7457.4	1124
2160 min Winter	2.487	0.0	10768.5	1596
2880 min Winter	2.040	0.0	11697.3	2048
4320 min Winter	1.540	0.0	12792.2	2936
5760 min Winter	1.260	0.0	14912.2	3800
7200 min Winter	1.078	0.0	15927.2	4608
8640 min Winter	0.949	0.0	16781.0	5440
10080 min Winter	0.852	0.0	17472.5	6160

Summary of Results for 200 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.247	0.247	37.0	1813.7	O K
30 min Summer	0.347	0.347	40.9	2567.3	O K
60 min Summer	0.461	0.461	43.6	3437.2	O K
120 min Summer	0.576	0.576	48.5	4329.5	O K
180 min Summer	0.645	0.645	51.2	4878.3	O K
240 min Summer	0.694	0.694	53.1	5264.4	O K
360 min Summer	0.760	0.760	55.4	5788.3	O K
480 min Summer	0.801	0.801	56.9	6124.1	O K
600 min Summer	0.829	0.829	57.8	6349.9	O K
720 min Summer	0.848	0.848	58.4	6501.8	O K
960 min Summer	0.872	0.872	59.2	6698.5	O K
1440 min Summer	0.901	0.901	60.2	6936.5	O K
2160 min Summer	0.918	0.918	60.7	7075.2	O K
2880 min Summer	0.917	0.917	60.7	7062.4	O K
4320 min Summer	0.889	0.889	59.8	6833.6	O K
5760 min Summer	0.848	0.848	58.4	6503.9	O K
7200 min Summer	0.805	0.805	57.0	6157.2	O K
8640 min Summer	0.763	0.763	55.5	5815.8	O K
10080 min Summer	0.723	0.723	54.1	5493.0	O K
15 min Winter	0.276	0.276	40.9	2031.1	O K
30 min Winter	0.388	0.388	40.9	2879.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	65.916	0.0	1310.8	19
30 min Summer	46.953	0.0	1972.5	34
60 min Summer	31.728	0.0	3161.9	64
120 min Summer	20.376	0.0	4097.3	124
180 min Summer	15.587	0.0	4708.6	182
240 min Summer	12.841	0.0	5167.3	242
360 min Summer	9.743	0.0	5849.5	362
480 min Summer	7.993	0.0	6346.8	482
600 min Summer	6.850	0.0	6726.7	600
720 min Summer	6.036	0.0	7017.9	720
960 min Summer	4.940	0.0	7384.4	836
1440 min Summer	3.722	0.0	7487.3	1084
2160 min Summer	2.804	0.0	10837.9	1492
2880 min Summer	2.292	0.0	11730.1	1904
4320 min Summer	1.721	0.0	12749.7	2728
5760 min Summer	1.403	0.0	14824.5	3568
7200 min Summer	1.197	0.0	15784.3	4328
8640 min Summer	1.051	0.0	16583.3	5112
10080 min Summer	0.941	0.0	17215.9	5944
15 min Winter	65.916	0.0	1501.9	19
30 min Winter	46.953	0.0	2225.3	33

Summary of Results for 200 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.515	0.515	46.0	3853.9	O K
120 min Winter	0.643	0.643	51.2	4860.4	O K
180 min Winter	0.721	0.721	54.1	5482.1	O K
240 min Winter	0.776	0.776	56.0	5921.7	O K
360 min Winter	0.851	0.851	58.5	6526.9	O K
480 min Winter	0.900	0.900	60.1	6924.7	O K
600 min Winter	0.934	0.934	61.2	7201.6	O K
720 min Winter	0.957	0.957	62.0	7398.5	O K
960 min Winter	0.986	0.986	62.9	7637.9	O K
1440 min Winter	1.011	1.011	63.6	7842.2	O K
2160 min Winter	1.022	1.022	64.0	7936.1	O K
2880 min Winter	1.010	1.010	63.6	7834.3	O K
4320 min Winter	0.956	0.956	61.9	7386.7	O K
5760 min Winter	0.890	0.890	59.8	6842.1	O K
7200 min Winter	0.823	0.823	57.6	6296.9	O K
8640 min Winter	0.759	0.759	55.4	5786.5	O K
10080 min Winter	0.701	0.701	53.3	5316.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	31.728	0.0	3560.4	62
120 min Winter	20.376	0.0	4601.1	122
180 min Winter	15.587	0.0	5277.4	180
240 min Winter	12.841	0.0	5781.4	238
360 min Winter	9.743	0.0	6520.8	354
480 min Winter	7.993	0.0	7044.6	470
600 min Winter	6.850	0.0	7425.0	582
720 min Winter	6.036	0.0	7693.0	694
960 min Winter	4.940	0.0	7957.2	906
1440 min Winter	3.722	0.0	8053.0	1140
2160 min Winter	2.804	0.0	12133.6	1604
2880 min Winter	2.292	0.0	13108.6	2072
4320 min Winter	1.721	0.0	14039.6	2944
5760 min Winter	1.403	0.0	16613.7	3808
7200 min Winter	1.197	0.0	17688.1	4616
8640 min Winter	1.051	0.0	18588.9	5448
10080 min Winter	0.941	0.0	19319.1	6256

