Trace Design

Transport and Civil Engineering

DRAINAGE STATEMENT

Report Reference 19013 – A -DS – 17 Apartments

Land off Exeter Road, Topsham

Prepared by Jamie Law

January 2022

Trace Design

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DOCUMENT ISSUE RECORD

Project Summary - 19013				
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-	First Issue	26.01.2022	J Law	W Pahl
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Appendices

1 Introduction

1.1 Trace Design were appointed to undertake a drainage statement for a proposed development of 17 apartments on land off Exeter Road, Topsham, EX3 0FB. The site is located at Ordnance Survey grid reference SX 95753 88992.

1.2 The site is located within Flood Zone 1 and has a developable area less than 1ha, therefore, a flood risk assessment is not required.

2 Proposed Drainage Strategy

2.1 Best current practice should be used to determine suitable Sustainable Drainage Systems (SuDS) selection wherever possible. Surface water runoff generated from the proposed impermeable areas should seek to meet the following design objectives:

- Infiltration into the ground should be as close as possible to the source to recharge the groundwater and watercourses base flows (depending on ground condition and existing site uses),
- Attenuate and control surface water runoff from proposed impermeable areas to the equivalent of the Greenfield runoff rate,
- Manage surface water runoff from the site so that it does not increase flood risk to third parties and where possible, reduce this flood risk;
- Improve the quality of surface water discharge.

2.2 Several SuDS are ideally used throughout a site, linked together to form a SuDS train providing treatment, control and attenuation processes.

2.3 The proposed disposal of surface water runoff from the development will need to follow the hierarchal approach as outlined below:

- Discharge into the ground via infiltration;
- Discharge to a surface waterbody;
- Discharge to a surface water sewer, highways drain or another drainage system;
- Discharge to a combined sewer (subject to Sewerage Undertaker carrying out capacity evaluation)

2.4 The use of infiltration structures presents the most desirable solution for the surface water disposal in terms of sustainability following the surface water management train. This is achieved by collecting surface water runoff from impermeable areas and redirecting it back into the ground.

2.5 No ground investigation report or infiltration testing has yet been undertaken for the site. However, there are several constraints that restrict the use of infiltration within the site and these are:

- 5m offset from the proposed building;
- 2.5m offset from the proposed site boundary;
- 5m offset from the adopted highway, Exeter Road.

2.6 Once all these offsets had been considered, there is very limited remaining space for soakaways. Therefore, the next option that was reviewed was discharge into the River Exe to the south of the site.

2.7 For this there were two options, discharge directly into the River Exe or indirectly via the existing South West Water (SWW) surface water sewer. Refer to Appendix A for the online mapping of SWW's sewers.

2.8 A direct discharge would allow for an unattenuated discharge into the River Exe, as this part of the river is the estuary. However, agreements would be required to cross third party land all the way to the proposed outfall location, as well as consent from the Environment Agency for the installation of the headwall.

2.9 Therefore, it is proposed to connect into SWW's surface water sewer, and this connection is to be undertaken via sewer requisition. This proposed discharge is shown by drawing 19013-220-Proposed Drainage Strategy – 17 Apartments in Appendix B.

2.10 SWW have agreed a maximum discharge rate of 10 l/s into their network and the email correspondence can be seen within Appendix C.

2.11 The proposed attenuation has been designed to cater for a 1 in 100-year storm event with an allowance of 40% for climate change and an additional 10% for urban creep. A summary of the attenuation requirements is shown in Table 1 and for full micro drainage calculations, refer to Appendix D.

Table 1: Attenuation requirements and discharge rates for various return periods

Return Period +40% CC	Discharge Rate (l/s)	Attenuation Volume (m^3)
1 in 2	7.4	16.2
1 in 30	10.0	34.5
1 in 100	10.0	46.7

2.12 The attenuation has been sized so that it can operate by itself, or in tandem with the adjacent development so that the maximum discharge rate will be 10l/s from the entire area.

2.13 A summary of the overall discharge rates and attenuation volumes for both developments, to show how the drainage could work in tandem to maintain the 10 l/s discharge rate is shown in Table 2. For the associated micro drainage calculations, refer to Appendix E.

Table 2: Attenuation requirements and discharge rates for various return periods

Return Period +40% CC	Discharge Rate (l/s)	Attenuation Volume (m^3)
1 in 1	8.9	32.3
1 in 30	10.0	67.4
1 in 100	10.0	89.1

2.14 A summary of the SUDS that have been reviewed as part of the surface water drainage strategy and their suitability are listed in Table 3.

Table 3: SuDS Feature with general description from CIRIA C753 SUDS Manual

SUDS Feature	Description	Potential for Application
Rainwater Harvesting	Rainwater Harvesting (RWH) is the collection of rainwater runoff for use. Runoff can be collected from roofs and other impermeable areas, stored, treated (where required) and then used for domestic, commercial, industrial, or institutional properties.	Rainwater harvesting is to be explored during the detailed design to determine the efficiency and benefits the system can provide.
Green Roofs	Green roofs are areas of vegetation installed on the top of buildings, for reasons including visual benefit, ecological value, enhanced building performance and the reduction of surface water runoff.	Green roofs are not considered to be suitable for the site, due to there being a lot of terracing, electrical plant and solar panels on the roof.
Infiltration Systems	There are various types of infiltration structures which can include: soakaways, infiltration trenches, infiltration blankets, infiltration basins and permeable subbases. Infiltration can contribute to reducing runoff rates and volumes while supporting baseflow and groundwater recharge processes.	When considering the 5 m offset required from buildings/adopted highways, there is insufficient space to provide traditional soakaways.
Proprietary Treatment Systems	Proprietary treatment systems are manufactured products that remove specified pollutants from surface water runoff.	This option can be explored during the detailed design stage if further treatment is required for the surface water runoff.

SUDS Feature	Description	Potential for Application
Filter Strips	Filter strips are uniformly graded and gently sloping strips of grass or other dense vegetation that are designed to treat runoff from adjacent impermeable areas by promoting sedimentation, filtration, and infiltration (where acceptable).	Due to site constraints, there is very limited space to provide filter strips.
Filter Drains	These are shallow trenches filled with stone/gravel that create temporary subsurface storage for the attenuation, conveyance, and filtration of surface water runoff.	Due to site constraints, there is very limited space to provide filter strips.
Swales	Swales are shallow, flat bottomed, vegetated open channels designed to convey, treat, and often attenuate surface water runoff.	There is very limited space available on site and therefore, swales are not considered suitable.
Bio Retention Systems (including tree pits)	Bioretention systems (including rain gardens) are shallow landscaped depressions that can reduce runoff rates and volumes and treat pollution using engineered soils and vegetation.	Unlined systems would need to be treated similarly to a soakaway and are to be located at least 5m from buildings etc. Furthermore, there is very limited space available to provide bioretention systems.
Pervious Pavements	Pervious pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into the underlying structural layers.	This option can be explored during the detailed design for parking areas that are located outside of the roof of the building.

SUDS Feature	Description	Potential for Application
Attenuation Storage (below ground)	Below ground storage is typically a void space for the temporary storage of surface water before infiltration, controlled release, or use. There are various forms which are, but not limited to; geocellular storage systems, oversized pipes, concrete boxes etc.	Below ground storage is used as part of drainage strategy.
Attenuation Basins	These are landscaped depressions that are normally dry except during and immediately following storm events.	There is insufficient space on site to provide an attenuation basin.
Ponds and Wetlands	Ponds and wetlands are features with a permanent pool of water that provide both attenuation and treatment of surface water runoff.	There is insufficient space on site to provide a pond or wetlands.
Trees	Trees can provide various benefits for the water quality, amenity, and biodiversity for a site,	No additional trees are proposed as part of the development.

Foul Drainage Strategy

2.15 There are no existing foul sewers on site but there are several SWW combined sewers located to the south west of the site.

2.16 Due to levels, it is proposed to provide a private pump station on the site and discharge into the private foul drainage within the adjacent development, The Chasse, which is also owned by the client. There is sufficient capacity within the network to accommodate the proposed development

3 Operation and Maintenance

3.1 In order to ensure that the drainage systems can operate throughout the lifetime of the development, it is important that there is regular maintenance of the system. This prevents issues such as blockages and means that the system can continue to operate as designed. There are many different techniques for maintaining the system and these include but are not restricted to jetting and emptying silt traps and trapped gullies.

