Scottish & Southern Electricity Networks

TRANSMISSION

Annex K - Drainage Impact Assessment

December 2022

CRAIG MURRAIL SUBSTATION

ANNEX K
DRAINAGE IMPACT ASSESSMENT

DECEMBER 2022

Prepared by
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TABLE OF CONTENTS

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1 INTRODUCTION

1.1 Background

This Drainage Impact Assessment (DIA) has been produced in support of a planning application for the construction of a 275 kV substation (the Proposed Development) on greenfield land north of Lochgilphead (the Site).

The Proposed Development is accompanied by Associated Development, a permanent overhead line (OHL) tie in comprising of 6 no. towers and access tracks. This is not included within this DIA given the absence of impermeable surfaces associated with it and therefore this DIA assesses only the Proposed Development.

This DIA has been prepared by Arcus Consultancy Services Ltd (Arcus), on behalf of SSEN Transmission (the Applicant) to satisfy the following requirements:

- Scottish Government, Planning Advice Note 61: Planning and Sustainable Urban Drainage Systems[1];
- Scottish Government, Planning Advice Note 79: Planning Advice Note 79: Water and Drainage[2];
- Scottish Environmental Protection Agency (SEPA), Technical Flood Risk Guidance for Stakeholders[3];
- Scottish Water, Sewers for Scotland 4th Edition[4];
- CIRIA, The SuDS Manual (C753)[5];
- Argyll and Bute (AB), Sustainable Design Guide[6];
- Argyll and Bute, Flood Risk Management Policy and Strategy[7];
- Working Party SuDS, Water Assessment and Drainage Guide[8];
- SEPA, Regulatory Method 8 (WAT-RM-08) SuDS[9]; and
- Argyll and Bute Council Proposed Local Development Plan Supplementary Guidance[10].

The Proposed Development Layout Plan can be found in **Appendix A** of this DIA.

1.2 Site Context

The Site comprises an area of maximum 8 hectares (ha) and is located approximately 3.2 kilometres (km) north-east of Lochgilphead at National Grid Reference (NGR) E 187701, N 690911. The Site is approximately 850 metres (m) west of Dipping Burn.

The Proposed Development is in an area of commercial forestry as well as an area of semi-natural broadleaved woodland with higher ecological importance. Existing access tracks will

[1] Scottish Government, Planning Advice Note 61: Planning and Sustainable Urban Drainage Systems (2001). [Online]. Available at: https://www.gov.scot/publications/pan-61-sustainable-urban-drainage-systems/

[2] Scottish Government, Planning Advice note 79: Water and Drainage (2006). [Online]. Available at: https://www.gov.scot/publications/planning-advice-note-pan-79-water-drainage/

[3] SEPA, Technical Flood Risk Guidance for Stakeholders (2019). [Online]. Available at: https://www.sepa.org.uk/environment/land/planning/guidance-and-advice-notes/

[4] Scottish Water, Sewers for Scotland (2018). [Online]. Available at: https://www.scottishwater.co.uk/-/media/ScottishWater/Document-Hub/Business-and-Developers/Connecting-to-our-network/All-connections-information/SewersForScotlandv4.pdf (Accessed 30/09/2021)

[5] CIRIA, The SuDS Manual (C753) (2015). [Online]. Available at: https://www.ciria.org/AsiCommon/Controls/BSA/Downloader.aspx

[6] Argyll and Bute Council Sustainable Design Guide (2011). [Online]. Available at: Design Guides (argyll-bute.gov.uk)

[7] Argyll and Bute Council Flood Risk Management Policy and Strategy (2015). [Online]. Available at: Flood_Risk_Management_Policy_and_Strategy%20-%20Final%20draft%20110315.pdf (argyll-bute.gov.uk)

[8] SEPA, Working Party SuDS, Water Assessment and Drainage Guide. [Online]. Available at: Water drainage assessment guide (sepa.org.uk)

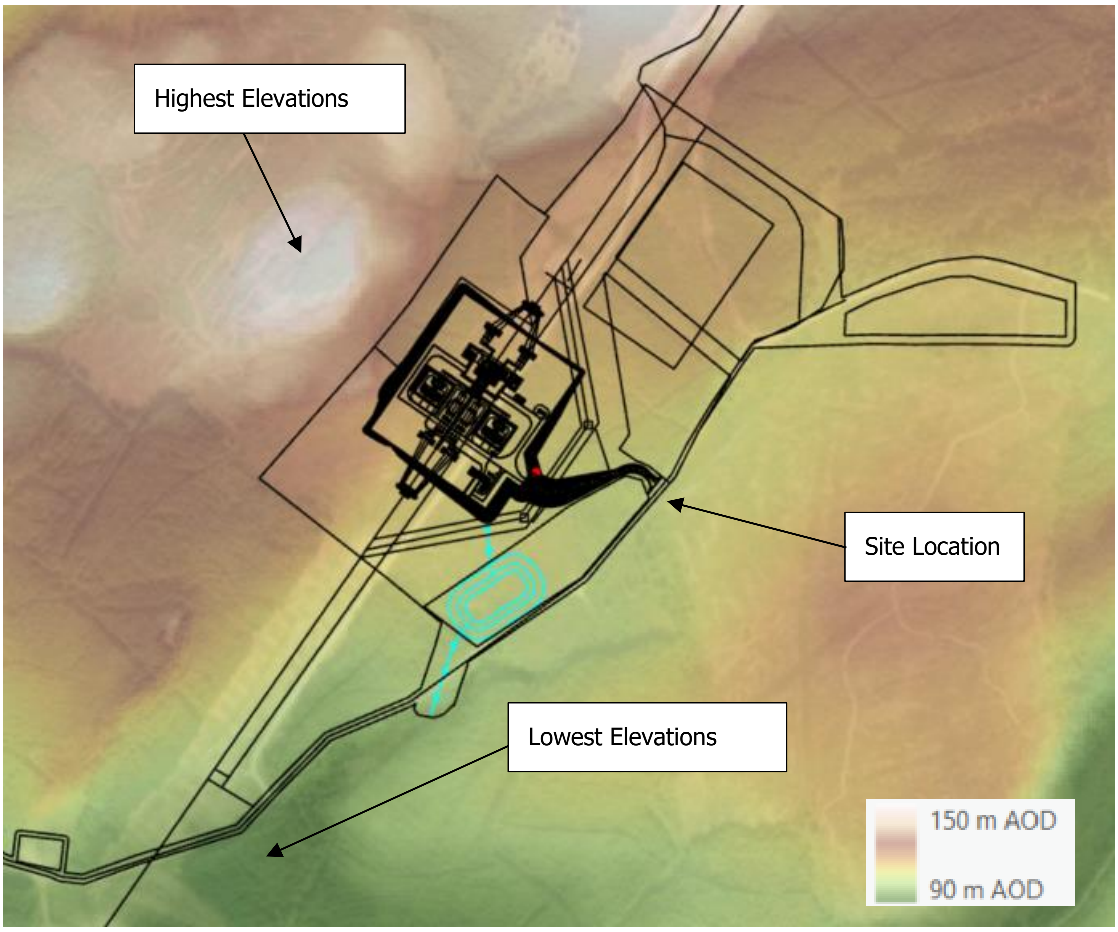
[9] SEPA, Regulatory Method (WAT-RM-08) SuDS (2019). [Online]. Available at: Regulatory Method (WAT-RM-08) (sepa.org.uk)

