

TECHNICAL NOTE

Date : 3 December 2019

Project : Land at Summer Lane, Pagham

Project Ref : 196790

Report Ref : 196790-01

Report Title : Technical note on proposed drainage strategy

DOCUMENT CONTROL

REV	ISSUE PURPOSE	AUTHOR	CHECKED	APPROVED	DATE
-	For Planning	JE	JE	BC	3-12-2019
				<i>BC Celly</i>	

SITE: Land at Summer Lane, Pagham

1. INTRODUCTION

Ardent have been commissioned by Rogers Cory Partnership Ltd (RCP) on behalf of Drew Smith Group to provide technical advice with respect to a Surface Water Drainage Strategy and SuDS Statement in support of a Reserved Matters submission for a proposed residential development located on Land to the north of Summer Lane, Pagham at National Grid Reference SZ 889985 (refer to **Figure 1** below).

Outline planning permission for the Site was granted under application reference P/58/15/OUT. The Surface Water Drainage Strategy and SuDS Statement submitted by RCP (report ref TRS/E4761/17424) was submitted as part of a reserved matters application in June 2019.

The existing Site is divided into two separate parcels. Both are green field with the eastern parcel consisting of open grassed fields and the western parcel being arable farmland. The Site is bound to the east by residential properties on Sylvia Close and Brooks End. To the north, the Site is curtailed by a ditch (hereby referred to as Ditch A). To the north of Ditch A, is a recently constructed residential development (referred to as the 'Crayfern' site) to the south and west the Site is immediately bound by a second ditch (Ditch B) and Summer Lane with open fields beyond. A third ditch arising from the south, Ditch C, flows northwards towards the Site however it is not possible to confirm whether Ditch C is connected to Ditch B or flows westwards, as no pipes are identified on the topographic survey however this is likely to be the case (refer to **Appendix A**).

The proposed development is for provision of 90 residential units and associated access and open space.