3.2 Regular ongoing maintenance will be required to ensure the continued operation of the SuDS to design performance standards. The SuDS Manual C753 provides a generic maintenance schedule for guidance purposes. The schedule details necessary maintenance actions and the frequency at which they need to occur.

3.3 The generic maintenance schedule within the SuDS manual can be used as a guide for setting out a maintenance agreement with a private maintenance company. It should be noted that the manual states that the tables *'provide guidance on the type of operational and maintenance requirement that may be appropriate. The list of actions is not exhaustive, and some actions may not always be required.'*

3.4 Some of the regular maintenance actions that are required for the attenuation are and for further information, refer to Appendix F:

- Checking to see if the system is operating properly and that all the components are in good working condition, if not then remedial action needs to be undertaken
- Inspect for debris/sediment build up and remove any debris/sediment that may have accumulated within the attenuation and manhole which would otherwise reduce the maximum storage capacity

3.5 If on inspection there are issues, then remedial action will be required. Where damage with any component has been found, these will either need to be replaced or rehabilitated.

3.6 Drainage on site is to remain private and will be maintained by a private maintenance company.

4 Summary and Conclusions

4.1 This drainage statement is to support a planning application for a proposed development of 17 apartments on land off Exeter Road, Topsham, EX3 0FB.

4.2 Based on the offsets required from proposed buildings (5m), adopted highways (5m) and site boundary (2.5m), there is insufficient space to provide soakaways.

4.3 Therefore, it is proposed to discharge into SWW's surface water sewer to the south at a maximum rate of 10 l/s as agreed with them.

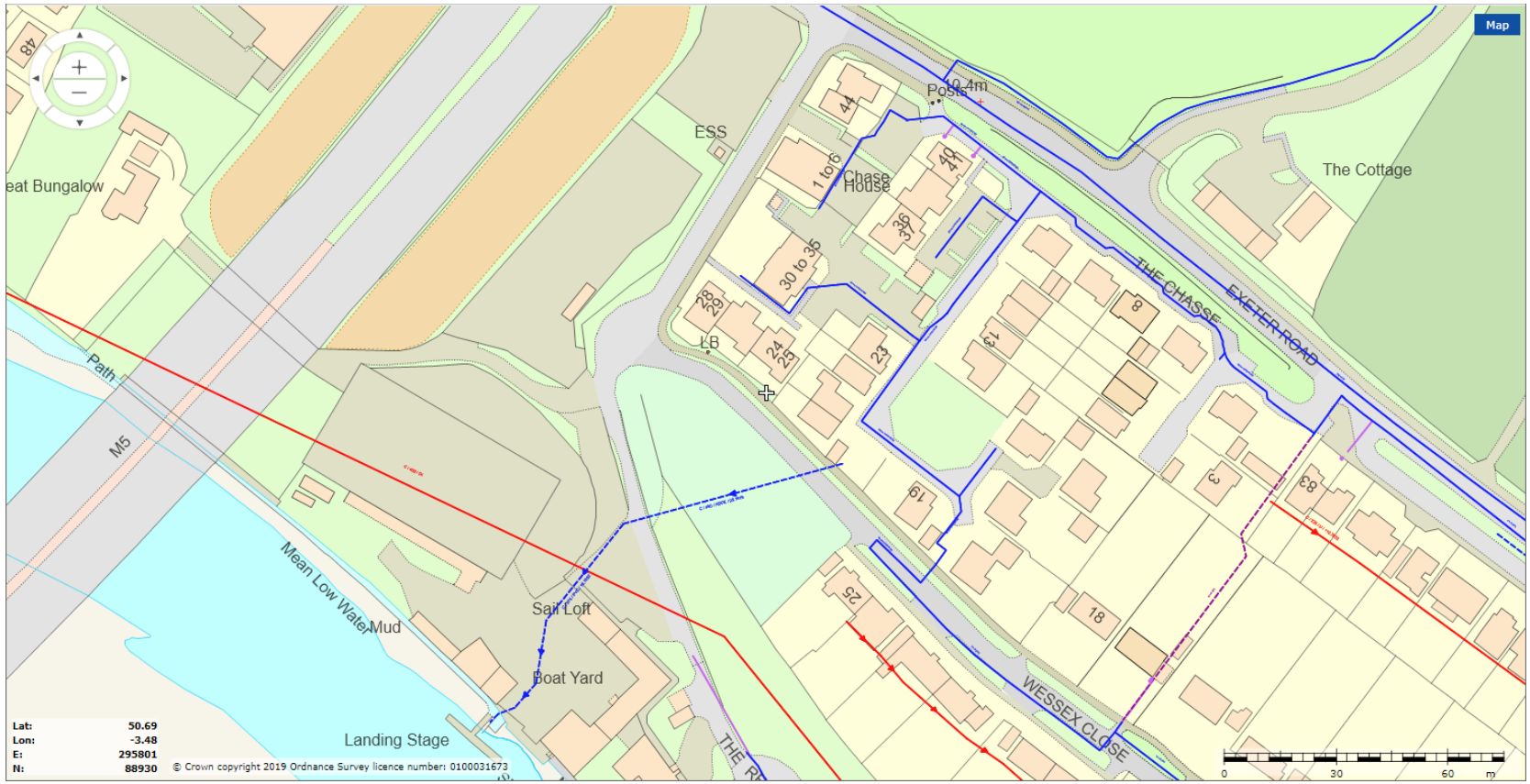
4.4 The attenuation that is to be provided will cater for this development and will be able to work in tandem with the adjacent development to ensure the overall maximum discharge rate will remain at 10 l/s.

4.5 The use of permeable paving, for the parking areas not within the building are to be reviewed during the detailed design.

4.6 Foul water will be conveyed to a private pump station on site and discharge into the private drainage within the adjacent site, The Chasse. There is sufficient capacity within that site to accommodate the development.