[10] Argyll and Bute, Proposed Local Development Plan Supplementary Guidance (2012). [Online]. Available at: FINALSGdocument1.pdf (argyll-bute.gov.uk)

be utilised to access the Proposed Development from the existing road to ensure operational access is maintained.

Ordnance Survey (OS) Terrain 5 data indicates Site elevations are in the approximate range of 120 to 105 m Above Ordnance Datum (AOD) with topography falling from a high point in the north to the lower elevations in the south of the Site, as shown by **Plate 1**.

Plate 1: Site Location and Elevations



There are no British Geological Survey (BGS) borehole scans available within close proximity to the Site. However, the BGS Geology of Britain Viewer[11] indicates that the site is underlain by bedrock geology consisting of Ardrishaig Phyllite Formation, with no superficial deposits recorded.

Site specific ground investigations were conducted by SLR in 2016 and excavated 20 test pits. Of the 20 pits 11 comprised peats to depths of 0.6 to 3.9 m below ground level (bgl), underlain by gravelly silt, with a variety of results in the other nine.

A site visit indicated soils and ground conditions are extremely boggy with high water table, indicating infiltration would not be feasible.

Further details on peat depths associated are available in **Annex N: Peat Management Plan** of the Craig Murrail Substation Environmental Appraisal.

1.3 The Proposed Development Infrastructure

The Associated Development is not considered to have any significant impermeable materials and therefore has not been considered within this appraisal. Impermeable areas

[11] British Geological Survey: Geology of Britain Viewer. [Online]. Available at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html

associated with the Proposed Development are therefore limited to the buildings storing the diesel generator, feeder building, telecoms, mess and store room, LVAC room, battery room, switch room, the substation electrical infrastructure and access tracks.

The impermeable elements will create a total impermeable area of approximately 0.83 ha. The total contributing area including the substation platform to be attenuated and discharged is approximately 3.01 ha.

2 SURFACE WATER DESIGN CONDITIONS

In accordance with the SuDS Manual an evaluation has been undertaken to determine the most appropriate option to dispose of surface water from the Proposed Development.

2.1 Surface Water Discharge Options

The Proposed Development will require a welfare facility; however, it will not be permanently manned, with infrequent maintenance visits. Therefore, there will be no demand for water re-use.

Consultations[12] with ABC have confirmed that infiltration testing is not required at the Planning Application submission stage and that the potential for infiltration drainage will be assessed through an estimated infiltration rate sought via the SuDS Manual. The conversations are shown in **Appendix B.**

2.2 Estimated Infiltration Rate

Table 25.1 of the SuDS Manual outlines estimated infiltration rates based on the Infiltration Drainage – Manual of Good Practice[13]. Table 25.1 indicates silt media has a typical maximum infiltration rate of an infiltration rate of 0.036 metres per hour (m/h).

Acknowledging the underlying site conditions, infiltration as a means of drainage is assessed as unfeasible and surface water will be disposed of by controlled discharge to a nearby watercourse.

2.3 Greenfield Run-off rates

Greenfield run-off rates for the 3.01 ha of impermeable area have been calculated using the ICP SuDS method[14] via Micro Drainage Software with rates shown in **Table 1** below and **Appendix C** of this DIA.

Q_{BAR} will be utilised as the outflow rate.

The application of this approach leads to the run-off from the Site to be attenuated and discharged to the greenfield run-off rate of 27.7 l/s in up to the 1:200-year return period, with appropriate climate change allowances.

