Appendix A Surface Water Management Plan

A.1 Overview

In order that runoff from the proposed development does not increase flood risk elsewhere, it is recommended that measures are taken to mitigate the rates of runoff from the site. As discussed in Section 3d, the site is underlain by soils described as *loamy and clayey soils of coastal flats with naturally high groundwater*. On site infiltration is unlikely to be a practical means of surface water management, since the soil infiltration rate is unlikely to be sufficiently rapid to half drain the infiltration structure within 24 hours and the invert of the structure would be within 1 m of the water table. Since these are both requirements for infiltration structures defined in the SuDS Manual (CIRIA, 2015), it is recommended that the runoff from the impermeable surfaces on site is detained and released at attenuated rates.

The site includes existing commercial / agricultural buildings and areas of currently undeveloped agricultural land. It is understood that a surface water management scheme based on attenuation has been implemented at the site as part of the existing development. The currently undeveloped part of the site has no special drainage arrangements in place, such that runoff rates from this part of the site are likely to be equivalent to Greenfield rates.

Accordingly, the aim of the surface water management plan is to manage runoff from the proposed new impermeable surfaces only. The plan presented below outlines an attenuation system that would reduce runoff rates to no greater than Greenfield rates.

A.2 Greenfield Runoff Rates

The estimation of peak rates of pre-development runoff (i.e. Greenfield runoff) has previously used the IH 124[3] (Marshall and Bayliss) method. This method uses parameters related to catchment and soil characteristics to establish a peak rate of runoff. More recently, the rainfall runoff modelling approach of ReFH version 2 (ReFH2) has been used. This method was found in work by the CEH (2015) to give a closer match to observed peak rates of runoff, and also provides a full hydrograph, rather than simply the peak flow derived by the former method. Following additional research and testing, ReFH2 was released in 2015. In particular, and with significance for the current site, ReFH2 incorporates a set of adjustments for “plot scale” conditions. These adjustments address the use of models and data for catchments to the scale of individual development plots. This is important since such plots tend to be much smaller than topographic catchments.

ReFH2 runoff calculations reference a subset of catchment descriptors generated by the FEH web service, imported as an .xml file. Several descriptors are then changed in order to achieve the “plot-scale” adjustments. The base flow descriptor BFIHOST for the catchment as a whole is unlikely to be representative of the site, and so this descriptor was changed from 0.72 to 0.45 to better reflect the impeded drainage at the site. The AREA descriptor for the catchment was changed from approximately 0.955 km^2 to 0.5 km^2, in order to calibrate several routing and base flow parameters, and then finally to 0.021 km^2 to reflect the area of the proposed impermeable surface (21,108 m^2). These adjustments enabled the generation of Greenfield runoff hydrographs in l/s for the site. Scaling from the area of the impermeable surface to an area of 1 ha enabled the determination of target, peak Greenfield rates in l/s/ha.

The peak Greenfield runoff rates determined using ReFH2 are shown in Table A-1. The peak Greenfield rates in l/s for the impermeable area are shown in column 2. The equivalent rates in l/s/ha are shown in column 3.

[3] IH124: Institute of Hydrology Report No. 124 Flood Estimation for Small Catchments, June 1994

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

Table A-1 Greenfield (target) runoff rates (proposed impermeable surfaces only)

Return period (years)	*Greenfield Runoff rates (l/s)*	*Greenfield Runoff rates (l/s/ha)*
2	5.60	2.66
30	13.94	6.64
100	20.39	9.71

A.3 Attenuation Basin Design

The characteristics of the attenuation features were analysed using the *Source Control* module of the industry leading WinDES suite of software developed by Micro Drainage/XP Solutions. The following conservative assumptions and design parameters were applied within the Source Control module.

- Point rainfall time series were obtained using the FEH methodology, based on the catchment descriptors for the site generated by the FEH web service.
- Rainfall values were increased by 20% to allow for climate change over the 60 year design life of the proposed commercial / agricultural development, as described in Section 4 of the main report, and in line with the requirements of NPPF.
- The proposed impermeable area on site as listed in Table *6* of the main report, equal to approximately 21,108 m^2 (excluding access road). The top surface area of the basin was added to the proposed impermeable area in order to determine the total rainfall catchment area.
- 100% of the runoff from the proposed impermeable surfaces is directed to a single attenuation basin.
- A 100% void ratio was modelled, corresponding to an empty open basin.
- The outflow is regulated by a compound structure comprising a lower and upper orifice overflows.
- A factor of safety of 2 was applied, as recommended in CIRIS C753, to reflect the minor consequences of exceedence