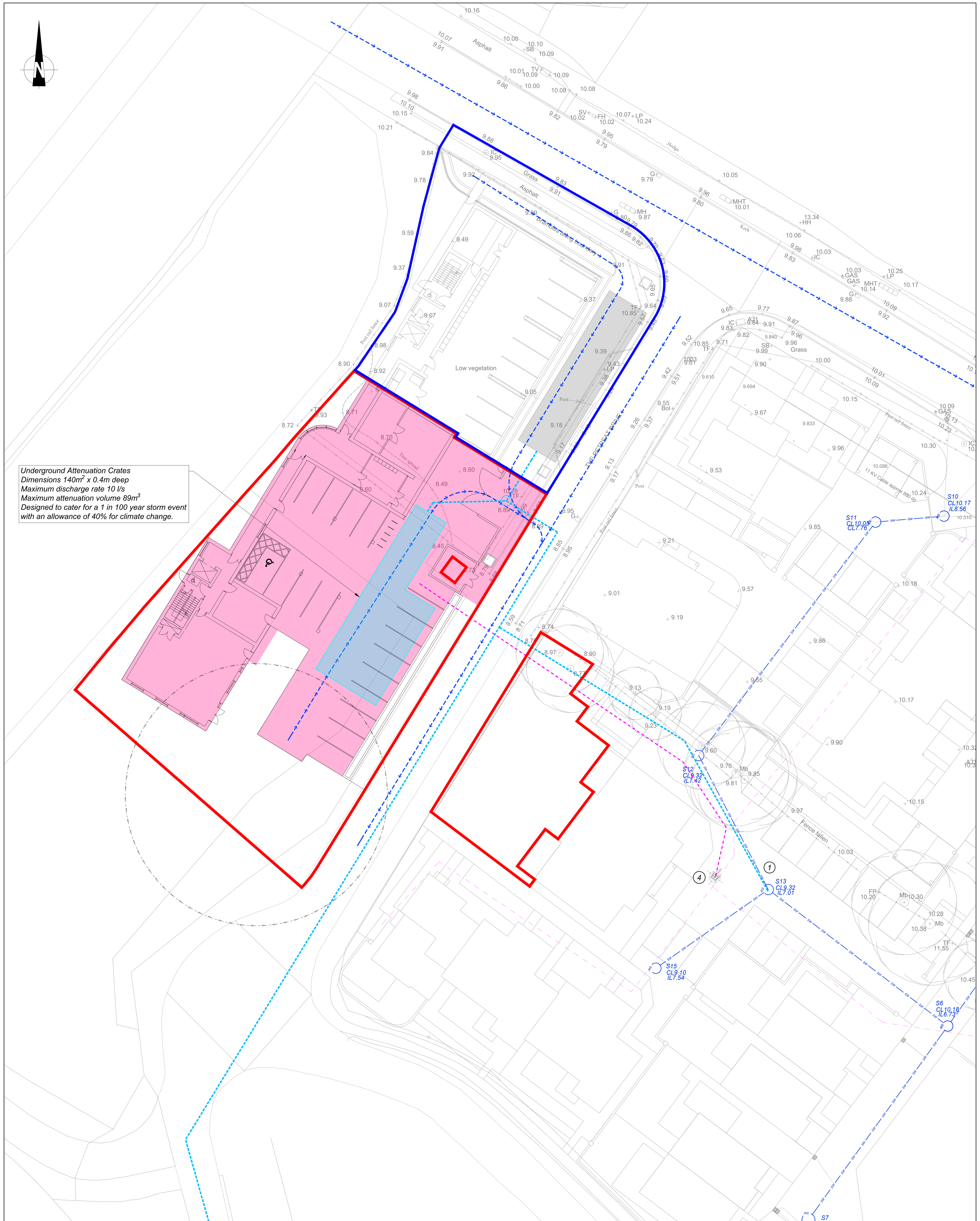
Appendix A

Existing South West Water Asset Record Plan

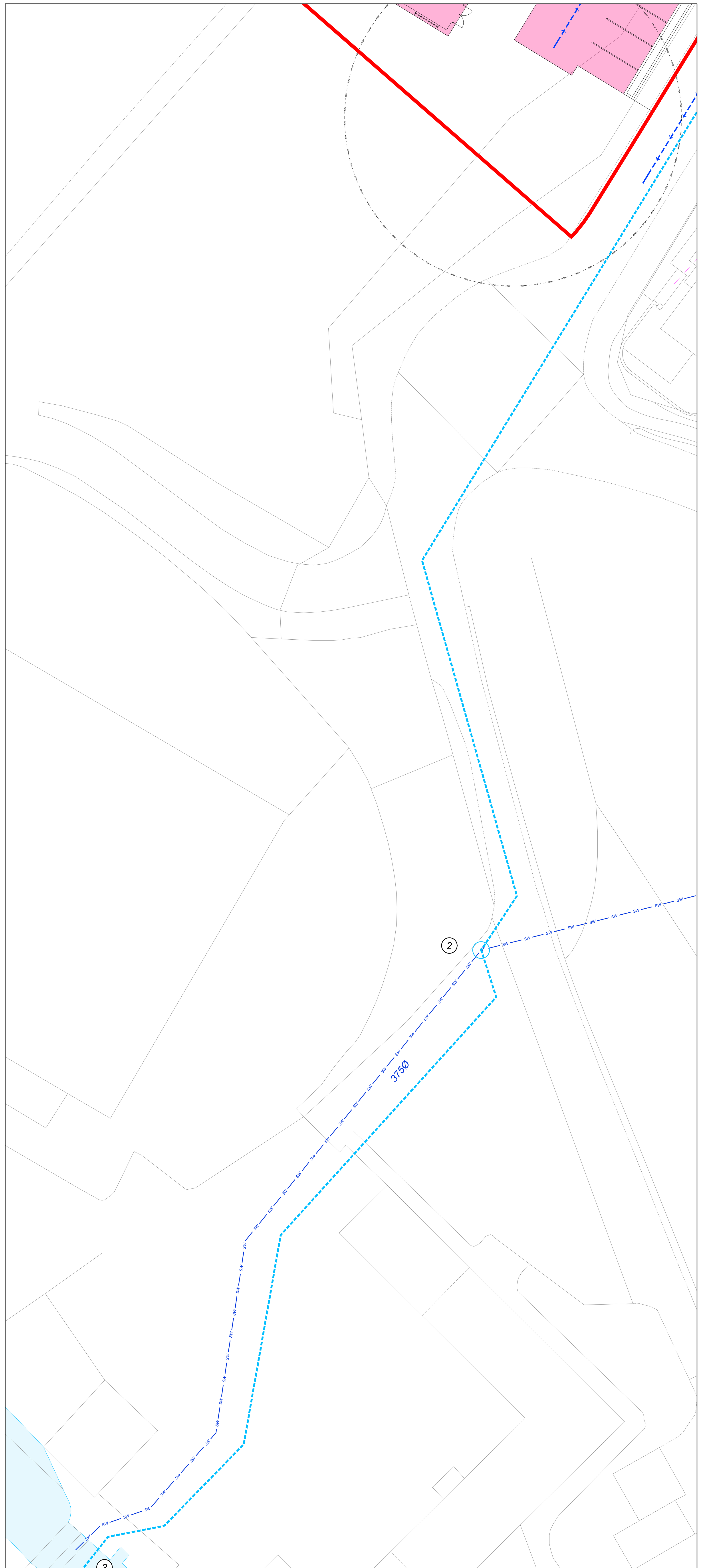


Appendix B

Proposed Drainage Strategy



Site Plan
Scale 1:250



Offsite Discharge Location
Scale 1:250

GENERAL NOTES

- This drawing is to be read in conjunction with all other relevant Architect's, Engineers & Specialist drawings, details and the relevant Health and Safety Plan (as appropriate).
- Do not scale from this drawing. Use figured dimensions only.
- Existing statutory undertakers plant provided by third party utility companies and indicated for information only. Other plant may be present onsite that may not have been identified. The exact locations should be determined prior to any excavations.
- Connection subject to S106 application by contractor

Key

- Planning application boundary
- Approved 10 unit scheme boundary ref 21/1610/VOC
- Existing South West Water surface water sewer
- Existing foul drainage
- Proposed surface water drainage
- River Exe
- Root protection area
- Proposed impermeable area (953m²)
- Proposed underground attenuation crates based on maximum 10 l/s discharge rate
- Adjacent underground attenuation
- Flood exceedance routes

1. Surface water discharge option 1: Connection into the surface water sewer system at The Chasse subject to capacity within the network, attenuated discharge will be required. Agreement to cross the private road will also be required.
2. Surface water discharge option 2: Connection into South West Water's surface water sewer located to the south of the development to be undertaken via sewer requisition. SWW have confirmed that they would accept a discharge of 10 l/s into their network. Agreement to cross third party land or sewer requisition will be required.
3. Surface water discharge option 3: Discharge directly into the River Exe Estuary, no attenuation required. To be undertaken via agreement or sewer requisition.
4. Proposed connection into existing private foul pump station to the east. Subject to sufficient capacity for the 24 hour emergency storage.

Rev	Date	Description	Drawn	Check
A	18.02.2022	Revised architectural layout	JL	WP
-	26.01.2022	Issued for information	JL	WP

Trace Design
Transport and Civil Engineering

Ground Floor
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Fair Oak Close
Clyst Honiton
Exeter, Devon
EX5 2UX

Drawing Status: FOR PLANNING	Scale @ A1: 1:250
Project: Land off Exeter Road, Topsham	Project No.: 19013
Drawing: Proposed Drainage Strategy 17 Apartments	Drawing No.: 220
	Revision: A

Appendix C

Email Correspondence with South West Water

Jamie Law

From: Dunn, Martyn J <mdunn@southwestwater.co.uk>
Sent: 20 June 2019 16:15
To: Jamie Law
Cc: Willi Pahl
Subject: RE: Land off Exeter Road, Topsham

Jamie we would accept around 10l/s.

Regards

Martyn Dunn Development Coordinator

South West Water

D: 01392 443702

Peninsula House, Rydon Lane, Exeter, EX2 7HR
www.southwestwater.co.uk

Please note that the Water Act 2014 has brought in changes that mean that all water companies are being asked to modify the way they charge customers for Developer Services related activities from April 2018.

PRICE PROMISE

From: Jamie Law [mailto:jamie@trace-design.co.uk]
Sent: 20 June 2019 15:57
To: Dunn, Martyn J
Cc: Willi Pahl
Subject: RE: Land off Exeter Road, Topsham

Martyn,

The discharge rate was calculated for the entire area shown by the red boundary .

1/3 of the site has been allocated (17/1656/FUL) and it is anticipated that the remaining 2/3 of the area will be put forward for planning.

We are proposing to future proof the proposed connection into your system that discharge into the estuary for the future developments.

What would be the maximum allowable discharge rate for surface water that you would accept?