Table 1: Site Run-off Flow Rates (taken from Micro Drainage)

Return Period	Q (l/s)
Q_{BAR}	27.7
1	23.5
30	52.3
100	68.7

[12] Email and telephone communications between D. Moore (ABC) and R. Duff (Arcus) January 2022.
[13] R, Bettess. Infiltration Drainage – Manual of Good Practice (1996). CIRIA R156.
[14] National SuDS Working Group, Interim Code of Practice for Sustainable Drainage Systems (2004). [Online]. Available at: https://www.susdrain.org/files/resources/other-guidance/nswg_icop_for_suds_0704.pdf

200	77.8

2.4 Return Period and Climate Change Allowance

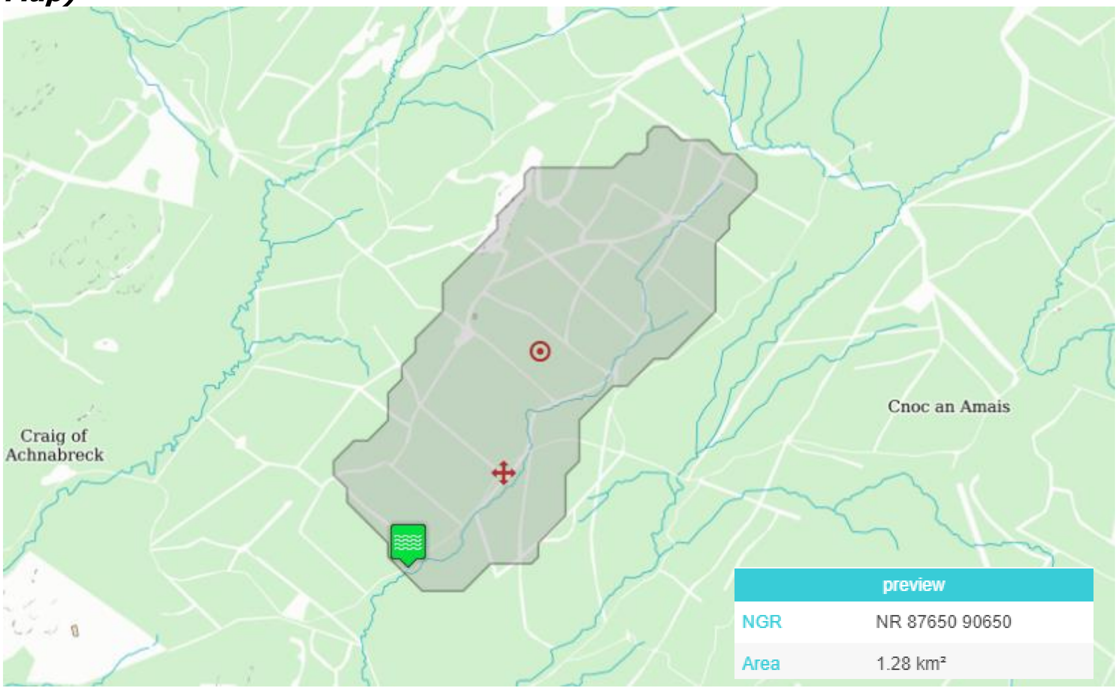
In accordance with Map 1 of SEPA's climate change (+CC) allowances[15] a 46% allowance has been incorporated into the drainage design (+46% CC).

Attenuation is required in up to and including the 1:30-year (+CC) event with exceedance events up to the 1:200-year (+CC) event to be considered for offsite flooding.

2.5 Discharge to Watercourse

The UK CEH (FEH) web map[16] indicates that an unnamed watercourse serves a catchment of 1.28 km² as shown in **Plate 2**. This watercourse is located approximately 165 m south east of the Site. The watercourse flows in a southerly direction until it joins the Dipping Burn approximately 1.10 km south of the Site.

Plate 2: Receiving Watercourse Catchment Extents (Source: UKCEH FEH Web Map)



3 SURFACE WATER DRAINAGE DESIGN

The measures outlined in the following sections will be implemented by the Applicant's chosen Contractor to ensure that greenfield run-off rates are maintained during the construction and operational phases of the Proposed Development.

Should the drainage measures or final locations of infrastructure differ to what is outlined within this document, then the final detailed drainage design will be provided to ABC under an agreed pre-construction condition.

[15] SEPA, Climate Change Allowances for Flood Risk Assessment in Land Use Planning (2019). [Online]. Available at: https://www.sepa.org.uk/media/426913/lups_cc1.pdf

[16] UK Centre for Ecology and Hydrology, Flood Estimation Handbook. [Online]. Available at: https://fehweb.ceh.ac.uk/GB/map

3.1 Hierarchical Drainage Options

In accordance with the SuDS Manual (C753)[17] the information within **Table 2** outlines the most appropriate option to dispose of surface water from the Development along with the rationale.

Table 2: Surface Water Discharge Methods

Disposal route	Feasible?	Rationale
Re-use onsite	✘	Site will be unmanned with infrequent maintenance visits, therefore no demand for water reuse.
Infiltration to ground	✘	British Geological Survey mapping indicate infiltration is unlikely to be feasible.
Discharge to watercourse	✓	The nearest watercourse has been determined to be a feasible discharge location and therefore will be utilised within the strategy..
Discharge to surface water	✘	Discharge to the nearest watercourse has been deemed practicable.
Discharge to combined sewer	✘	Discharge to the nearest watercourse has been deemed practicable.