Using an iterative, trial and error approach to varying the attenuation basin area, and the diameter and invert of the lower and upper orifice overflows, a range of attenuation designs were assessed. The software was used to analyse the response of the designs to the 1 in 2, 1 in 30 and 1 in 100 year plus climate change summer and winter storms of durations between 15 minutes and 10080 minutes (7 days). The design imperatives were that outflow rates should ideally be no greater than the target, Greenfield rates for the site, while at the same time being within practical limits for the attenuation feature area, depth and diameter of outflow devices.

The attenuation basin design is open and receives direct rainfall, and therefore the area of the attenuation basin was added to the impermeable surface area for the purpose of calculating total rainfall catchment area and Greenfield (target) attenuated rates.

It was found that an attenuation basin with the following attributes would enable runoff rates from the proposed impermeable area to be reduced to below target Greenfield rates for the critical duration 1 in 2, 1 in 30 and 1 in 100 year storms plus an allowance for climate change. It is assumed that outflow would be below Greenfield rates at all return periods within this range.

- a basal surface area of 1,800 m^2;
- a depth of 0.9 m;
- side slope of 1 in 3 (approximately 18 degrees), resulting in a top surface area of approximately 2,180 m^2;
- a compound outflow structure comprising a lower 75 mm diameter orifice outlet at an invert of 0 m (base of the basin), and an upper 100 mm diameter orifice outlet orifice at an invert of 0.45 m.

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

The performance of the attenuation basin is summarised in Table A-2. The full results produced by the software are reproduced in Appendix B.

Table A-2 Attenuation basin performance

Return period (years)	*Target Attenuated Outflow Rates (l/s/ha)*	*Target Attenuated Outflow Rates (l/s)*	*Peak Outlow Rates (l/s)*	*Maximum Water Depth (m)*
2	2.66	6.21	6.2	0.318
30	6.64	15.46	15.0	0.591
100	9.71	22.61	20.8	0.768

Note: the target attenuated outflow rates are calculated using the Greenfield rates in l/s/ha, multiplied by the sum of the impermeable surface area and attenuation basin (top) area.

The results confirm that the design attenuation basin would reduce peak runoff rates to or below Greenfield rates for the critical 1 in 2, 1 in 30 and 1 in 100 year plus climate change winter storms, and is assumed to do so for all intermediate return period storms. The maximum depth indicated is 0.768 m for the 1 in 100 year plus climate change storm. An attenuation basin of depth 0.9 m would therefore be of sufficient depth to accommodate the maximum depth of water (with a freeboard of 132 mm).

A.4 Interception and routing of Runoff

Runoff from the roofs of the proposed poultry units should be collected via gutters located downslope of the roofs, and discharged via downpipes to interceptor channels positioned along the base of each unit. A range of solutions are possible, but a simple arrangement of 0.5 m wide and 0.5 m deep drainage channels along the length of each unit should be adequate to intercept and convey runoff to a large diameter pipe, that would drain eastwards to the attenuation basin. The grading of drainage channels and drainage pipe should be 1:100 or steeper.

Runoff from the concrete apron will also need to be routed to the attenuation basin. The concrete apron is also used for waste washing, and the facility to switch outflows from the attenuation basin (for rainfall runoff collection) to the waste processing tank would be implemented at the site. The concrete apron would be surrounded by a low wall to contain all washed process waste, which is routed to underground tanks during the cleaning phase.