Kind Regards,

Jamie

Jamie Law **MEng (Hons)** **Engineer**	**e:** jamie@trace-design.co.uk **t:** +44 (0)1392 363 835 **w:** www.trace-design.co.uk	3 Silverdown Office Park Fair Oak Close Exeter, Devon EX5 2UX

From: Dunn, Martyn J <mdunn@southwestwater.co.uk>
Sent: 11 June 2019 12:02
To: Jamie Law <jamie@trace-design.co.uk>
Cc: Willi Pahl <willi@trace-design.co.uk>
Subject: RE: Land off Exeter Road, Topsham

Jamie this application is only for 10 apartments I would like to see how you have come to a 1 in 30 year rate of this volume for such a small the impermeable area.

In any event we could not accept such a rate.

Regards

Martyn Dunn Development Coordinator

South West Water

D: 01392 443702

Peninsula House, Rydon Lane, Exeter, EX2 7HR
www.southwestwater.co.uk

Please note that the Water Act 2014 has brought in changes that mean that all water companies are being asked to modify the way they charge customers for Developer Services related activities from April 2018.

From: Jamie Law [mailto:jamie@trace-design.co.uk]
Sent: 11 June 2019 08:39
To: Dunn, Martyn J

Cc: Willi Pahl
Subject: RE: Land off Exeter Road, Topsham

Dear Martyn,

The 1 in 30 is based on the new impermeable area. The site currently has planning permission under 17/1656/FUL.

It is proposed to develop the two areas to the south of this site, in the future, and they too will connect into the existing surface water.

Kind Regards,

Jamie

Jamie Law
MEng (Hons)
Engineer

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w: www.trace-design.co.uk

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Trace Design

From: Dunn, Martyn J <mdunn@southwestwater.co.uk>
Sent: 06 June 2019 08:59
To: Jamie Law <jamie@trace-design.co.uk>
Subject: RE: Land off Exeter Road, Topsham

Jamie no the public sewer would not have capacity – what is the 1 in 30 year based on the new impermeable rather than the greenfield rate for the site area as a whole?

Martyn Dunn Development Coordinator

South West Water

D: 01392 443702

Peninsula House, Rydon Lane, Exeter, EX2 7HR
www.southwestwater.co.uk

Please note that the Water Act 2014 has brought in changes that mean that all water companies are being asked to modify the way they charge customers for Developer Services related activities from April 2018.

From: Jamie Law [mailto:jamie@trace-design.co.uk]
Sent: 05 June 2019 17:04
To: Dunn, Martyn J
Cc: Willi Pahl
Subject: Land off Exeter Road, Topsham

Dear Martyn,

We have a proposed development on land off topsham road, please see the red boundary on the attached markup.

We are proposing to connect into the existing surface water sewer located to the south west of the development at an unattenuated rate (1in30) at 143.1 l/s (around the green circle). The existing surface water sewer discharges into the estuary.

Would this be acceptable?

Kind
Regards,

Jamie

Jamie Law
MEng (Hons)
Engineer

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Appendix D

Micro Drainage Attenuation Calculations – 17 Apartments

Summary of Results for 2 year Return Period (+40%)

Half Drain Time : 29 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.093	0.093	0.0	4.9	4.9	12.3	O K
30 min Summer	0.106	0.106	0.0	6.1	6.1	14.1	O K
60 min Summer	0.114	0.114	0.0	6.8	6.8	15.2	O K
120 min Summer	0.122	0.122	0.0	7.4	7.4	16.2	O K
180 min Summer	0.119	0.119	0.0	7.2	7.2	15.9	O K
240 min Summer	0.115	0.115	0.0	6.8	6.8	15.3	O K
360 min Summer	0.106	0.106	0.0	6.1	6.1	14.1	O K
480 min Summer	0.099	0.099	0.0	5.4	5.4	13.1	O K
600 min Summer	0.093	0.093	0.0	4.9	4.9	12.3	O K
720 min Summer	0.088	0.088	0.0	4.5	4.5	11.7	O K
960 min Summer	0.080	0.080	0.0	3.8	3.8	10.6	O K
1440 min Summer	0.069	0.069	0.0	3.0	3.0	9.2	O K
2160 min Summer	0.060	0.060	0.0	2.3	2.3	8.0	O K
2880 min Summer	0.055	0.055	0.0	1.9	1.9	7.3	O K
4320 min Summer	0.048	0.048	0.0	1.5	1.5	6.3	O K
5760 min Summer	0.044	0.044	0.0	1.3	1.3	5.8	O K
7200 min Summer	0.041	0.041	0.0	1.1	1.1	5.4	O K
8640 min Summer	0.039	0.039	0.0	1.0	1.0	5.1	O K
10080 min Summer	0.037	0.037	0.0	0.9	0.9	4.9	O K
15 min Winter	0.093	0.093	0.0	4.9	4.9	12.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	50.319	0.0	14.2	16
30 min Summer	32.600	0.0	18.5	24
60 min Summer	20.454	0.0	23.4	40
120 min Summer	13.665	0.0	31.3	74
180 min Summer	10.630	0.0	36.5	106
240 min Summer	8.847	0.0	40.5	136
360 min Summer	6.786	0.0	46.7	198
480 min Summer	5.587	0.0	51.2	258
600 min Summer	4.791	0.0	54.9	320
720 min Summer	4.220	0.0	58.0	378
960 min Summer	3.445	0.0	63.2	502
1440 min Summer	2.576	0.0	70.8	740
2160 min Summer	1.928	0.0	79.7	1104
2880 min Summer	1.578	0.0	87.0	1468
4320 min Summer	1.206	0.0	99.6	2204
5760 min Summer	1.009	0.0	111.3	2936
7200 min Summer	0.889	0.0	122.6	3672
8640 min Summer	0.807	0.0	133.6	4400
10080 min Summer	0.748	0.0	144.3	5136
15 min Winter	50.319	0.0	14.2	16

Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.106	0.106	0.0	6.1	6.1	14.1	O K
60 min Winter	0.112	0.112	0.0	6.5	6.5	14.8	O K
120 min Winter	0.113	0.113	0.0	6.7	6.7	15.1	O K
180 min Winter	0.108	0.108	0.0	6.2	6.2	14.4	O K
240 min Winter	0.102	0.102	0.0	5.7	5.7	13.5	O K
360 min Winter	0.091	0.091	0.0	4.8	4.8	12.2	O K
480 min Winter	0.084	0.084	0.0	4.1	4.1	11.1	O K
600 min Winter	0.078	0.078	0.0	3.6	3.6	10.3	O K
720 min Winter	0.073	0.073	0.0	3.2	3.2	9.7	O K
960 min Winter	0.066	0.066	0.0	2.7	2.7	8.7	O K
1440 min Winter	0.056	0.056	0.0	2.0	2.0	7.5	O K
2160 min Winter	0.049	0.049	0.0	1.6	1.6	6.5	O K
2880 min Winter	0.044	0.044	0.0	1.3	1.3	5.8	O K
4320 min Winter	0.038	0.038	0.0	1.0	1.0	5.1	O K
5760 min Winter	0.035	0.035	0.0	0.8	0.8	4.6	O K
7200 min Winter	0.033	0.033	0.0	0.7	0.7	4.3	O K
8640 min Winter	0.031	0.031	0.0	0.6	0.6	4.1	O K
10080 min Winter	0.030	0.030	0.0	0.6	0.6	3.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	32.600	0.0	18.5	25
60 min Winter	20.454	0.0	23.4	44
120 min Winter	13.665	0.0	31.3	78
180 min Winter	10.630	0.0	36.5	110
240 min Winter	8.847	0.0	40.5	142
360 min Winter	6.786	0.0	46.7	204
480 min Winter	5.587	0.0	51.2	264
600 min Winter	4.791	0.0	54.9	326
720 min Winter	4.220	0.0	58.0	386
960 min Winter	3.445	0.0	63.2	508
1440 min Winter	2.576	0.0	70.9	752
2160 min Winter	1.928	0.0	79.7	1116
2880 min Winter	1.578	0.0	87.0	1472
4320 min Winter	1.206	0.0	99.6	2192
5760 min Winter	1.009	0.0	111.3	2928
7200 min Winter	0.889	0.0	122.6	3640
8640 min Winter	0.807	0.0	133.6	4416
10080 min Winter	0.748	0.0	144.3	5016

Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 295747 88989 SX 95747 88989
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.115