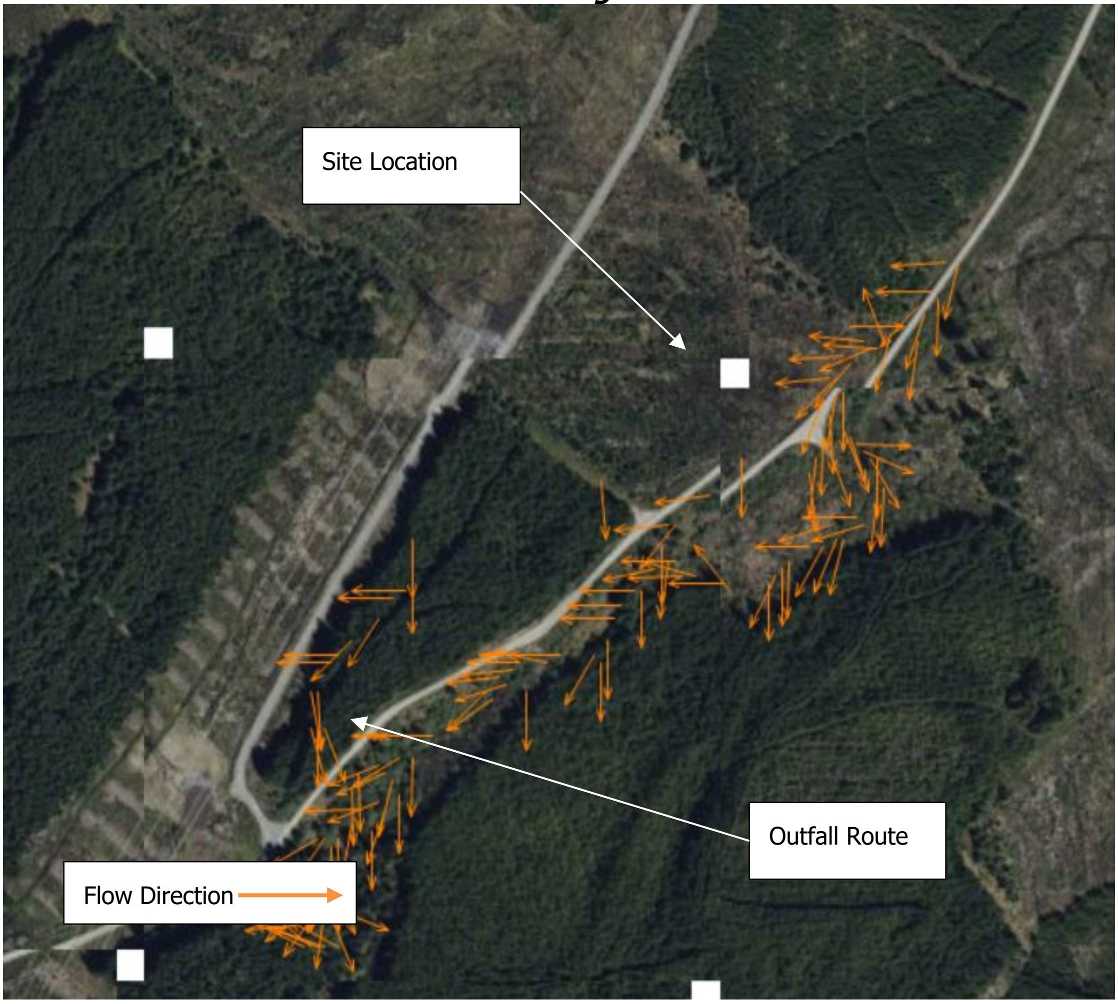
3.2 Proposed Surface Water Drainage Scheme

It is proposed that the impermeable areas within the Development will be connected to an attenuation basin to the west of the Site via a piped filter drain system. Due to the volume of attenuation required, swales have been discounted as a viable storage option as the structure length would be prohibitive and exceed the boundaries of the Site.

The attenuation basin will enable surface water to be intercepted in accordance with existing topography and overland flow routes. The outfall from the attenuation basin will fall in accordance with existing flow routes as shown by **Plate 4.**

[17] CIRIA, The SuDS Manual (2015). [Online]. Available at: https://www.susdrain.org/resources/SuDS_Manual.html

Plate 4: Overland Flow Routes Surrounding the Site



An attenuation basin was selected as the most viable SuDS option due to the outfall location to the nearest watercourse being located approximately 165 m south west of the Site, as such both swales and filter drains were considered not to be feasible due to these distances.

The outfall to the open land drain is located within the extents of the existing land ownership and no third-party access agreements are required for the route to the discharge point.

The outflow of the basin to the unnamed watercourse will be controlled by a Hydro-Brake (or other flow control device) and discharge to the watercourse to the west at 27.7 l/s.

In order to provide the Site with suitable attenuation of surface water in relation to the storage structure requirements (see Section 2.3) and acknowledging the nature of the Development, the attenuation basin will comprise of the approximate dimensions in accordance with the SuDS Manual with the final detailed design will be proposed prior to construction:

- Depth: 0.9 m;
- Slope: 1 in 4;
- Base area: 3,300.0 m²;
- Total area: 4,073.8 m²; and
- Maximum water depth: 0.899 m.

The gradients of the SuDS attenuation basin bank slope between any access track/path and the permanent water level should be varied along their length to reflect the naturally occurring topography of the immediate surroundings.

The attenuation basin should include a forebay to trap sediment immediately beneath the inlet occupying an area of approximately 10 % of the permanent basin surface area.

The critical storm event in up to a 1:200-year (+46 % CC) event is shown in Plate 4 with the designed feature able to attenuate surface water flows without surcharge.

Details of critical events for the 1:200 year (+46 % CC) event and a cross-section of the attenuation basin design output can be found in **Appendix D**.

Plate 4: Network 1:200-Year (+CC) Critical Storm Event (Taken from Micro Drainage)

Storm Event	Rain (mm/hr)	Time to Vol Peak	Max Water Level	Max Depth (m)	Flooded Volume	Max Control (l/s)	Discharge Volume	Σ Max Outflow (l/s)	Maximum Volume	Status
960 min Winter	10.912	914	112.999	0.899	0.0	27.4	3995.0	27.4	3307.6	Flood Risk

3.3 Water Quality

The proposed Development will involve the construction and operation of a substation involving less than 300 traffic movements per day. Table 26.2 *Pollution hazard indices for different land use classifications* of the SuDS Manual identifies that the Proposed Development has a Pollution Hazard Level of Low, taken from the 'Low Traffic Roads e.g. residential roads and general access roads, < 300 traffic movements/day' scenario.