A.5 Location, Elevation and Outlet of Attenuation Basin

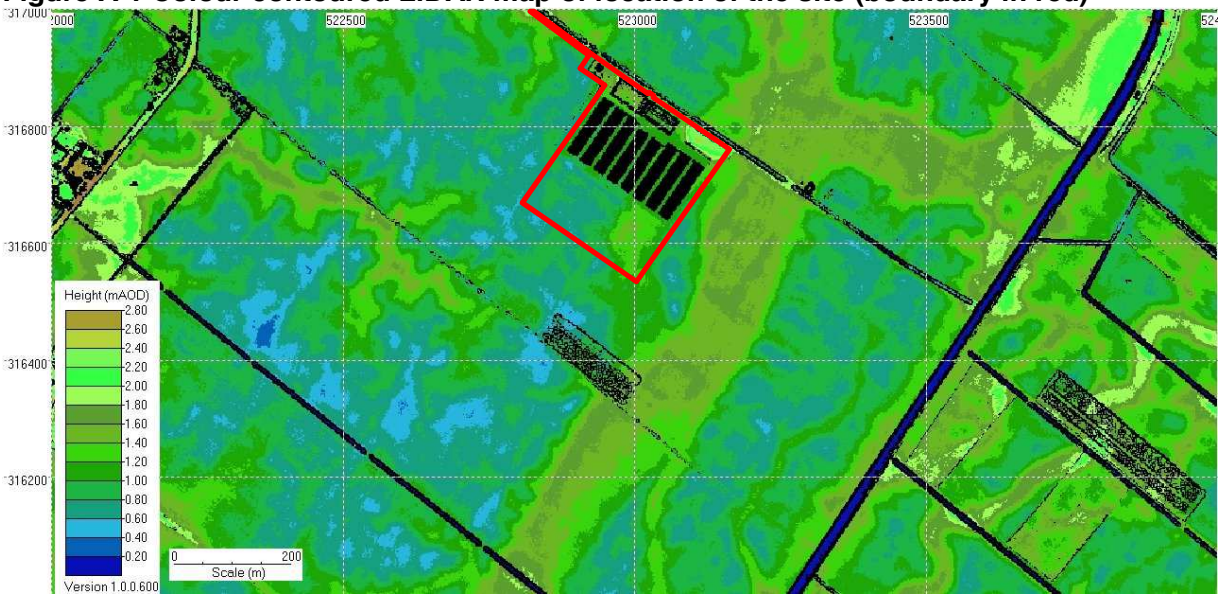
A shown in Figure 8 of the main report, the preferred location of the attenuation basin would be to the west of the proposed poultry units. The attenuation basin top surface area of approximately 2,180 m^2 easily fits into this location.

The colour contoured LiDAR of the location of the site is shown in Figure A-1 below. It may be seen that the average ground elevation at the location of the basin is between 0.8 mAOD and 1.0 mAOD. It is recommended that the top of the basin be built up to at least 1.0 mAOD, ideally higher, notwithstanding providing adequate slope from the proposed impermeable surfaces to enable runoff to be routed to the basin. Allowing for a basin top elevation of 1.0 mAOD and a depth of 0.9m would result in a base elevation of 0.1 mAOD.

Outflow from the basin should be routed to the existing drainage channel adjacent to the northern boundary if the site, a distance of approximately 190 m. It is recommended that a survey be conducted at the site in order to determine the practical arrangements for this aspect of the attenuation design.

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

Figure A-1 Colour contoured LiDAR map of location of the site (boundary in red)



A.6 Residual Risks

The text below relates to the risks in relation to the attenuation basin only and are summarised in Section 8 of the main report.

In the event that partial blockage went undetected or a rainstorm occurred which was in excess of the 1:100 year plus climate change design storm, water level within the basin could rise above the calculated maximum depth of 0.768 m summarised in Table A-2. The recommended basin depth of 0.9 m allows for a freeboard of 132 mm above the maximum water level.

For rainfall events greatly exceeding the 1:100 year plus climate change design rainstorm, the basin embankment could be overtopped, and the resulting overflow could possibly cut through a natural earth embankment and lead to failure. It is therefore recommended a 2 m wide weir be constructed at an invert of 0.85 m above the base of the basin, which would act as a spillway to convey exceedance flows away from sensitive areas of the site and towards the drain at the northern boundary of the site.

A.7 Conclusion

The attenuation scheme described above would maintain the peak outflow from the proposed impermeable surfaces at the site at a level below no greater than Greenfield runoff rates for all return periods. Other combinations of basin dimensions and outflow regulators are of course possible, but the analysis illustrates one way in which the necessary reduction in flood risk can be achieved.