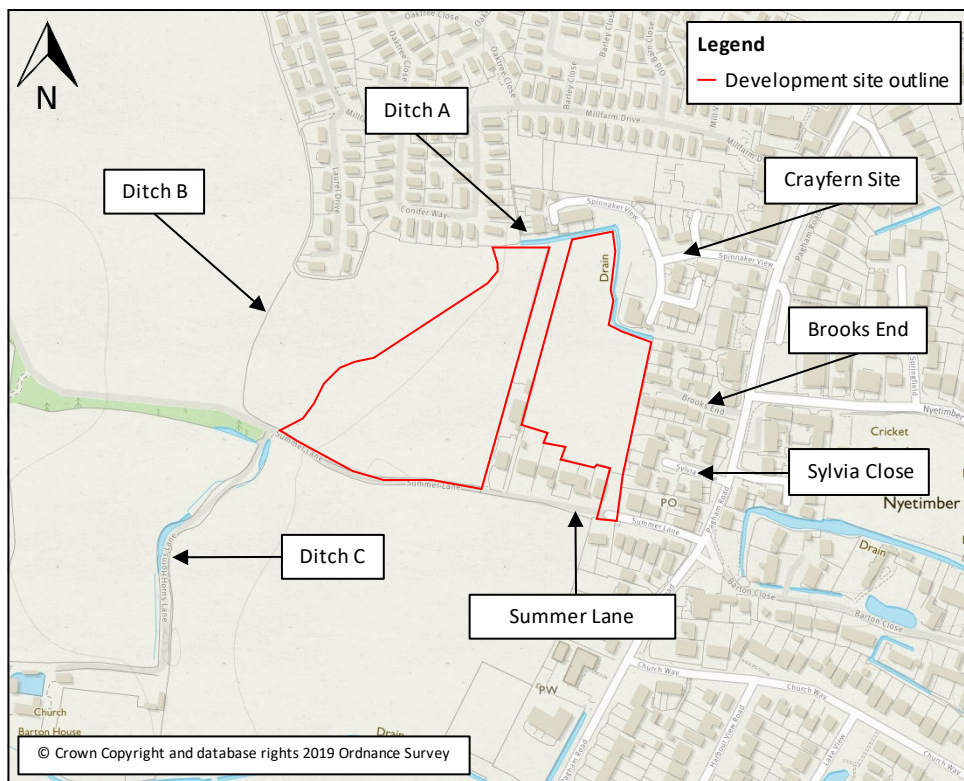


Figure 1: Site Location

It is understood that Arun District Council (ADC) have raised concerns with respect to the proposed drainage strategy put forward to date. The strategy proposes to discharge surface water from the eastern parcel towards Ditch A. Ditch A then conveys flow westwards where a 525 mm diameter pipe will convey runoff into the drainage network and SuDS system serving the western parcel. This drainage network then discharges to Ditch B at a restricted rate equivalent to the existing greenfield run off rate for the 1 in 100 year, 0.327 ha site i.e. 7.9 l/s. This is presented in the indicative drainage layout in **Appendix B**.

ADC has requested confirmation that both Ditch A and Ditch B have capacity to convey flows from both development parcels without increasing flood risk. It should be noted that Ditch A also receives flows from the adjacent Crayfern site. This report aims to demonstrate that both ditches have capacity to convey surface runoff from both developments sustainably.

2. DITCH A

Ardent have been provided with topographic survey data of both Ditch A and Ditch B. This is provided in **Appendix A**. This survey identified two outfalls from the Crayfern Site discharging to Ditch A. Details of the Crayfern drainage strategy are provided in **Appendix C**. This drainage strategy confirms that two outfalls are present from the Site and are designed to discharge to the ditch at a rate of 8.0 l/s and 4.6 l/s during the 1 in 100 year plus 40% climate change scenario.

A review of the RCP drainage strategy shows that the maximum discharge from the eastern parcel of the proposed development site is 22.8 l/s during the 1 in 100 year scenario.

No other outfalls have been identified discharging to Ditch A. Ardent have also reviewed topographic survey data and LiDAR data for the surrounding areas and it is considered that there is no other additional contributing catchment area to the Ditch other than the two development sites. Therefore, the maximum anticipated discharge to Ditch A equals 35.4 l/s.

Ardent have undertaken calculations to determine whether Ditch A has capacity to convey this flow.

These calculations are based on the following equations:

$$Q = A V$$

Where:

Q = Flow (cubic metres per second)

A = Cross sectional area of the channel (metres squared)

V = Velocity of water (metres per second)

Velocity has been calculated adopting the Manning's Formula empirical equation which is as follows:

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

Where:

R = The hydraulic radius of the channel (metres)

S = The slope of the channel

n = The roughness of the channel (Manning's 'n' roughness value)

Therefore:

$$Q = \frac{A R^{2/3} S^{1/2}}{n}$$

Ardent have reviewed the topographic data provided in Appendix A for two cross sections towards the upstream (eastern) end of Ditch A. Assuming a 'V' shaped channel, a calculated gradient of 1:175, bank top width of 2.75 m and depth of 1.06 m and Manning's 'n' value of 0.055, it was calculated that Ditch A has a minimum capacity of 4.60 m³/s. Refer to **Appendix D** for details of Manning's calculations.

Moving from east to west, the topographic data shows that the channel actually becomes both wider and deeper and becomes more trapezoidal in shape. Therefore, the carrying capacity of the ditch increases.

The drainage strategy prepared by RCP shows that a 525 mm diameter inlet pipe with a gradient of 1:487 takes flow from the ditch and conveys into a basin within the western parcel of the development. A review of the HR Wallingford Tables for Hydraulic Design of Pipes, Sewers and Channels, 8th edition (2006) shows that this pipe will have a maximum capacity of 217 l/s and therefore also has capacity to convey flows arising from both development sites. Extracts from the Wallingford Pipe Tables are presented in **Appendix D**.

3. DITCH B

As stated above, the western development receives flows from Ditch A via the 525mm diameter inlet. The SuDS system on the western parcel manages surface water runoff arising from impermeable surfaces here, as well as the additional incoming flow from Ditch A, through permeable paving, attenuation basins and a swale as well as a two flow control chambers. The network subsequently discharges to Ditch B in the south west corner of the Site at a maximum rate of 7.9 l/s during the 1 in 100 year plus 40% climate change event.

The discharge point is approximately 7 m upstream of a 300 mm diameter, 6 m long pipe intended to convey flow through an access point from Summer Lane to the arable farmland.

Ardent have referred to the HR Wallingford Pipe Tables and Manning's Empirical Equation to determine the capacity of both the 300 mm diameter pipe and the ditch upstream and downstream of this control structure.