Time (mins) From:	To:	Area (ha)
0	4	0.115

Model Details

Storage is Online Cover Level (m) 1.500

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	140.0	0.0	0.401	0.0	0.0
0.400	140.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0153-1000-0400-1000
Design Head (m)	0.400
Design Flow (l/s)	10.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	153
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.400	10.0
Flush-Flo™	0.216	10.0
Kick-Flo®	0.338	9.2
Mean Flow over Head Range	-	7.6

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	5.5	1.200	16.8	3.000	26.1	7.000	39.4
0.200	10.0	1.400	18.1	3.500	28.1	7.500	40.8
0.300	9.7	1.600	19.3	4.000	30.0	8.000	42.2
0.400	10.0	1.800	20.4	4.500	31.5	8.500	43.5
0.500	11.1	2.000	21.5	5.000	33.2	9.000	44.8
0.600	12.1	2.200	22.5	5.500	34.9	9.500	46.0
0.800	13.9	2.400	23.4	6.000	36.5		
1.000	15.4	2.600	24.3	6.500	38.0		

Summary of Results for 30 year Return Period (+40%)

Half Drain Time : 44 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.199	0.199	0.0	10.0	10.0	26.5	O K
30 min Summer	0.237	0.237	0.0	10.0	10.0	31.5	O K
60 min Summer	0.259	0.259	0.0	10.0	10.0	34.5	O K
120 min Summer	0.248	0.248	0.0	10.0	10.0	33.0	O K
180 min Summer	0.227	0.227	0.0	10.0	10.0	30.2	O K
240 min Summer	0.205	0.205	0.0	10.0	10.0	27.3	O K
360 min Summer	0.169	0.169	0.0	9.9	9.9	22.5	O K
480 min Summer	0.148	0.148	0.0	9.3	9.3	19.7	O K
600 min Summer	0.134	0.134	0.0	8.4	8.4	17.9	O K
720 min Summer	0.124	0.124	0.0	7.6	7.6	16.6	O K
960 min Summer	0.110	0.110	0.0	6.4	6.4	14.7	O K
1440 min Summer	0.093	0.093	0.0	4.9	4.9	12.4	O K
2160 min Summer	0.079	0.079	0.0	3.7	3.7	10.5	O K
2880 min Summer	0.071	0.071	0.0	3.1	3.1	9.4	O K
4320 min Summer	0.061	0.061	0.0	2.3	2.3	8.1	O K
5760 min Summer	0.055	0.055	0.0	2.0	2.0	7.3	O K
7200 min Summer	0.051	0.051	0.0	1.7	1.7	6.8	O K
8640 min Summer	0.049	0.049	0.0	1.6	1.6	6.5	O K
10080 min Summer	0.047	0.047	0.0	1.4	1.4	6.2	O K
15 min Winter	0.199	0.199	0.0	10.0	10.0	26.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	110.275	0.0	31.4	16
30 min Summer	72.373	0.0	41.3	27
60 min Summer	45.511	0.0	52.2	44
120 min Summer	27.235	0.0	62.5	78
180 min Summer	20.153	0.0	69.4	110
240 min Summer	16.268	0.0	74.7	142
360 min Summer	12.015	0.0	82.7	200
480 min Summer	9.680	0.0	88.9	258
600 min Summer	8.181	0.0	93.9	320
720 min Summer	7.126	0.0	98.2	378
960 min Summer	5.725	0.0	105.1	500
1440 min Summer	4.201	0.0	115.7	738
2160 min Summer	3.094	0.0	128.0	1104
2880 min Summer	2.505	0.0	138.2	1468
4320 min Summer	1.886	0.0	155.9	2204
5760 min Summer	1.561	0.0	172.3	2928
7200 min Summer	1.365	0.0	188.3	3672
8640 min Summer	1.233	0.0	204.1	4384
10080 min Summer	1.138	0.0	219.7	5104
15 min Winter	110.275	0.0	31.4	16

Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.236	0.236	0.0	10.0	10.0	31.4	O K
60 min Winter	0.252	0.252	0.0	10.0	10.0	33.5	O K
120 min Winter	0.226	0.226	0.0	10.0	10.0	30.1	O K
180 min Winter	0.193	0.193	0.0	10.0	10.0	25.7	O K
240 min Winter	0.166	0.166	0.0	9.8	9.8	22.0	O K
360 min Winter	0.136	0.136	0.0	8.5	8.5	18.1	O K
480 min Winter	0.119	0.119	0.0	7.2	7.2	15.9	O K
600 min Winter	0.108	0.108	0.0	6.2	6.2	14.4	O K
720 min Winter	0.100	0.100	0.0	5.5	5.5	13.3	O K
960 min Winter	0.088	0.088	0.0	4.5	4.5	11.7	O K
1440 min Winter	0.074	0.074	0.0	3.3	3.3	9.9	O K
2160 min Winter	0.063	0.063	0.0	2.5	2.5	8.3	O K
2880 min Winter	0.056	0.056	0.0	2.0	2.0	7.5	O K
4320 min Winter	0.048	0.048	0.0	1.5	1.5	6.4	O K
5760 min Winter	0.044	0.044	0.0	1.3	1.3	5.8	O K
7200 min Winter	0.041	0.041	0.0	1.1	1.1	5.4	O K
8640 min Winter	0.039	0.039	0.0	1.0	1.0	5.1	O K
10080 min Winter	0.037	0.037	0.0	0.9	0.9	4.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	72.373	0.0	41.3	28
60 min Winter	45.511	0.0	52.2	46
120 min Winter	27.235	0.0	62.5	82
180 min Winter	20.153	0.0	69.4	116
240 min Winter	16.268	0.0	74.7	144
360 min Winter	12.015	0.0	82.7	202
480 min Winter	9.680	0.0	88.9	264
600 min Winter	8.181	0.0	93.9	324
720 min Winter	7.126	0.0	98.2	384
960 min Winter	5.725	0.0	105.1	502
1440 min Winter	4.201	0.0	115.7	748
2160 min Winter	3.094	0.0	128.0	1104
2880 min Winter	2.505	0.0	138.2	1460
4320 min Winter	1.886	0.0	155.9	2156
5760 min Winter	1.561	0.0	172.3	2920
7200 min Winter	1.365	0.0	188.3	3648
8640 min Winter	1.233	0.0	204.1	4360
10080 min Winter	1.138	0.0	219.7	5064

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 295747 88989 SX 95747 88989
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.115

Time (mins) From:	To:	Area (ha)
0	4	0.115

Model Details

Storage is Online Cover Level (m) 1.500

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	140.0	0.0	0.401	0.0	0.0
0.400	140.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0153-1000-0400-1000
Design Head (m)	0.400
Design Flow (l/s)	10.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	153
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.400	10.0
Flush-Flo™	0.216	10.0
Kick-Flo®	0.338	9.2
Mean Flow over Head Range	-	7.6

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	5.5	1.200	16.8	3.000	26.1	7.000	39.4
0.200	10.0	1.400	18.1	3.500	28.1	7.500	40.8
0.300	9.7	1.600	19.3	4.000	30.0	8.000	42.2
0.400	10.0	1.800	20.4	4.500	31.5	8.500	43.5
0.500	11.1	2.000	21.5	5.000	33.2	9.000	44.8
0.600	12.1	2.200	22.5	5.500	34.9	9.500	46.0
0.800	13.9	2.400	23.4	6.000	36.5		
1.000	15.4	2.600	24.3	6.500	38.0		