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

Appendix B Attenuation Design Results

B.1 1 in 2 year plus climate change storm

Hydro Consultancy		Page 1
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Summary of Results for 2 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.115	0.115	3.3	210.6	O K
30 min Summer	0.139	0.139	3.7	254.6	O K
60 min Summer	0.167	0.167	4.2	306.1	O K
120 min Summer	0.197	0.197	4.7	364.3	O K
180 min Summer	0.216	0.216	5.0	400.1	O K
240 min Summer	0.230	0.230	5.1	425.2	O K
360 min Summer	0.247	0.247	5.4	458.3	O K
480 min Summer	0.257	0.257	5.5	478.1	O K
600 min Summer	0.263	0.263	5.6	490.0	O K
720 min Summer	0.268	0.268	5.6	498.7	O K
960 min Summer	0.276	0.276	5.7	514.3	O K
1440 min Summer	0.286	0.286	5.9	532.7	O K
2160 min Summer	0.290	0.290	5.9	541.3	O K
2880 min Summer	0.289	0.289	5.9	538.5	O K
4320 min Summer	0.266	0.266	5.6	495.5	O K
5760 min Summer	0.245	0.245	5.3	454.6	O K
7200 min Summer	0.226	0.226	5.1	418.3	O K
8640 min Summer	0.209	0.209	4.9	386.4	O K
10080 min Summer	0.195	0.195	4.7	358.7	O K
15 min Winter	0.129	0.129	3.5	235.9	O K
30 min Winter	0.155	0.155	4.0	285.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	48.780	0.0	139.7	27
30 min Summer	29.657	0.0	175.3	41
60 min Summer	18.030	0.0	266.9	70
120 min Summer	10.962	0.0	329.6	128
180 min Summer	8.193	0.0	371.8	188
240 min Summer	6.664	0.0	404.5	246
360 min Summer	4.981	0.0	454.2	364
480 min Summer	4.052	0.0	491.5	482
600 min Summer	3.452	0.0	521.1	590
720 min Summer	3.028	0.0	545.4	634
960 min Summer	2.473	0.0	585.6	760
1440 min Summer	1.859	0.0	632.8	1018
2160 min Summer	1.397	0.0	835.9	1432
2880 min Summer	1.141	0.0	905.5	1848
4320 min Summer	0.824	0.0	958.0	2644
5760 min Summer	0.654	0.0	1076.7	3456
7200 min Summer	0.547	0.0	1121.9	4184
8640 min Summer	0.472	0.0	1156.9	4936
10080 min Summer	0.417	0.0	1180.8	5664
15 min Winter	48.780	0.0	159.9	26
30 min Winter	29.657	0.0	199.1	41

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 2 year plus climate change storm (contd.)

Hydro Consultancy		Page 2
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Summary of Results for 2 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.186	0.186	4.5	343.2	O K
120 min Winter	0.221	0.221	5.0	409.0	O K
180 min Winter	0.242	0.242	5.3	449.7	O K
240 min Winter	0.257	0.257	5.5	478.5	O K
360 min Winter	0.277	0.277	5.7	516.9	O K
480 min Winter	0.290	0.290	5.9	540.8	O K
600 min Winter	0.298	0.298	6.0	556.1	O K
720 min Winter	0.303	0.303	6.0	565.8	O K
960 min Winter	0.309	0.309	6.1	578.6	O K
1440 min Winter	0.318	0.318	6.2	594.7	O K
2160 min Winter	0.318	0.318	6.2	594.6	O K
2880 min Winter	0.311	0.311	6.1	581.2	O K
4320 min Winter	0.277	0.277	5.7	515.4	O K
5760 min Winter	0.246	0.246	5.4	456.9	O K
7200 min Winter	0.220	0.220	5.0	406.9	O K
8640 min Winter	0.198	0.198	4.7	365.0	O K
10080 min Winter	0.179	0.179	4.4	329.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	18.030	0.0	302.1	70
120 min Winter	10.962	0.0	372.1	126
180 min Winter	8.193	0.0	419.3	184
240 min Winter	6.664	0.0	455.7	242
360 min Winter	4.981	0.0	510.4	356
480 min Winter	4.052	0.0	551.2	470
600 min Winter	3.452	0.0	583.6	580
720 min Winter	3.028	0.0	610.3	686
960 min Winter	2.473	0.0	653.6	794
1440 min Winter	1.859	0.0	699.4	1090
2160 min Winter	1.397	0.0	938.4	1548
2880 min Winter	1.141	0.0	1016.0	1992
4320 min Winter	0.824	0.0	1072.3	2852
5760 min Winter	0.654	0.0	1207.9	3640
7200 min Winter	0.547	0.0	1259.0	4408
8640 min Winter	0.472	0.0	1299.1	5192
10080 min Winter	0.417	0.0	1327.1	5952

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 2 year plus climate change storm (contd.)