Table 3 outlines that the Proposed Development includes land uses which have the following Simple Index Approach (SIA) indices.

Table 3: Pollution Hazard Indices for Land Use Classifications

Land Use	Pollution Level Hazard	Total Suspended Soils	Metal	Hydrocarbons
Commercial/Industrial Roofing: Low Potential for Metal Leaching	Low	0.3	0.4	0.4

A SIA has been developed on behalf of the CIRIA to support the implementation of the water quality management design methods set out in the SuDS Manual, with appropriate cross referencing to the relevant 'Design Conditions' in the tool.

The Proposed Development has been categorised as 'Commercial/Industrial roofing: Low potential for metal leaching' within the SIA tool.

All internal roads will be impermeable. Gullies and channel drains will be required to capture surface water leading to a filter drain system. The substation platform will be permeable to effectively mitigate any suspended solids, metals and hydrocarbons held within surface water at the Proposed Development prior to discharging into the receiving watercourse under expected conditions i.e., in the absence of large hydrocarbon spills.

The SIA outputs as shown in **Table 4**, demonstrate that the combined Pollution Mitigation Indices for the run-off area are met by the utilisation of the substation platform as a surface water attenuation structure.

Table 4: SIA outputs for Low Pollution Hazard Level scenario

	Total Suspended Solids	Metals	Hydrocarbons
Pollution Hazard Indices	0.5	0.4	0.5
Pond	0.7	0.7	0.5

The outputs of the SIA tool indicate that the SuDS network has the required treatment potential in relation to the potential pollution hazard of the Proposed Development in the absence of significant spillages of hydrocarbons or other pollutants.

3.4 Construction Phase

The drainage measures implemented within the temporary works area (TWA) will be the responsibility of the appointed contractor. This area will comprise aggregate underlain by a permeable membrane. The contractor will implement temporary construction drainage measures in accordance with best practice guidance which will prevent any significant run-off in relation to the compaction of soils during construction (e.g., spill kits, drip trays, plant nappies, designated refuelling points, emergency response plans). Following the construction of the Development, the TWA will be decommissioned, with underlying ground reinstated to its original condition.

Therefore, the TWA not contribute to a significant increase in surface water run-off rates and need not be served by a formal drainage network.

The nature of hydrological incidents that could result from construction activities will be mitigated through the implementation of construction phase SuDS and the application of industry good practice as per CIRIA Guidance (C741)[18].

To prevent any sediment increase in associated run-off during the construction phase mitigation measures (e.g., spill kits, bunds, drip trays, plant nappies, designated refuelling points and emergency response plans) will effectively prevent sediment entering surrounding watercourses.

4 FOUL WATER DRAINAGE

During the construction phase a temporary a 'porta-loo' facility will be onsite., with waste being stored, managed and carried offsite by a licensed waste management courier.

During operation, a packaged sewage treatment plant will be located at the Site, with the treated water to be discharged to a watercourse or via an underground soakaway system.

A SEPA Controlled Activity Regulations (CAR) approval will be needed in regard to pollution control. This will be sought in consultation with SEPA as required.

5 LONG TERM MANAGEMENT AND TIMESCALES

5.1 Long Term Management

It will be the responsibility of SSEN Transmission to maintain effective drainage measures and rectify drainage measures that are not functioning adequately. A nominated person will also have responsibility for reporting on the functionality of drainage measures.

Where impermeable areas remain through the lifetime of the Proposed Development, the SuDS measures serving these areas will be checked on a regular basis. Should drainage measures require dredging or unblocking, this will be undertaken as soon as practicable by a local contractor engaged by SSEN Transmission.

It is not anticipated that ABC or Scottish Water will adopt the new drainage network. Therefore, it will be the responsibility of SSEN Transmission to maintain effective drainage measures and rectify drainage measures that are not functioning adequately.

An outline management / maintenance plan is provided in **Table 5.** The table shows the management of a pond as that closely matches the characteristics of the proposed attenuation basin.

[18] The Construction Industry Research and information Association (CIRIA), (2015), Environmental Good Practice on Site Guide (C741), CIRIA: London.

Table 5: Outline Long-term Maintenance schedule for the Pond [19]

Maintenance schedule	**Required action**	**Typical frequency**
Regular Maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut meadow grass	Half yearly (spring, before nesting season and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Inspect inlets, outlets, banksides, structures, pipework etc for evidence of blockage and/or physical damage	Monthly
	Inspect water body for signs of poor water quality	Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options	Half yearly
	Check any mechanical devices, eg penstocks	Half yearly
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level	Annually
	Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay.	Every 1-5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays.	Every 5 years, or as required
Occasional Maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant, where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required

[19] Based on Table 20.15 - Operation and maintenance requirements for pervious pavements of the SuDS Manual.

	Realign rip-rap or repair other damages	As required
	Repair/rehabilitate inlets. Outlets and overflows	As required

An outline management / maintenance plan for any filter drains is provided in **Table 6.**

***Table 6: Outline Long-term Maintenance schedule for Filter Drains*[20]**

Maintenance Schedule	Required Action	Typical frequency
Regular Maintenance	Remove litter including leaf litter and debris from filter drain surface, access chambers and pre-treatment devices	Monthly (or as required)
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies	Six Monthly
	Remove sediment from pre-treatment devices	Six Monthly, or as required
Occasional Maintenance	Remove or control tree roots where they are encroaching the sides of the filter drain, using recommended methods (e.g. NJUG, 2007 or BS 3998:2010)	As required
	At locations with high pollution loads, remove surface geotextile and replace, and wash or replace overlying filter medium	Five yearly, or as required
	Clear perforated pipework of blockages	As required

5.2 Timescales

Drainage measures outlined within this DIA should be implemented as soon as practical by the Applicant's Contractor but as a minimum before the construction of any impermeable surfaces which are proposed to drain into the approved drainage system.