These are shown in **Table 1** below.

Table 1: Carrying capacity of Ditch B and 300 mm dia. pipe

Location	Capacity	
	m ³ /s	l/s
Ditch B - Upstream	2.64	2640
300 mm pipe	0.17	173
Ditch B - Downstream	4.58	4580

Table 1 shows that all three features have sufficient capacity to convey runoff from the proposed development. However, Ardent have undertaken a hydrological assessment to determine what volumes of runoff can be expected from the surrounding areas that contribute to Ditch B.

Reviewing LiDAR data of the area, Ardent have determined a total catchment area of catchment 0.38 km² (assuming connectivity between Ditch C and Ditch B). Ditch C was calculated to have a catchment area of 0.09 km². Refer to **Figure 2** below.

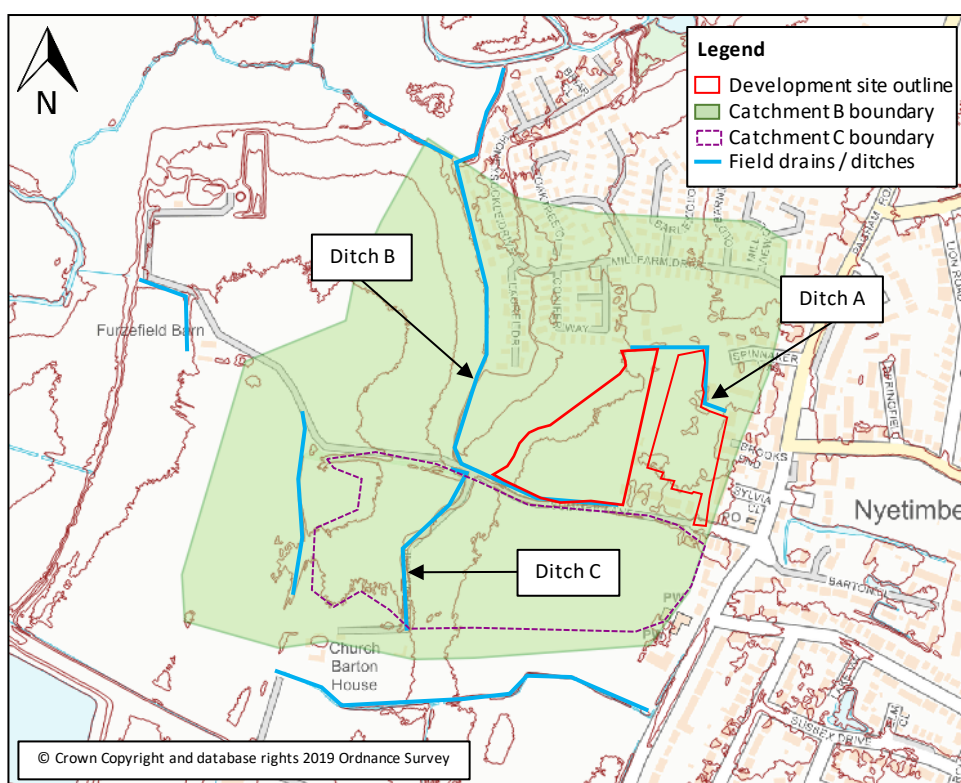


Figure 2: Ditch B catchment and drainage features

A comparison was undertaken to determine peak runoff rates from the surrounding catchment looking at ReFH2 methods and Institute of Hydrology Report No 124 method (IoH124). The Flood Estimation Handbook (FEH) online resource was not able to delineate the catchment for Ditch B due to its size and flat topography. Therefore catchment descriptors from a donor catchment less than 2.5 km away were utilised. All descriptors were reviewed however it was only necessary to adjust the 'area' parameter as all other descriptors were appropriate.

The results of this comparison are shown in **Table 2** below and are also presented in **Appendix E**.

Table 2: Hydrological analysis

Catchment	Catchment area		Return Period Event	Runoff (l/s)		
	km ²	Hectares		IoH124	ReFH2 Summer	ReFH2 Winter
Ditch B	0.38	38	1 in 100	344	200	130
			+40% CC	482	280	182
Ditch C	0.09	9	1 in 100	82	47	31
			+40% CC	114	66	43

Based on the figures presented in **Table 1** and **Table 2** it can be seen that Ditch B has sufficient capacity to accommodate flows both from the surrounding catchment as well as the additional 7.9 l/s arising from the development.