Hydro Consultancy		Page 3
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
Site Location	GB 523750 316750 TE 23750 16750
C (1km)	-0.023
D1 (1km)	0.298
D2 (1km)	0.312
D3 (1km)	0.213
E (1km)	0.317
F (1km)	2.490
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time Area Diagram

Total Area (ha) 2.329

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.776	4	8	0.776	8	12	0.776

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 2 year plus climate change storm (contd.)

Hydro Consultancy		Page 4
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Model Details

Storage is Online Cover Level (m) 0.800

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1800.0	0.800	2179.1

Complex Outflow Control

Orifice

Diameter (m) 0.075 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice

Diameter (m) 0.100 Discharge Coefficient 0.600 Invert Level (m) 0.450

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

B.2 1 in 30 year plus climate change storm

Hydro Consultancy		Page 1
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.289	0.289	5.9	539.6	O K
30 min Summer	0.334	0.334	6.4	625.9	O K
60 min Summer	0.383	0.383	6.9	723.0	O K
120 min Summer	0.436	0.436	7.4	828.7	O K
180 min Summer	0.467	0.467	7.8	891.8	O K
240 min Summer	0.489	0.489	8.6	934.5	O K
360 min Summer	0.514	0.514	10.0	985.1	Flood Risk
480 min Summer	0.526	0.526	10.6	1009.8	Flood Risk
600 min Summer	0.531	0.531	10.9	1020.2	Flood Risk
720 min Summer	0.533	0.533	11.0	1024.4	Flood Risk
960 min Summer	0.538	0.538	11.3	1035.0	Flood Risk
1440 min Summer	0.543	0.543	11.7	1045.4	Flood Risk
2160 min Summer	0.541	0.541	11.6	1042.1	Flood Risk
2880 min Summer	0.534	0.534	11.1	1027.9	Flood Risk
4320 min Summer	0.499	0.499	9.1	955.2	O K
5760 min Summer	0.463	0.463	7.7	882.0	O K
7200 min Summer	0.426	0.426	7.3	808.2	O K
8640 min Summer	0.393	0.393	7.0	743.0	O K
10080 min Summer	0.364	0.364	6.7	686.0	O K
15 min Winter	0.323	0.323	6.3	604.5	O K
30 min Winter	0.372	0.372	6.8	701.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	124.740	0.0	373.1	27
30 min Summer	72.652	0.0	418.0	41
60 min Summer	42.315	0.0	652.6	70
120 min Summer	24.646	0.0	755.3	130
180 min Summer	17.965	0.0	819.6	188
240 min Summer	14.354	0.0	866.5	248
360 min Summer	10.463	0.0	933.7	364
480 min Summer	8.360	0.0	980.0	482
600 min Summer	7.025	0.0	1013.3	600
720 min Summer	6.094	0.0	1038.4	650
960 min Summer	4.889	0.0	1076.0	760
1440 min Summer	3.584	0.0	1103.3	1010
2160 min Summer	2.627	0.0	1584.1	1424
2880 min Summer	2.108	0.0	1674.1	1844
4320 min Summer	1.484	0.0	1670.4	2688
5760 min Summer	1.157	0.0	1916.0	3528
7200 min Summer	0.954	0.0	1970.4	4328
8640 min Summer	0.815	0.0	2012.0	5104
10080 min Summer	0.713	0.0	2037.7	5856
15 min Winter	124.740	0.0	407.5	27
30 min Winter	72.652	0.0	453.5	41

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 30 year plus climate change storm (contd.)