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 41 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.258	0.258	0.0	10.0	10.0	34.3	O K
30 min Summer	0.317	0.317	0.0	10.0	10.0	42.2	O K
60 min Summer	0.351	0.351	0.0	10.0	10.0	46.7	O K
120 min Summer	0.335	0.335	0.0	10.0	10.0	44.6	O K
180 min Summer	0.307	0.307	0.0	10.0	10.0	40.9	O K
240 min Summer	0.278	0.278	0.0	10.0	10.0	37.0	O K
360 min Summer	0.227	0.227	0.0	10.0	10.0	30.2	O K
480 min Summer	0.189	0.189	0.0	10.0	10.0	25.1	O K
600 min Summer	0.162	0.162	0.0	9.8	9.8	21.6	O K
720 min Summer	0.147	0.147	0.0	9.2	9.2	19.5	O K
960 min Summer	0.128	0.128	0.0	7.9	7.9	17.0	O K
1440 min Summer	0.107	0.107	0.0	6.1	6.1	14.2	O K
2160 min Summer	0.089	0.089	0.0	4.6	4.6	11.9	O K
2880 min Summer	0.079	0.079	0.0	3.7	3.7	10.5	O K
4320 min Summer	0.067	0.067	0.0	2.8	2.8	8.9	O K
5760 min Summer	0.060	0.060	0.0	2.3	2.3	8.0	O K
7200 min Summer	0.056	0.056	0.0	2.0	2.0	7.4	O K
8640 min Summer	0.053	0.053	0.0	1.8	1.8	7.0	O K
10080 min Summer	0.051	0.051	0.0	1.7	1.7	6.7	O K
15 min Winter	0.258	0.258	0.0	10.0	10.0	34.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	139.469	0.0	39.8	17
30 min Summer	92.478	0.0	52.9	30
60 min Summer	58.435	0.0	67.1	48
120 min Summer	34.349	0.0	78.9	82
180 min Summer	25.224	0.0	86.9	116
240 min Summer	20.274	0.0	93.1	148
360 min Summer	14.902	0.0	102.7	208
480 min Summer	11.978	0.0	110.0	266
600 min Summer	10.108	0.0	116.1	322
720 min Summer	8.796	0.0	121.2	380
960 min Summer	7.060	0.0	129.7	500
1440 min Summer	5.164	0.0	142.3	738
2160 min Summer	3.777	0.0	156.3	1104
2880 min Summer	3.036	0.0	167.5	1468
4320 min Summer	2.253	0.0	186.3	2200
5760 min Summer	1.845	0.0	203.6	2936
7200 min Summer	1.601	0.0	220.8	3672
8640 min Summer	1.438	0.0	237.9	4400
10080 min Summer	1.321	0.0	255.0	5120
15 min Winter	139.469	0.0	39.8	17

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.317	0.317	0.0	10.0	10.0	42.1	O K
60 min Winter	0.345	0.345	0.0	10.0	10.0	45.9	O K
120 min Winter	0.313	0.313	0.0	10.0	10.0	41.7	O K
180 min Winter	0.270	0.270	0.0	10.0	10.0	35.9	O K
240 min Winter	0.228	0.228	0.0	10.0	10.0	30.4	O K
360 min Winter	0.168	0.168	0.0	9.8	9.8	22.3	O K
480 min Winter	0.141	0.141	0.0	8.8	8.8	18.7	O K
600 min Winter	0.125	0.125	0.0	7.7	7.7	16.7	O K
720 min Winter	0.115	0.115	0.0	6.8	6.8	15.3	O K
960 min Winter	0.100	0.100	0.0	5.5	5.5	13.4	O K
1440 min Winter	0.084	0.084	0.0	4.1	4.1	11.1	O K
2160 min Winter	0.070	0.070	0.0	3.0	3.0	9.3	O K
2880 min Winter	0.062	0.062	0.0	2.4	2.4	8.3	O K
4320 min Winter	0.053	0.053	0.0	1.8	1.8	7.1	O K
5760 min Winter	0.048	0.048	0.0	1.5	1.5	6.3	O K
7200 min Winter	0.044	0.044	0.0	1.3	1.3	5.9	O K
8640 min Winter	0.042	0.042	0.0	1.2	1.2	5.5	O K
10080 min Winter	0.040	0.040	0.0	1.1	1.1	5.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	92.478	0.0	52.9	30
60 min Winter	58.435	0.0	67.1	50
120 min Winter	34.349	0.0	78.9	86
180 min Winter	25.224	0.0	86.9	122
240 min Winter	20.274	0.0	93.1	152
360 min Winter	14.902	0.0	102.7	210
480 min Winter	11.978	0.0	110.0	264
600 min Winter	10.108	0.0	116.1	324
720 min Winter	8.796	0.0	121.2	384
960 min Winter	7.060	0.0	129.7	504
1440 min Winter	5.164	0.0	142.3	748
2160 min Winter	3.777	0.0	156.3	1104
2880 min Winter	3.036	0.0	167.5	1472
4320 min Winter	2.253	0.0	186.3	2192
5760 min Winter	1.845	0.0	203.6	2904
7200 min Winter	1.601	0.0	220.8	3656
8640 min Winter	1.438	0.0	237.9	4400
10080 min Winter	1.321	0.0	255.0	5088

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 295747 88989 SX 95747 88989
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.115

Time (mins) From:	To:	Area (ha)
0	4	0.115

Model Details

Storage is Online Cover Level (m) 1.500

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	140.0	0.0	0.401	0.0	0.0
0.400	140.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0153-1000-0400-1000
Design Head (m)	0.400
Design Flow (l/s)	10.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	153
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.400	10.0
Flush-Flo™	0.216	10.0
Kick-Flo®	0.338	9.2
Mean Flow over Head Range	-	7.6

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	5.5	1.200	16.8	3.000	26.1	7.000	39.4
0.200	10.0	1.400	18.1	3.500	28.1	7.500	40.8
0.300	9.7	1.600	19.3	4.000	30.0	8.000	42.2
0.400	10.0	1.800	20.4	4.500	31.5	8.500	43.5
0.500	11.1	2.000	21.5	5.000	33.2	9.000	44.8
0.600	12.1	2.200	22.5	5.500	34.9	9.500	46.0
0.800	13.9	2.400	23.4	6.000	36.5		
1.000	15.4	2.600	24.3	6.500	38.0		

Appendix E

Micro Drainage Attenuation Calculations – Both Developments

Summary of Results for 2 year Return Period (+40%)

Half Drain Time : 49 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.095	0.095	0.0	5.1	5.1	21.7	O K
30 min Summer	0.112	0.112	0.0	6.5	6.5	25.5	O K
60 min Summer	0.124	0.124	0.0	7.6	7.6	28.2	O K
120 min Summer	0.139	0.139	0.0	8.7	8.7	31.7	O K
180 min Summer	0.142	0.142	0.0	8.9	8.9	32.3	O K
240 min Summer	0.140	0.140	0.0	8.8	8.8	31.9	O K
360 min Summer	0.133	0.133	0.0	8.3	8.3	30.3	O K
480 min Summer	0.125	0.125	0.0	7.7	7.7	28.5	O K
600 min Summer	0.118	0.118	0.0	7.1	7.1	27.0	O K
720 min Summer	0.113	0.113	0.0	6.6	6.6	25.7	O K
960 min Summer	0.103	0.103	0.0	5.8	5.8	23.5	O K
1440 min Summer	0.090	0.090	0.0	4.7	4.7	20.6	O K
2160 min Summer	0.078	0.078	0.0	3.7	3.7	17.8	O K
2880 min Summer	0.071	0.071	0.0	3.1	3.1	16.2	O K
4320 min Summer	0.062	0.062	0.0	2.4	2.4	14.2	O K
5760 min Summer	0.057	0.057	0.0	2.1	2.1	12.9	O K
7200 min Summer	0.053	0.053	0.0	1.8	1.8	12.1	O K
8640 min Summer	0.051	0.051	0.0	1.7	1.7	11.5	O K
10080 min Summer	0.049	0.049	0.0	1.6	1.6	11.1	O K
15 min Winter	0.096	0.096	0.0	5.1	5.1	21.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	50.319	0.0	23.2	17
30 min Summer	32.600	0.0	30.3	29
60 min Summer	20.454	0.0	38.6	44
120 min Summer	13.665	0.0	51.8	78
180 min Summer	10.630	0.0	60.5	110
240 min Summer	8.847	0.0	67.1	142
360 min Summer	6.786	0.0	77.3	206
480 min Summer	5.587	0.0	84.9	266
600 min Summer	4.791	0.0	91.0	328
720 min Summer	4.220	0.0	96.2	390
960 min Summer	3.445	0.0	104.7	510
1440 min Summer	2.576	0.0	117.4	752
2160 min Summer	1.928	0.0	132.3	1120
2880 min Summer	1.578	0.0	144.3	1472
4320 min Summer	1.206	0.0	165.2	2204
5760 min Summer	1.009	0.0	184.8	2936
7200 min Summer	0.889	0.0	203.5	3672
8640 min Summer	0.807	0.0	221.7	4400
10080 min Summer	0.748	0.0	239.4	5136
15 min Winter	50.319	0.0	23.2	17

Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.113	0.113	0.0	6.6	6.6	25.7	O K
60 min Winter	0.123	0.123	0.0	7.5	7.5	28.0	O K
120 min Winter	0.133	0.133	0.0	8.3	8.3	30.4	O K
180 min Winter	0.132	0.132	0.0	8.2	8.2	30.1	O K
240 min Winter	0.127	0.127	0.0	7.8	7.8	29.0	O K
360 min Winter	0.117	0.117	0.0	7.0	7.0	26.8	O K
480 min Winter	0.108	0.108	0.0	6.2	6.2	24.7	O K
600 min Winter	0.101	0.101	0.0	5.6	5.6	23.1	O K
720 min Winter	0.095	0.095	0.0	5.1	5.1	21.7	O K
960 min Winter	0.086	0.086	0.0	4.3	4.3	19.6	O K
1440 min Winter	0.074	0.074	0.0	3.3	3.3	16.8	O K
2160 min Winter	0.063	0.063	0.0	2.5	2.5	14.5	O K
2880 min Winter	0.057	0.057	0.0	2.1	2.1	13.0	O K
4320 min Winter	0.050	0.050	0.0	1.6	1.6	11.3	O K
5760 min Winter	0.045	0.045	0.0	1.4	1.4	10.3	O K
7200 min Winter	0.042	0.042	0.0	1.2	1.2	9.6	O K
8640 min Winter	0.040	0.040	0.0	1.1	1.1	9.1	O K
10080 min Winter	0.039	0.039	0.0	1.0	1.0	8.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	32.600	0.0	30.3	29
60 min Winter	20.454	0.0	38.6	46
120 min Winter	13.665	0.0	51.8	82
180 min Winter	10.630	0.0	60.5	116
240 min Winter	8.847	0.0	67.1	150
360 min Winter	6.786	0.0	77.3	214
480 min Winter	5.587	0.0	84.9	276
600 min Winter	4.791	0.0	91.0	338
720 min Winter	4.220	0.0	96.2	398
960 min Winter	3.445	0.0	104.7	522
1440 min Winter	2.576	0.0	117.4	766
2160 min Winter	1.928	0.0	132.3	1128
2880 min Winter	1.578	0.0	144.3	1472
4320 min Winter	1.206	0.0	165.2	2204
5760 min Winter	1.009	0.0	184.8	2936
7200 min Winter	0.889	0.0	203.5	3672
8640 min Winter	0.807	0.0	221.7	4400
10080 min Winter	0.748	0.0	239.4	5016

Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 295747 88989 SX 95747 88989
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.191

Time (mins) From:	To:	Area (ha)
0	4	0.191

Model Details

Storage is Online Cover Level (m) 1.500

Complex Structure

Cellular Storage

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	100.0	0.0	0.401	0.0	0.0
0.400	100.0	0.0			

Cellular Storage

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	140.0	0.0	0.401	0.0	0.0
0.400	140.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0153-1000-0400-1000
Design Head (m)	0.400
Design Flow (l/s)	10.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	153
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.400	10.0
Flush-Flo™	0.216	10.0
Kick-Flo®	0.338	9.2
Mean Flow over Head Range	-	7.6

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

Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.5	1.200	16.8	3.000	26.1	7.000	39.4
0.200	10.0	1.400	18.1	3.500	28.1	7.500	40.8
0.300	9.7	1.600	19.3	4.000	30.0	8.000	42.2
0.400	10.0	1.800	20.4	4.500	31.5	8.500	43.5
0.500	11.1	2.000	21.5	5.000	33.2	9.000	44.8
0.600	12.1	2.200	22.5	5.500	34.9	9.500	46.0
0.800	13.9	2.400	23.4	6.000	36.5		
1.000	15.4	2.600	24.3	6.500	38.0		

Summary of Results for 30 year Return Period (+40%)

Half Drain Time : 59 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.207	0.207	0.0	10.0	10.0	47.1	O K
30 min Summer	0.256	0.256	0.0	10.0	10.0	58.3	O K
60 min Summer	0.289	0.289	0.0	10.0	10.0	65.9	O K
120 min Summer	0.296	0.296	0.0	10.0	10.0	67.4	O K
180 min Summer	0.289	0.289	0.0	10.0	10.0	65.9	O K
240 min Summer	0.277	0.277	0.0	10.0	10.0	63.2	O K
360 min Summer	0.249	0.249	0.0	10.0	10.0	56.7	O K
480 min Summer	0.220	0.220	0.0	10.0	10.0	50.3	O K
600 min Summer	0.196	0.196	0.0	10.0	10.0	44.7	O K
720 min Summer	0.176	0.176	0.0	9.9	9.9	40.2	O K
960 min Summer	0.150	0.150	0.0	9.5	9.5	34.3	O K
1440 min Summer	0.125	0.125	0.0	7.6	7.6	28.5	O K
2160 min Summer	0.105	0.105	0.0	6.0	6.0	23.9	O K
2880 min Summer	0.094	0.094	0.0	5.0	5.0	21.4	O K
4320 min Summer	0.080	0.080	0.0	3.8	3.8	18.3	O K
5760 min Summer	0.073	0.073	0.0	3.2	3.2	16.5	O K
7200 min Summer	0.067	0.067	0.0	2.8	2.8	15.4	O K
8640 min Summer	0.064	0.064	0.0	2.5	2.5	14.5	O K
10080 min Summer	0.061	0.061	0.0	2.4	2.4	13.9	O K
15 min Winter	0.207	0.207	0.0	10.0	10.0	47.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	110.275	0.0	51.8	17
30 min Summer	72.373	0.0	68.2	31
60 min Summer	45.511	0.0	86.5	54
120 min Summer	27.235	0.0	103.6	86
180 min Summer	20.153	0.0	115.0	120
240 min Summer	16.268	0.0	123.8	154
360 min Summer	12.015	0.0	137.2	218
480 min Summer	9.680	0.0	147.4	282
600 min Summer	8.181	0.0	155.7	340
720 min Summer	7.126	0.0	162.8	398
960 min Summer	5.725	0.0	174.4	512
1440 min Summer	4.201	0.0	191.8	750
2160 min Summer	3.094	0.0	212.4	1108
2880 min Summer	2.505	0.0	229.3	1472
4320 min Summer	1.886	0.0	258.6	2204
5760 min Summer	1.561	0.0	286.0	2936
7200 min Summer	1.365	0.0	312.6	3672
8640 min Summer	1.233	0.0	338.8	4400
10080 min Summer	1.138	0.0	364.5	5136
15 min Winter	110.275	0.0	51.8	17

Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.256	0.256	0.0	10.0	10.0	58.4	O K
60 min Winter	0.288	0.288	0.0	10.0	10.0	65.6	O K
120 min Winter	0.286	0.286	0.0	10.0	10.0	65.3	O K
180 min Winter	0.271	0.271	0.0	10.0	10.0	61.7	O K
240 min Winter	0.250	0.250	0.0	10.0	10.0	57.0	O K
360 min Winter	0.207	0.207	0.0	10.0	10.0	47.3	O K
480 min Winter	0.172	0.172	0.0	9.9	9.9	39.3	O K
600 min Winter	0.150	0.150	0.0	9.5	9.5	34.3	O K
720 min Winter	0.137	0.137	0.0	8.6	8.6	31.3	O K
960 min Winter	0.119	0.119	0.0	7.2	7.2	27.2	O K
1440 min Winter	0.099	0.099	0.0	5.4	5.4	22.6	O K
2160 min Winter	0.083	0.083	0.0	4.1	4.1	19.0	O K
2880 min Winter	0.074	0.074	0.0	3.3	3.3	16.9	O K
4320 min Winter	0.063	0.063	0.0	2.5	2.5	14.4	O K
5760 min Winter	0.057	0.057	0.0	2.1	2.1	13.0	O K
7200 min Winter	0.053	0.053	0.0	1.8	1.8	12.1	O K
8640 min Winter	0.050	0.050	0.0	1.6	1.6	11.5	O K
10080 min Winter	0.048	0.048	0.0	1.5	1.5	11.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	72.373	0.0	68.2	31
60 min Winter	45.511	0.0	86.5	58
120 min Winter	27.235	0.0	103.6	90
180 min Winter	20.153	0.0	115.0	128
240 min Winter	16.268	0.0	123.8	162
360 min Winter	12.015	0.0	137.2	228
480 min Winter	9.680	0.0	147.4	286
600 min Winter	8.181	0.0	155.7	338
720 min Winter	7.126	0.0	162.8	398
960 min Winter	5.725	0.0	174.4	520
1440 min Winter	4.201	0.0	191.8	762
2160 min Winter	3.094	0.0	212.4	1124
2880 min Winter	2.505	0.0	229.3	1476
4320 min Winter	1.886	0.0	258.6	2208
5760 min Winter	1.561	0.0	286.0	2936
7200 min Winter	1.365	0.0	312.7	3672
8640 min Winter	1.233	0.0	338.8	4408
10080 min Winter	1.138	0.0	364.6	5136