Furthermore, the 300 mm dia. pipe immediately downstream of the proposed outfall to Ditch B has sufficient capacity to convey flows both from the development and arising from the upstream catchment area of Ditch C in the 1 in 100 year plus 40% climate change event. However, it should be acknowledged that a 300 mm diameter could potentially be prone to blockage which could pose a potential flood risk.

4. CONCLUSIONS

Ardent were commissioned by RCP Consulting to carry out an exercise to determine the potential impact of a proposed SuDS strategy involving discharge to two separate drainage ditches.

There was a potential concern that runoff arising from the proposed development and an adjacent development may result in flooding.

However, Ardent have been able to demonstrate through a hydrological analysis as well as use of the Manning's Empirical Equation that the both Ditch A and Ditch B have appropriate capacity to convey flows arising from both developments. The proposed drainage strategy should therefore be considered appropriate and fit for purpose.

Appendix A
Topographic Survey



Measurements to internal walls have been taken to the wall finishes at approximately 1m above floor level and assumed to be vertical.

AIF	Angle Iron Fence	Overhead Wire	
BWF	Barbed Wire Fence	Drainage information	
CBF	Close Boarded Fence		
CIF	Coated Iron Fence		
CLF	Chainlink Fence		
IR	Iron Railings		
LLF	Larch Lath Fence	Tactile Paving	
OF	Open Boarded Fence		
PMR	Post & Rail Fence	Trees	
PRo	Post & Rod Fence		
PSW	Post & Wire Fence		
PSW	Retaining Wall		
(CPS/PTP)	(Cyc Post/Steel Post/Timber Post)		



Topographic & Measured Building Surveys, Setting Out
3D Laser Scanning, Elevations, Sections, Floorplans

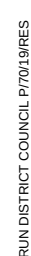
Client:
DREW SMITH

Drawing Title:
TOPOGRAPHIC SURVEY

Project:
SUMMER LANE
PAGHAM
BOGNOR REGIS

The horizontal & vertical control of this survey is based on Ordnance Survey grid as translated from GPS co-ordinates using the OSTN02 & OSGM02 transformation as supplied by OS. We have applied a reverse scale factor to maintain true ground distances. Vertical values may differ from existing OS benchmarks in the vicinity which should be disregarded. All levels should be taken from LDS survey stations.

Scale: 1:1000 Plotted on A1	Drawing No: LDS/15342-P1/A © Land Development Services Ltd. 2019
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Appendix B
RCP Drainage Strategy



NOTES

1. All dimensions are in metres unless stated otherwise.
2. Do not scale from this drawing. Only written dimensions are to be used.
3. Site layout based on Kenn Scaddan Associates Ltd site plan issued to RCP in DWG format on 17.07.2019.
4. Topographic Survey as per Siteline Level Survey, drawing number 657PG01 dated July 2012.
5. Additional topographic Survey as per ADA Solutions Ltd Topographical Survey, drawing number 0614-HP2-T1 dated June 2014.
6. Ditch survey based on Siteline Ditch Level Survey drawing number 657PG05 dated 30.01.19
7. The current surface water drainage proposals only show primary SW drainage runs. An allowance must be made for secondary drainage which is all subject to design development

KEY

- Red Line Boundary as per Outline Application
- Permeable Paving
- Proposed Surface Water Network
- Proposed outfall headwall

SCALE BAR 1:500 at A1

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Rev.	Date	Details	By	Chkd	Appd
E	17.07.19	Update to latest site layout	TRS	TRS	TRS
D	11.07.19	Update to latest site layout	TRS	TRS	TRS
C	10.07.19	Update to latest site layout	TRS	TRS	TRS
B	03.07.19	Update to latest site layout	TRS	TRS	TRS
A	02.07.19	Update to latest site layout	TRS	TRS	TRS