Hydro Consultancy		Page 2
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.427	0.427	7.3	810.7	O K
120 min Winter	0.486	0.486	8.5	929.6	O K
180 min Winter	0.520	0.520	10.3	998.4	Flood Risk
240 min Winter	0.542	0.542	11.6	1043.2	Flood Risk
360 min Winter	0.567	0.567	13.3	1094.5	Flood Risk
480 min Winter	0.578	0.578	14.1	1118.4	Flood Risk
600 min Winter	0.583	0.583	14.4	1128.0	Flood Risk
720 min Winter	0.584	0.584	14.5	1129.9	Flood Risk
960 min Winter	0.590	0.590	14.9	1141.9	Flood Risk
1440 min Winter	0.591	0.591	15.0	1144.8	Flood Risk
2160 min Winter	0.581	0.581	14.3	1124.2	Flood Risk
2880 min Winter	0.567	0.567	13.3	1095.0	Flood Risk
4320 min Winter	0.523	0.523	10.4	1003.5	Flood Risk
5760 min Winter	0.482	0.482	8.3	920.8	O K
7200 min Winter	0.435	0.435	7.4	825.7	O K
8640 min Winter	0.391	0.391	7.0	738.4	O K
10080 min Winter	0.353	0.353	6.6	664.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	42.315	0.0	729.1	70
120 min Winter	24.646	0.0	841.0	128
180 min Winter	17.965	0.0	912.2	184
240 min Winter	14.354	0.0	965.0	242
360 min Winter	10.463	0.0	1041.0	356
480 min Winter	8.360	0.0	1094.1	466
600 min Winter	7.025	0.0	1133.9	570
720 min Winter	6.094	0.0	1164.6	658
960 min Winter	4.889	0.0	1211.6	742
1440 min Winter	3.584	0.0	1251.6	1046
2160 min Winter	2.627	0.0	1778.6	1496
2880 min Winter	2.108	0.0	1878.2	1936
4320 min Winter	1.484	0.0	1856.3	2820
5760 min Winter	1.157	0.0	2147.7	3752
7200 min Winter	0.954	0.0	2208.6	4616
8640 min Winter	0.815	0.0	2255.4	5440
10080 min Winter	0.713	0.0	2286.2	6160

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 30 year plus climate change storm (contd.)

Hydro Consultancy		Page 3
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
Site Location	GB 523750 316750 TE 23750 16750
C (1km)	-0.023
D1 (1km)	0.298
D2 (1km)	0.312
D3 (1km)	0.213
E (1km)	0.317
F (1km)	2.490
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time Area Diagram

Total Area (ha) 2.329

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.776	4	8	0.776	8	12	0.776

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 30 year plus climate change storm (contd.)

Hydro Consultancy		Page 4
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Model Details

Storage is Online Cover Level (m) 0.800

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1800.0	0.800	2179.1

Complex Outflow Control

Orifice

Diameter (m) 0.075 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice

Diameter (m) 0.100 Discharge Coefficient 0.600 Invert Level (m) 0.450

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

B.3 1 in 100 year plus climate change storm

Hydro Consultancy		Page 1
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.435	0.435	7.4	825.8	O K
30 min Summer	0.491	0.491	8.7	939.8	O K
60 min Summer	0.551	0.551	12.2	1062.6	Flood Risk
120 min Summer	0.611	0.611	15.8	1185.5	Flood Risk
180 min Summer	0.642	0.642	17.0	1251.4	Flood Risk
240 min Summer	0.661	0.661	17.7	1291.8	Flood Risk
360 min Summer	0.681	0.681	18.3	1332.8	Flood Risk
480 min Summer	0.686	0.686	18.5	1344.8	Flood Risk
600 min Summer	0.688	0.688	18.5	1348.2	Flood Risk
720 min Summer	0.689	0.689	18.6	1351.1	Flood Risk
960 min Summer	0.693	0.693	18.7	1358.3	Flood Risk
1440 min Summer	0.692	0.692	18.6	1356.2	Flood Risk
2160 min Summer	0.679	0.679	18.2	1329.2	Flood Risk
2880 min Summer	0.661	0.661	17.7	1291.6	Flood Risk
4320 min Summer	0.605	0.605	15.6	1174.6	Flood Risk
5760 min Summer	0.567	0.567	13.3	1095.0	Flood Risk
7200 min Summer	0.536	0.536	11.2	1031.8	Flood Risk
8640 min Summer	0.509	0.509	9.7	975.6	Flood Risk
10080 min Summer	0.483	0.483	8.3	922.2	O K
15 min Winter	0.484	0.484	8.4	925.1	O K
30 min Winter	0.546	0.546	11.9	1051.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	190.647	0.0	507.5	27
30 min Summer	108.907	0.0	554.3	41
60 min Summer	62.213	0.0	946.8	70
120 min Summer	35.539	0.0	1075.1	128
180 min Summer	25.613	0.0	1155.4	186
240 min Summer	20.302	0.0	1213.5	246
360 min Summer	14.632	0.0	1296.7	362
480 min Summer	11.597	0.0	1355.1	478
600 min Summer	9.685	0.0	1398.7	522
720 min Summer	8.358	0.0	1432.2	580
960 min Summer	6.652	0.0	1484.6	702
1440 min Summer	4.821	0.0	1533.7	974
2160 min Summer	3.494	0.0	2119.7	1384
2880 min Summer	2.781	0.0	2221.8	1792
4320 min Summer	1.936	0.0	2174.6	2596
5760 min Summer	1.498	0.0	2484.7	3400
7200 min Summer	1.227	0.0	2538.8	4192
8640 min Summer	1.043	0.0	2578.4	5024
10080 min Summer	0.909	0.0	2599.9	5864
15 min Winter	190.647	0.0	548.3	27
30 min Winter	108.907	0.0	611.9	41