Summary of Results for 200 year Return Period (+35%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.332	0.332	40.9	2450.3	O K
30 min Summer	0.466	0.466	43.8	3476.2	O K
60 min Summer	0.617	0.617	50.2	4655.8	O K
120 min Summer	0.771	0.771	55.8	5878.0	O K
180 min Summer	0.865	0.865	59.0	6637.6	O K
240 min Summer	0.931	0.931	61.1	7179.9	O K
360 min Summer	1.022	1.022	63.9	7931.4	O K
480 min Summer	1.081	1.081	65.7	8430.5	O K
600 min Summer	1.123	1.123	66.9	8781.0	O K
720 min Summer	1.153	1.153	67.8	9032.8	O K
960 min Summer	1.189	1.189	68.8	9341.5	O K
1440 min Summer	1.230	1.230	69.9	9689.7	Flood Risk
2160 min Summer	1.259	1.259	70.7	9937.5	Flood Risk
2880 min Summer	1.265	1.265	70.9	9990.1	Flood Risk
4320 min Summer	1.243	1.243	70.3	9797.1	Flood Risk
5760 min Summer	1.202	1.202	69.2	9449.0	Flood Risk
7200 min Summer	1.155	1.155	67.8	9048.9	O K
8640 min Summer	1.107	1.107	66.5	8646.9	O K
10080 min Summer	1.061	1.061	65.1	8257.6	O K
15 min Winter	0.371	0.371	40.9	2746.4	O K
30 min Winter	0.520	0.520	46.2	3895.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	88.987	0.0	1861.8	19
30 min Summer	63.386	0.0	2683.8	34
60 min Summer	42.833	0.0	4318.0	64
120 min Summer	27.507	0.0	5550.2	124
180 min Summer	21.043	0.0	6337.3	182
240 min Summer	17.336	0.0	6910.3	242
360 min Summer	13.152	0.0	7707.5	362
480 min Summer	10.791	0.0	8204.4	482
600 min Summer	9.248	0.0	8493.0	602
720 min Summer	8.149	0.0	8649.0	720
960 min Summer	6.669	0.0	8879.1	934
1440 min Summer	5.024	0.0	9031.3	1156
2160 min Summer	3.785	0.0	14572.3	1556
2880 min Summer	3.094	0.0	15633.3	1960
4320 min Summer	2.324	0.0	15956.9	2808
5760 min Summer	1.894	0.0	20038.6	3632
7200 min Summer	1.616	0.0	21329.9	4464
8640 min Summer	1.418	0.0	22403.7	5264
10080 min Summer	1.270	0.0	23266.8	6048
15 min Winter	88.987	0.0	2106.2	19
30 min Winter	63.386	0.0	2983.2	33

Summary of Results for 200 year Return Period (+35%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.688	0.688	52.8	5218.6	O K
120 min Winter	0.860	0.860	58.8	6598.1	O K
180 min Winter	0.965	0.965	62.2	7458.9	O K
240 min Winter	1.039	1.039	64.5	8075.0	O K
360 min Winter	1.142	1.142	67.5	8940.0	O K
480 min Winter	1.211	1.211	69.4	9525.2	Flood Risk
600 min Winter	1.260	1.260	70.8	9947.0	Flood Risk
720 min Winter	1.296	1.296	71.7	10260.1	Flood Risk
960 min Winter	1.344	1.344	73.0	10673.3	Flood Risk
1440 min Winter	1.385	1.385	74.1	11025.7	Flood Risk
2160 min Winter	1.410	1.410	74.7	11248.0	Flood Risk
2880 min Winter	1.408	1.408	74.7	11226.7	Flood Risk
4320 min Winter	1.360	1.360	73.4	10807.1	Flood Risk
5760 min Winter	1.289	1.289	71.6	10198.6	Flood Risk
7200 min Winter	1.214	1.214	69.5	9552.3	Flood Risk
8640 min Winter	1.140	1.140	67.4	8920.0	O K
10080 min Winter	1.069	1.069	65.3	8323.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	42.833	0.0	4846.1	62
120 min Winter	27.507	0.0	6202.8	122
180 min Winter	21.043	0.0	7052.7	180
240 min Winter	17.336	0.0	7652.8	238
360 min Winter	13.152	0.0	8427.0	356
480 min Winter	10.791	0.0	8834.1	472
600 min Winter	9.248	0.0	9068.9	586
720 min Winter	8.149	0.0	9271.0	700
960 min Winter	6.669	0.0	9540.8	922
1440 min Winter	5.024	0.0	9680.8	1326
2160 min Winter	3.785	0.0	16242.5	1648
2880 min Winter	3.094	0.0	17265.1	2128
4320 min Winter	2.324	0.0	17308.4	3028
5760 min Winter	1.894	0.0	22450.0	3920
7200 min Winter	1.616	0.0	23893.3	4760
8640 min Winter	1.418	0.0	25086.6	5616
10080 min Winter	1.270	0.0	26014.8	6360

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