Client:-

DREW SMITH LIMITED

Site:-
SUMMER LANE
PAGHAM

Drawing Title:-
DRAINAGE
STRATEGY
LAYOUT

Date: February 2019 Scales: 1:500 at A1

Drawn: KK Checked: SRV Approved: TRS

Drawing No. DSM/E4761/001E

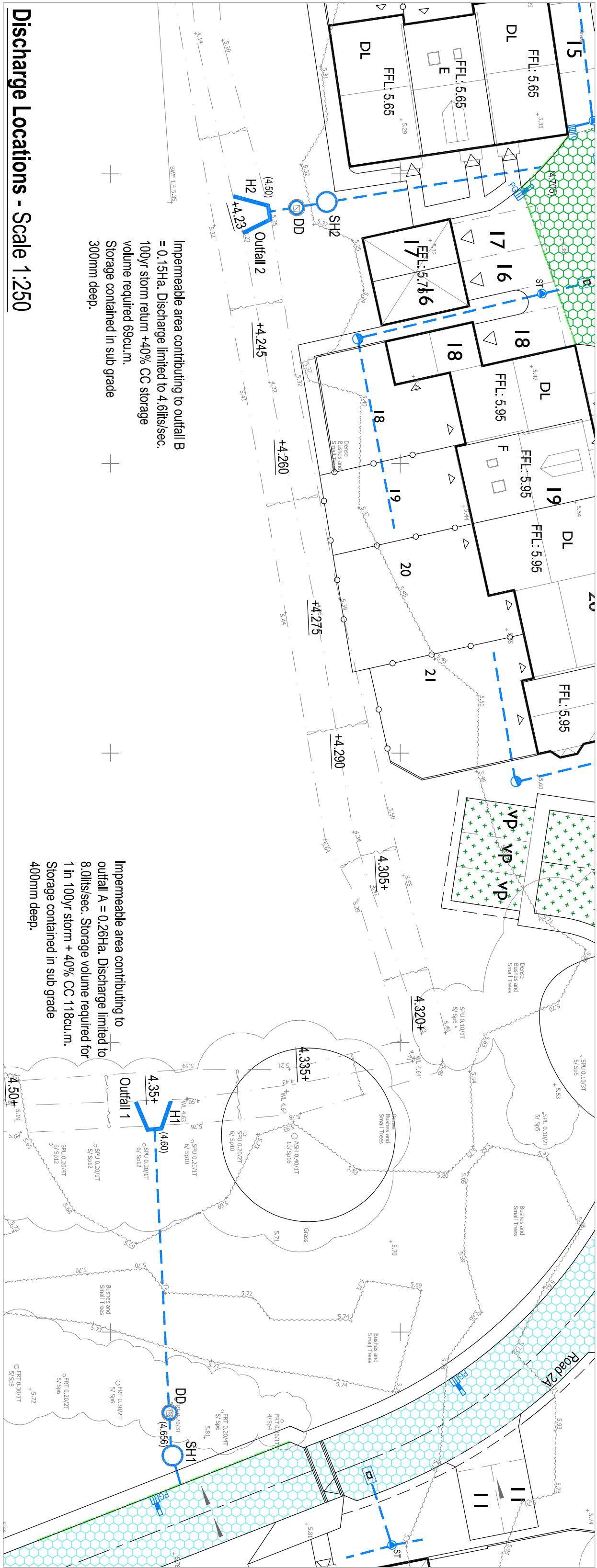
FOR INFORMATION ONLY



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Appendix C
Crayfern Drainage Strategy