6 CONCLUSION

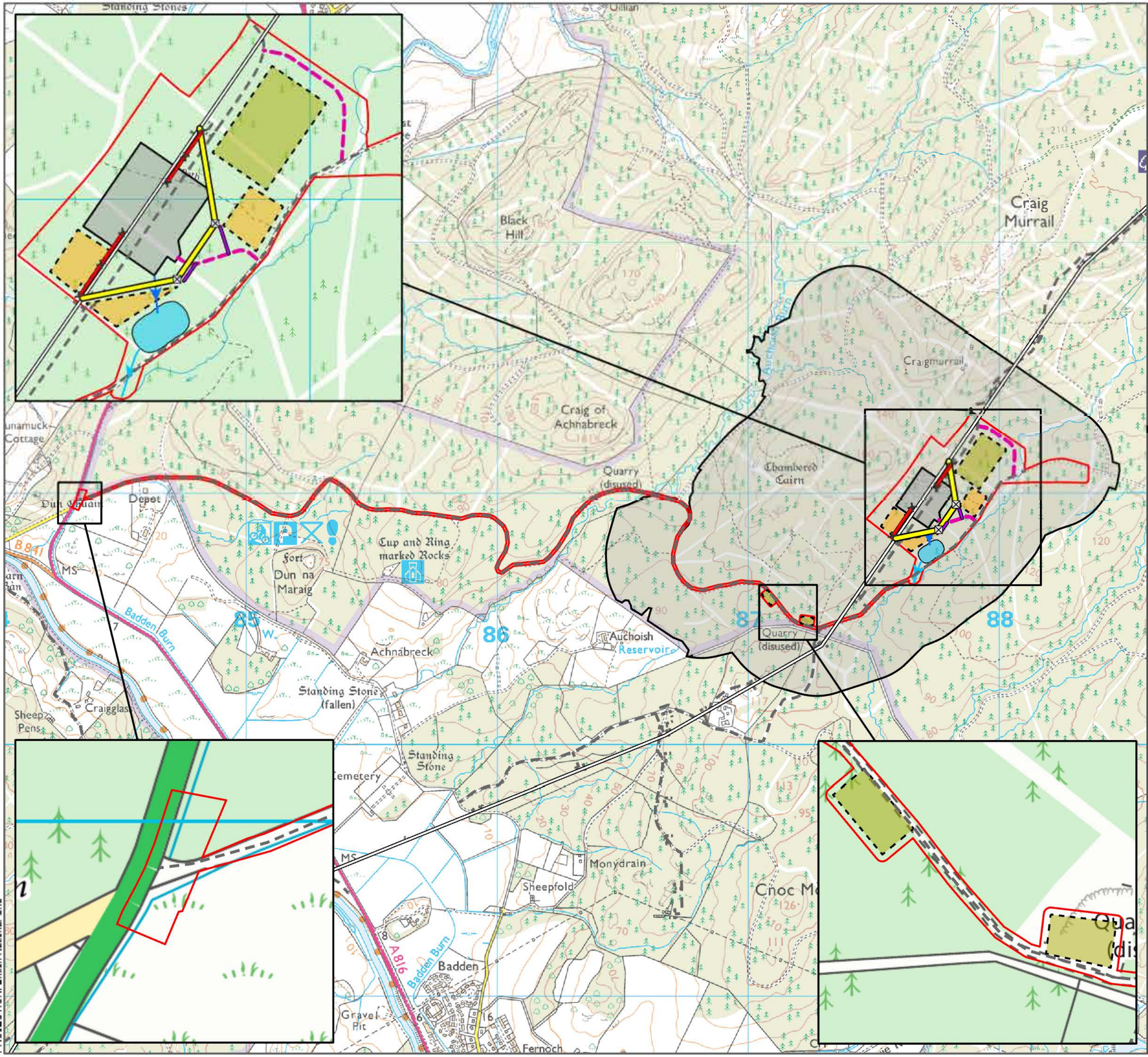
This DIA provides details on the volume of storage required to attenuate surface water run-off from the construction of the Proposed Development. The Associated Development have not been assessed in this DIA.

The Proposed Development will involve the installation of approximately 3.01 ha of impermeable elements.

[20] Based on Table 16.1 - Operation and maintenance requirements for filter drains of the SuDS Manual.

The proposed attenuation basin and associated piped network detailed within this report are shown to not surcharge during a 1:200-year (+46 % CC) event and discharge to the nearest watercourse at a 27.7 l/s.

APPENDIX A – SITE LAYOUT



PROJECTION: British National Grid

- Existing Inveraray to Crossaig Overhead Line
- Existing Access Track

Proposed Development:

- Proposed Permanent Access Track
- SUDs Inlet Pipeline
- SUDs Outfall Pipeline
- Town & Country Planning Boundary
- Proposed Substation Layout
- SUDs Pond
- Proposed Substation Temporary Works Area
- Temporary Peat Storage Area
- Potential Area for Peat Restoration

Associated Development:

- Proposed Tower Location
- Temporary Access Track
- OHL Downleads
- Temporary OHL Diversion

0 — 1,000
Metres

N

SCALE: See Scale Bar	VERSION: A03
SIZE: A4	DRAWN: DN
PROJECT: 0607366	CHECKED: WB
DATE: 25/11/2022	APPROVED: SW

Figure L.1
Craig Murrail Substation Red Line Boundary

ERM

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APPENDIX B – ARGYLL AND BUTE COUNCIL CONSULTATION

Reagan Duff

From: Moore, David <David.Moore@argyll-bute.gov.uk>
Sent: 27 January 2022 08:29
To: Reagan Duff
Subject: RE: Argyll Substation Drainage Arrangement [OFFICIAL]

Classification: OFFICIAL

Morning Reagan,

I am in general agreement with your summary. I do recall stating that it was important any land needed for any offsite suds were in the redline boundary and also that my preference would be for the details to be submitted with the application if the work is being done now anyway.