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 295747 88989 SX 95747 88989
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.191

Time (mins) From:	To:	Area (ha)
0	4	0.191

Model Details

Storage is Online Cover Level (m) 1.500

Complex Structure

Cellular Storage

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	100.0	0.0	0.401	0.0	0.0
0.400	100.0	0.0			

Cellular Storage

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	140.0	0.0	0.401	0.0	0.0
0.400	140.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0153-1000-0400-1000
Design Head (m)	0.400
Design Flow (l/s)	10.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	153
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.400	10.0
Flush-Flo™	0.216	10.0
Kick-Flo®	0.338	9.2
Mean Flow over Head Range	-	7.6

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

Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.5	1.200	16.8	3.000	26.1	7.000	39.4
0.200	10.0	1.400	18.1	3.500	28.1	7.500	40.8
0.300	9.7	1.600	19.3	4.000	30.0	8.000	42.2
0.400	10.0	1.800	20.4	4.500	31.5	8.500	43.5
0.500	11.1	2.000	21.5	5.000	33.2	9.000	44.8
0.600	12.1	2.200	22.5	5.500	34.9	9.500	46.0
0.800	13.9	2.400	23.4	6.000	36.5		
1.000	15.4	2.600	24.3	6.500	38.0		

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 80 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.265	0.265	0.0	10.0	10.0	60.5	O K
30 min Summer	0.338	0.338	0.0	10.0	10.0	77.0	O K
60 min Summer	0.389	0.389	0.0	10.0	10.0	88.8	O K
120 min Summer	0.391	0.391	0.0	10.0	10.0	89.1	O K
180 min Summer	0.383	0.383	0.0	10.0	10.0	87.4	O K
240 min Summer	0.371	0.371	0.0	10.0	10.0	84.6	O K
360 min Summer	0.339	0.339	0.0	10.0	10.0	77.3	O K
480 min Summer	0.302	0.302	0.0	10.0	10.0	69.0	O K
600 min Summer	0.269	0.269	0.0	10.0	10.0	61.3	O K
720 min Summer	0.240	0.240	0.0	10.0	10.0	54.7	O K
960 min Summer	0.194	0.194	0.0	10.0	10.0	44.3	O K
1440 min Summer	0.147	0.147	0.0	9.3	9.3	33.5	O K
2160 min Summer	0.120	0.120	0.0	7.3	7.3	27.4	O K
2880 min Summer	0.106	0.106	0.0	6.0	6.0	24.2	O K
4320 min Summer	0.089	0.089	0.0	4.6	4.6	20.4	O K
5760 min Summer	0.080	0.080	0.0	3.8	3.8	18.2	O K
7200 min Summer	0.074	0.074	0.0	3.3	3.3	16.8	O K
8640 min Summer	0.070	0.070	0.0	3.0	3.0	15.8	O K
10080 min Summer	0.067	0.067	0.0	2.8	2.8	15.2	O K
15 min Winter	0.266	0.266	0.0	10.0	10.0	60.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	139.469	0.0	65.7	17
30 min Summer	92.478	0.0	87.4	32
60 min Summer	58.435	0.0	111.2	60
120 min Summer	34.349	0.0	130.8	92
180 min Summer	25.224	0.0	144.1	126
240 min Summer	20.274	0.0	154.4	160
360 min Summer	14.902	0.0	170.3	228
480 min Summer	11.978	0.0	182.5	292
600 min Summer	10.108	0.0	192.5	354
720 min Summer	8.796	0.0	201.1	414
960 min Summer	7.060	0.0	215.2	530
1440 min Summer	5.164	0.0	236.0	752
2160 min Summer	3.777	0.0	259.4	1108
2880 min Summer	3.036	0.0	278.0	1472
4320 min Summer	2.253	0.0	309.2	2204
5760 min Summer	1.845	0.0	338.0	2936
7200 min Summer	1.601	0.0	366.6	3672
8640 min Summer	1.438	0.0	395.0	4376
10080 min Summer	1.321	0.0	423.3	5136
15 min Winter	139.469	0.0	65.7	17

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.338	0.338	0.0	10.0	10.0	77.0	O K
60 min Winter	0.389	0.389	0.0	10.0	10.0	88.7	O K
120 min Winter	0.385	0.385	0.0	10.0	10.0	87.7	O K
180 min Winter	0.369	0.369	0.0	10.0	10.0	84.2	O K
240 min Winter	0.347	0.347	0.0	10.0	10.0	79.2	O K
360 min Winter	0.293	0.293	0.0	10.0	10.0	66.7	O K
480 min Winter	0.242	0.242	0.0	10.0	10.0	55.1	O K
600 min Winter	0.200	0.200	0.0	10.0	10.0	45.7	O K
720 min Winter	0.170	0.170	0.0	9.9	9.9	38.7	O K
960 min Winter	0.140	0.140	0.0	8.8	8.8	32.0	O K
1440 min Winter	0.114	0.114	0.0	6.7	6.7	25.9	O K
2160 min Winter	0.094	0.094	0.0	5.0	5.0	21.4	O K
2880 min Winter	0.083	0.083	0.0	4.0	4.0	18.9	O K
4320 min Winter	0.070	0.070	0.0	3.0	3.0	16.0	O K
5760 min Winter	0.063	0.063	0.0	2.5	2.5	14.3	O K
7200 min Winter	0.058	0.058	0.0	2.2	2.2	13.2	O K
8640 min Winter	0.055	0.055	0.0	1.9	1.9	12.4	O K
10080 min Winter	0.052	0.052	0.0	1.8	1.8	11.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	92.478	0.0	87.4	31
60 min Winter	58.435	0.0	111.2	58
120 min Winter	34.349	0.0	130.8	96
180 min Winter	25.224	0.0	144.1	134
240 min Winter	20.274	0.0	154.4	172
360 min Winter	14.902	0.0	170.3	240
480 min Winter	11.978	0.0	182.5	302
600 min Winter	10.108	0.0	192.5	360
720 min Winter	8.796	0.0	201.1	412
960 min Winter	7.060	0.0	215.2	520
1440 min Winter	5.164	0.0	236.0	754
2160 min Winter	3.777	0.0	259.4	1124
2880 min Winter	3.036	0.0	278.0	1472
4320 min Winter	2.253	0.0	309.2	2208
5760 min Winter	1.845	0.0	338.0	2936
7200 min Winter	1.601	0.0	366.6	3632
8640 min Winter	1.438	0.0	395.0	4400
10080 min Winter	1.321	0.0	423.3	5144

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 295747 88989 SX 95747 88989
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.191

Time (mins) From:	To:	Area (ha)
0	4	0.191

Model Details

Storage is Online Cover Level (m) 1.500

Complex Structure

Cellular Storage

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	100.0	0.0	0.401	0.0	0.0
0.400	100.0	0.0			

Cellular Storage

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	140.0	0.0	0.401	0.0	0.0
0.400	140.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0153-1000-0400-1000
Design Head (m)	0.400
Design Flow (l/s)	10.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	153
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.400	10.0
Flush-Flo™	0.216	10.0
Kick-Flo®	0.338	9.2
Mean Flow over Head Range	-	7.6

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

Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.5	1.200	16.8	3.000	26.1	7.000	39.4
0.200	10.0	1.400	18.1	3.500	28.1	7.500	40.8
0.300	9.7	1.600	19.3	4.000	30.0	8.000	42.2
0.400	10.0	1.800	20.4	4.500	31.5	8.500	43.5
0.500	11.1	2.000	21.5	5.000	33.2	9.000	44.8
0.600	12.1	2.200	22.5	5.500	34.9	9.500	46.0
0.800	13.9	2.400	23.4	6.000	36.5		
1.000	15.4	2.600	24.3	6.500	38.0		

Appendix F

Excerpt from CIRIA SuDS Manual C753

TABLE 21.3 Operation and maintenance requirements for attenuation storage tanks

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary.	Annually
	Remove sediment from pre-treatment structures and/or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required