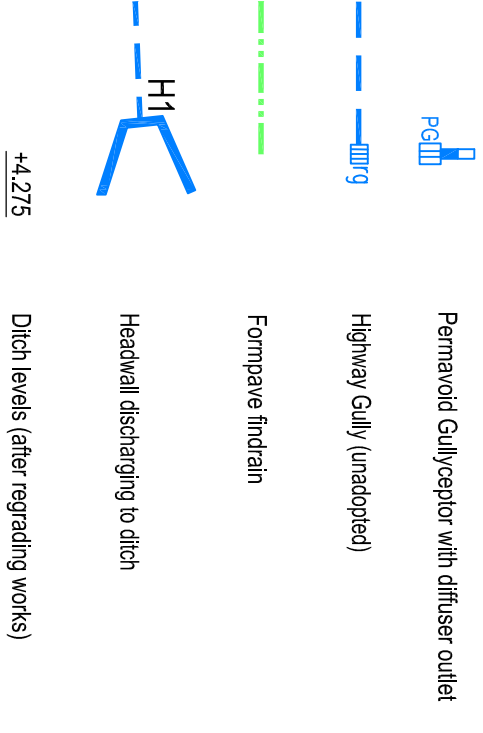
Discharge Locations - Scale 1:250

OUTFALL 1	
DATUM 2.00m AOD	
EXISTING GROUND LEVEL	6.00
SURFACE WATER SEWER	5.53
	4.52
	5.73
	5.69

OUTFALL 2	
DATUM 2.00m AOD	
EXISTING GROUND LEVEL	6.00
SURFACE WATER SEWER	5.32
	4.23
	5.25
	5.30

Sections - Scale H & V 1:100

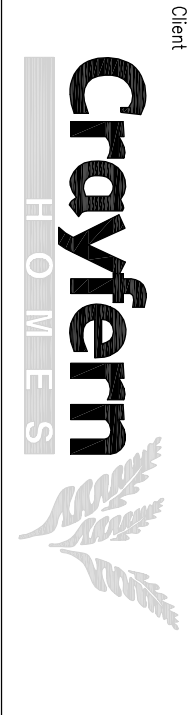
- General Notes:**
1. All levels relate to Ordnance Datum.
 2. Headwall construction to be in accordance with local Land Drainage Authority specifications and requirements.
 3. Wingwalls to be constructed flush with adjacent bank slope.
 4. The contractor must comply with all current legislation relating to Health and Safety. The contractor/client must familiarise himself with all service companies records of existing plant locations prior to any excavation works. All existing services/sewers to be traced/surveyed.
 5. All concrete and concrete products to be in accordance with BRE 363 for sulphates.



Rev	Date	Details	Initials
B	23.05.17	Ditch regraded; additional information added to details	KN
A	07.05.17	First issue	KN

FOR INFORMATION

Project
PAGHAM ROAD
PAGHAM



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Drawing Title Engineering Details Drainage Outfalls			
Drawn	Checked	Scales	Paper Size
KN	KN	As Shown	A2
Job No.	Drawing No.		Revision
ES1662	500-04		B

Appendix D

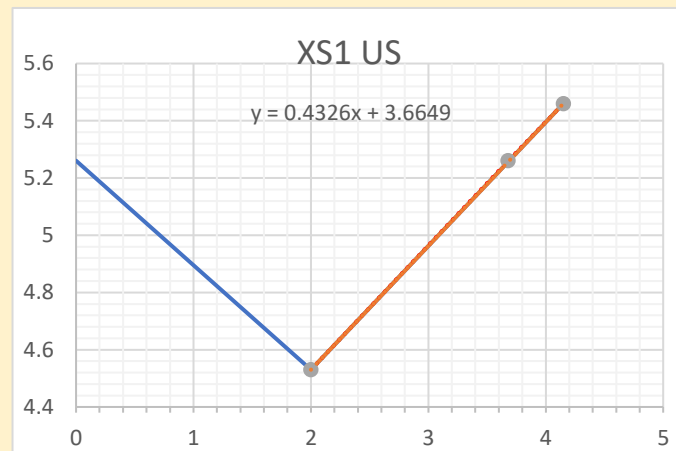
Hydraulic Calculations

DITCH 1 (upstream)

X	Y
0	5.26
2	4.53
4.15	5.46

2	4.53
4.15	5.46

2	4.53
3.68	5.26
4.15	5.46



Slope

Fall	1.14
Length	200
=	0.006

$S^{1/2}$	0.075
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Manning's 'n'

n =	0.055
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Hydraulic Radius

R	4.27
$R^{2/3}$	2.63

Area

Depth	0.73
Width	3.68
=	1.34

Flow

Q=	4.85 m ³ /s
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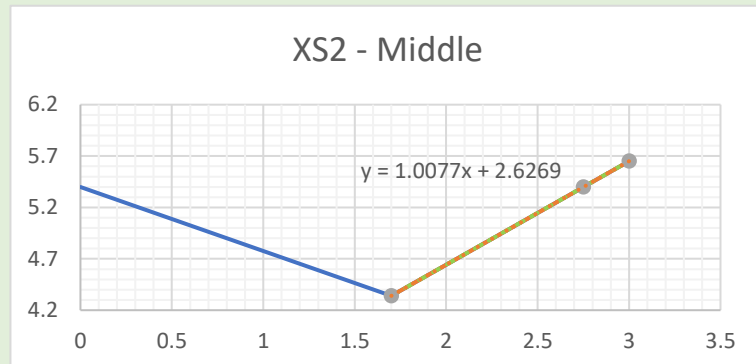
DITCH 1