I also referenced the need to ensure any peat matters are addressed.

Regards David

From: Reagan Duff <reagand@arcusconsulting.co.uk>
Sent: 26 January 2022 17:37
To: Moore, David <David.Moore@argyll-bute.gov.uk>
Subject: RE: Argyll Substation Drainage Arrangement

Hi David,

Thanks for your time on the phone earlier. I have summarised the outcomes of our discussion regarding the SuDS at the 4 substations in Argyll below:

- The developments located within the SEPA flood maps are those where SuDS should be focused upon, but it is preferable that SuDS at an outline level is provided for each;
- SuDS for each application will comprise a solution using infiltration utilising an assumed infiltration rate (without testing) and a solution not utilising infiltration;
- The wider details of the SuDS will be conditioned; and
- JBA will provide technical advice to the council and are likely to agree to the approach discussed.

I assume this is a true representation of the outcomes of our call and no response is required unless this is not the case.

Kind regards,

Reagan Duff
Senior Hydrologist
Arcus Consultancy Services Ltd

Tel: 01904 715470
Mobile: 07435911606
Email: ReaganD@arcusconsulting.co.uk
Web: www.arcusconsulting.co.uk

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From: Reagan Duff
Sent: 26 January 2022 12:01
To: david.moore@argyll-bute.gov.uk
Subject: Argyll Substation Drainage Arrangement

Hi David,

My colleague Sophie Williams passed on your details so that we can discuss the SuDS agreements/plans for the Argyll substation development which I believe you are the planning officer for.

Please could we arrange a brief call this week to discuss? If you provide me with a time that suits I can circulate a teams invite.

Kind regards,

Reagan Duff
Senior Hydrologist
Arcus Consultancy Services Ltd

Tel: 01904 715470
Mobile: 07435911606
Email: ReaganD@arcusconsulting.co.uk
Web: www.arcusconsulting.co.uk

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APPENDIX C – ICP SUDS OUTPUTS

ICP SUDS Mean Annual Flood

Input

Return Period (years)	200	Soil	0.400
Area (ha)	3.010	Urban	0.000
SAAR (mm)	1638	Region Number	Region 1

Results	**l/s**
QBAR Rural	27.7
QBAR Urban	27.7
Q200 years	77.8
Q1 year	23.5
Q30 years	52.3
Q100 years	68.7

APPENDIX D – MICRODRAINAGE OUTPUTS

Summary of Results for 200 year Return Period (+46%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	112.370	0.270	26.9	920.5	O K
30 min Summer	112.439	0.339	27.3	1165.1	O K
60 min Summer	112.522	0.422	27.3	1467.0	O K
120 min Summer	112.620	0.520	27.3	1829.1	O K
180 min Summer	112.683	0.583	27.3	2066.3	O K
240 min Summer	112.730	0.630	27.3	2244.1	Flood Risk
360 min Summer	112.797	0.697	27.3	2503.6	Flood Risk
480 min Summer	112.841	0.741	27.3	2677.6	Flood Risk
600 min Summer	112.872	0.772	27.3	2798.5	Flood Risk
720 min Summer	112.894	0.794	27.3	2884.3	Flood Risk
960 min Summer	112.895	0.795	27.3	2889.9	Flood Risk
1440 min Summer	112.889	0.789	27.3	2866.0	Flood Risk
2160 min Summer	112.867	0.767	27.3	2779.0	Flood Risk
2880 min Summer	112.837	0.737	27.3	2660.3	Flood Risk
4320 min Summer	112.819	0.719	27.3	2588.2	Flood Risk
5760 min Summer	112.784	0.684	27.3	2454.3	Flood Risk
7200 min Summer	112.739	0.639	27.3	2279.6	Flood Risk
8640 min Summer	112.692	0.592	27.3	2101.7	O K
10080 min Summer	112.647	0.547	27.3	1931.2	O K
15 min Winter	112.401	0.301	27.2	1032.4	O K
30 min Winter	112.479	0.379	27.3	1308.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	166.872	0.0	792.8	26
30 min Summer	106.468	0.0	1034.0	41
60 min Summer	67.929	0.0	1447.9	70
120 min Summer	43.340	0.0	1860.1	128
180 min Summer	33.321	0.0	2149.8	188
240 min Summer	27.652	0.0	2379.8	246
360 min Summer	21.260	0.0	2740.0	366
480 min Summer	17.642	0.0	3021.6	484
600 min Summer	15.266	0.0	3253.1	602
720 min Summer	13.564	0.0	3447.2	720
960 min Summer	10.912	0.0	3646.2	858
1440 min Summer	8.030	0.0	3808.0	1104
2160 min Summer	5.909	0.0	4722.4	1500
2880 min Summer	4.754	0.0	5054.7	1928
4320 min Summer	3.689	0.0	5826.0	2768
5760 min Summer	3.082	0.0	6644.4	3584
7200 min Summer	2.680	0.0	7218.6	4392
8640 min Summer	2.392	0.0	7716.0	5112
10080 min Summer	2.172	0.0	8141.5	5856
15 min Winter	166.872	0.0	898.5	26
30 min Winter	106.468	0.0	1166.3	40