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 100 year plus climate change storm (contd.)

Hydro Consultancy		Page 2
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.612	0.612	15.9	1187.5	Flood Risk
120 min Winter	0.678	0.678	18.2	1326.8	Flood Risk
180 min Winter	0.714	0.714	19.3	1402.6	Flood Risk
240 min Winter	0.736	0.736	19.9	1449.8	Flood Risk
360 min Winter	0.759	0.759	20.6	1499.8	Flood Risk
480 min Winter	0.767	0.767	20.8	1518.3	Flood Risk
600 min Winter	0.768	0.768	20.8	1520.4	Flood Risk
720 min Winter	0.766	0.766	20.8	1516.2	Flood Risk
960 min Winter	0.768	0.768	20.8	1519.9	Flood Risk
1440 min Winter	0.758	0.758	20.6	1498.9	Flood Risk
2160 min Winter	0.731	0.731	19.8	1439.0	Flood Risk
2880 min Winter	0.700	0.700	18.9	1372.8	Flood Risk
4320 min Winter	0.624	0.624	16.4	1213.9	Flood Risk
5760 min Winter	0.576	0.576	14.0	1113.7	Flood Risk
7200 min Winter	0.542	0.542	11.6	1042.4	Flood Risk
8640 min Winter	0.510	0.510	9.8	978.5	Flood Risk
10080 min Winter	0.479	0.479	8.2	915.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	62.213	0.0	1058.9	70
120 min Winter	35.539	0.0	1202.0	126
180 min Winter	25.613	0.0	1291.0	184
240 min Winter	20.302	0.0	1356.4	240
360 min Winter	14.632	0.0	1450.3	354
480 min Winter	11.597	0.0	1516.6	464
600 min Winter	9.685	0.0	1566.4	566
720 min Winter	8.358	0.0	1605.2	594
960 min Winter	6.652	0.0	1666.6	738
1440 min Winter	4.821	0.0	1728.9	1042
2160 min Winter	3.494	0.0	2377.4	1480
2880 min Winter	2.781	0.0	2493.2	1908
4320 min Winter	1.936	0.0	2434.1	2724
5760 min Winter	1.498	0.0	2785.0	3520
7200 min Winter	1.227	0.0	2845.3	4400
8640 min Winter	1.043	0.0	2888.9	5280
10080 min Winter	0.909	0.0	2910.1	6248

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 100 year plus climate change storm (contd.)

Hydro Consultancy		Page 3
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 523750 316750 TE 23750 16750
C (1km)	-0.023
D1 (1km)	0.298
D2 (1km)	0.312
D3 (1km)	0.213
E (1km)	0.317
F (1km)	2.490
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time Area Diagram

Total Area (ha) 2.329

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.776	4	8	0.776	8	12	0.776

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD

1 in 100 year plus climate change storm (contd.)

Hydro Consultancy		Page 4
Shearwater House Clevedon BS21 7RD	K0776 Deeping	
Date 06/12/2016 File Attenuation_basin.srcx	Designed by HLS Checked by PR	
Micro Drainage	Source Control 2016.1	

Model Details

Storage is Online Cover Level (m) 0.800

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1800.0	0.800	2179.1

Complex Outflow Control

Orifice

Diameter (m) 0.075 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice

Diameter (m) 0.100 Discharge Coefficient 0.600 Invert Level (m) 0.450

©1982-2016 XP Solutions

Hydro-Logic Services (International) Ltd Registered in England No. 03036787 Registered Office: Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD



Offices at

Bromyard

Reading

Sheffield

Stirling

Tiverton

Registered office

Hydro-Logic Services (International) Ltd
Shearwater House,
Clevedon Hall Estate,
Victoria Road,
Clevedon,
BS21 7RD

Registered in England 03036787