(middle section)

X	Y
0	5.4
1.7	4.34
3	5.65

1.7	4.34
3	5.65

1.7	4.34
2.75	5.4
3	5.65



Slope

Fall 1.14
Length 200
= 0.00570

$S^{1/2}$ 0.075

Manning's 'n'

n = 0.055

Hydraulic Radius

R 3.49
 $R^{2/3}$ 2.30

Area

Depth 1.06
Width 2.75
= 1.46

Flow

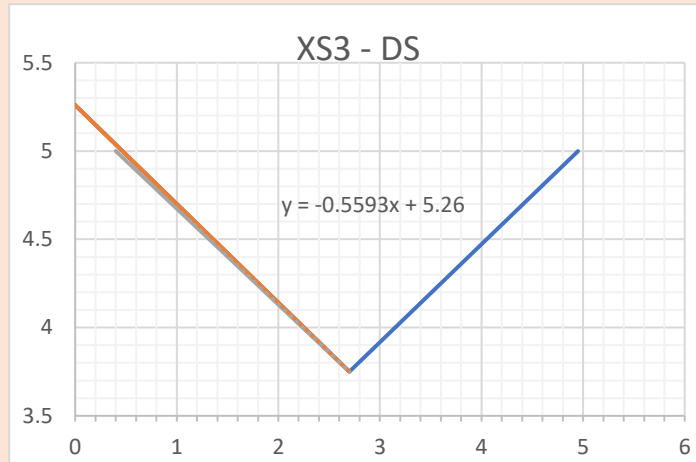
Q= 4.60 m³/s

DITCH 1 (downstream)

X	Y
0	5.26
2.7	3.75
4.95	5

2.7	3.75
0	5.26

0.4	5
2.7	3.75
4.95	5



Slope

Fall	1.14
Length	200
=	0.006

$S^{1/2}$	0.075
-----------	-------

Manning's 'n'

n =	0.055
-----	-------

Hydraulic Radius

R	5.18
$R^{2/3}$	2.99

Area

Depth	1.25
Width	4.55
=	2.84

Flow

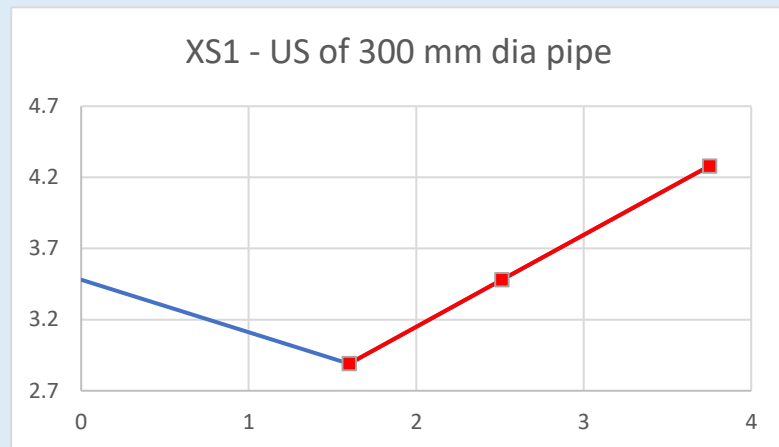
Q=	11.69 m ³ /s
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DITCH 2 (upstream of pipe)

X	Y
0	3.48
1.6	2.89
3.75	4.28

0	3.48
1.6	2.89
3.75	4.28

0	3.48
1.6	2.89
2.51	3.48
3.75	4.28



Slope

Fall 0.06
 Length 6.11
 = 0.010

$S^{1/2}$ 0.099

Manning's 'n'