Summary of Results for 200 year Return Period (+46%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	112.572	0.472	27.3	1649.5	O K
120 min Winter	112.682	0.582	27.3	2061.4	O K
180 min Winter	112.753	0.653	27.3	2334.6	Flood Risk
240 min Winter	112.807	0.707	27.3	2541.4	Flood Risk
360 min Winter	112.881	0.781	27.3	2834.0	Flood Risk
480 min Winter	112.931	0.831	27.3	3034.7	Flood Risk
600 min Winter	112.967	0.867	27.3	3180.2	Flood Risk
720 min Winter	112.994	0.894	27.3	3288.4	Flood Risk
960 min Winter	112.999	0.899	27.4	3307.6	Flood Risk
1440 min Winter	112.985	0.885	27.3	3250.9	Flood Risk
2160 min Winter	112.953	0.853	27.3	3122.6	Flood Risk
2880 min Winter	112.909	0.809	27.3	2943.6	Flood Risk
4320 min Winter	112.864	0.764	27.3	2765.9	Flood Risk
5760 min Winter	112.799	0.699	27.3	2509.5	Flood Risk
7200 min Winter	112.713	0.613	27.3	2178.3	Flood Risk
8640 min Winter	112.631	0.531	27.3	1869.6	O K
10080 min Winter	112.557	0.457	27.3	1593.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	67.929	0.0	1627.9	68
120 min Winter	43.340	0.0	2088.1	126
180 min Winter	33.321	0.0	2410.4	184
240 min Winter	27.652	0.0	2665.2	242
360 min Winter	21.260	0.0	3063.2	358
480 min Winter	17.642	0.0	3371.1	474
600 min Winter	15.266	0.0	3618.7	586
720 min Winter	13.564	0.0	3818.2	698
960 min Winter	10.912	0.0	3995.0	914
1440 min Winter	8.030	0.0	3973.9	1156
2160 min Winter	5.909	0.0	5289.9	1620
2880 min Winter	4.754	0.0	5659.3	2080
4320 min Winter	3.689	0.0	6495.3	2988
5760 min Winter	3.082	0.0	7444.2	3872
7200 min Winter	2.680	0.0	8089.8	4680
8640 min Winter	2.392	0.0	8650.0	5440
10080 min Winter	2.172	0.0	9134.0	6144

Rainfall Details

Rainfall Model	FEH
Return Period (years)	200
Site Location	GB 187650 690650 NR 87650 90650
C (1km)	-0.018
D1 (1km)	0.447
D2 (1km)	0.339
D3 (1km)	0.470
E (1km)	0.257
F (1km)	2.479
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+46

Time Area Diagram

Total Area (ha) 3.010

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	1.003	4	8	1.003	8	12	1.003

Model Details

Storage is Online Cover Level (m) 113.000

Tank or Pond Structure

Invert Level (m) 112.100

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	3300.0	0.900	4073.8

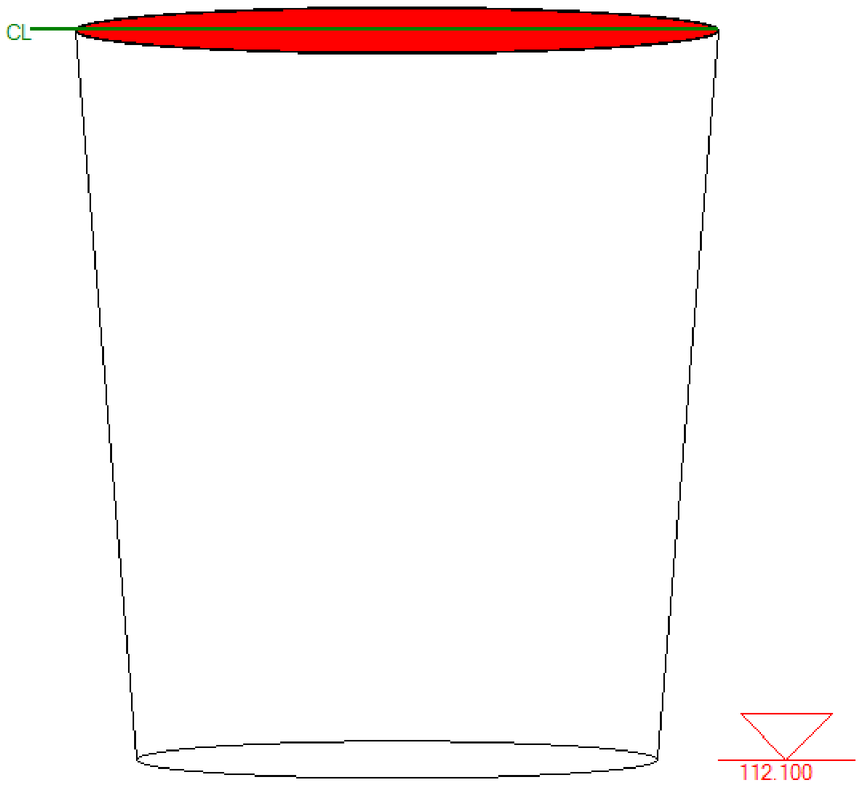
Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0229-2770-0900-2770
Design Head (m)	0.900
Design Flow (l/s)	27.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	229
Invert Level (m)	112.100
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1500

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.900	27.4
Flush-Flo™	0.359	27.3
Kick-Flo®	0.680	24.0
Mean Flow over Head Range	-	22.4

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	7.6	1.200	31.5	3.000	48.9	7.000	73.8
0.200	22.9	1.400	33.9	3.500	52.7	7.500	76.3
0.300	27.1	1.600	36.1	4.000	56.2	8.000	78.7
0.400	27.3	1.800	38.2	4.500	59.5	8.500	81.1
0.500	26.7	2.000	40.2	5.000	62.6	9.000	83.4
0.600	25.7	2.200	42.1	5.500	65.6	9.500	85.2
0.800	25.9	2.400	43.9	6.000	68.5		
1.000	28.8	2.600	45.6	6.500	71.2		



Invert Level of Structure (m): 112.100