n = 0.055

Hydraulic Radius

R 2.78
 $R^{2/3}$ 1.98

Area

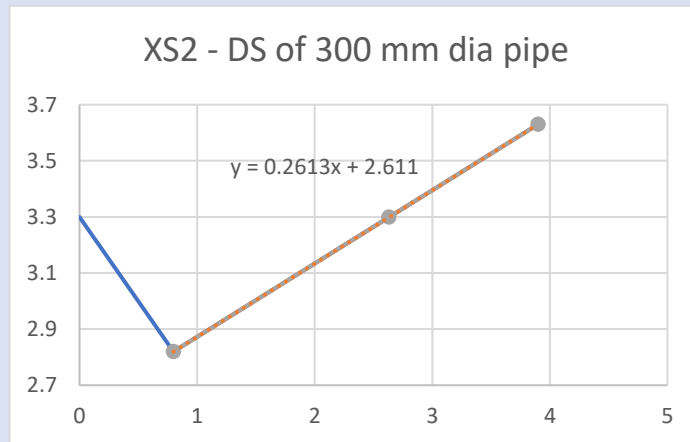
Depth 0.59
 Width 2.51
 = 0.74

Flow

Q= 2.64 m³/s

DITCH 2 (downstream of pipe)

X	Y
0	3.3
0.8	2.82
3.9	3.63
0	3.3
0.8	2.82
3.9	3.63
0	3.3
0.8	2.82
2.63	3.3
3.9	3.63



Slope

Fall 0.54
Length 13.5
= 0.040

$S^{1/2}$ 0.200

Manning's 'n'

n = 0.055

Hydraulic Radius

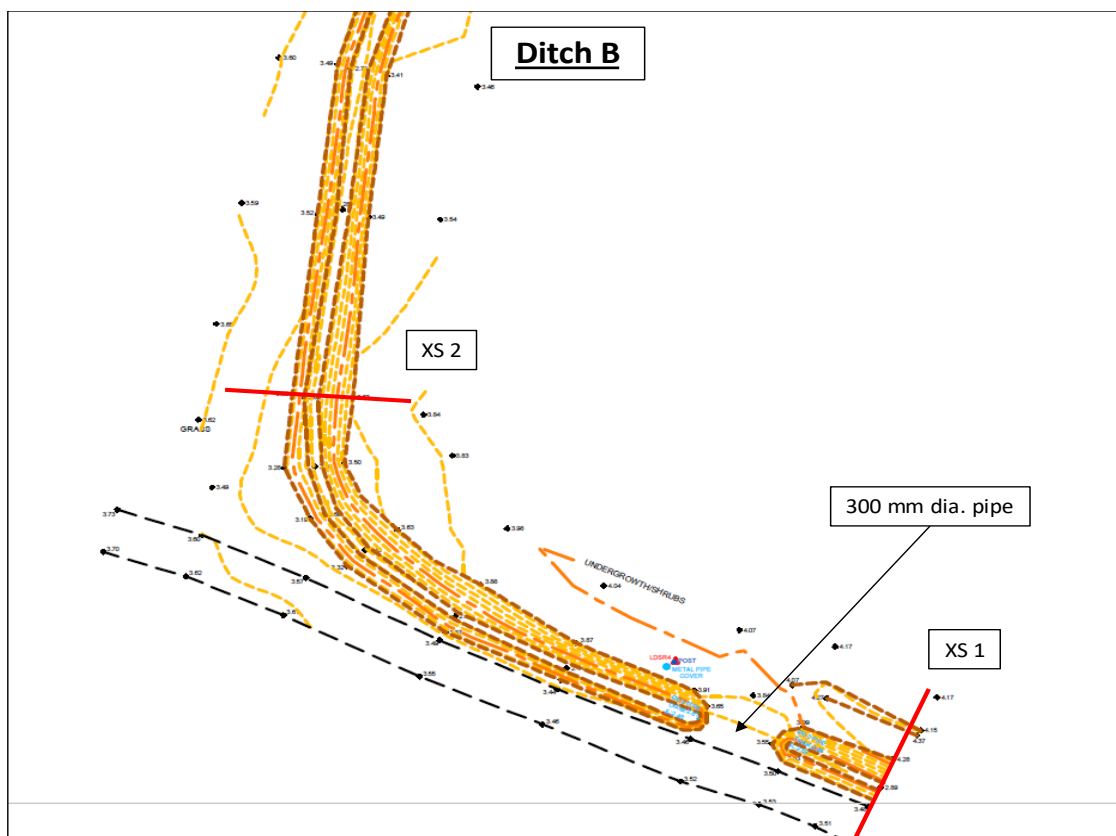
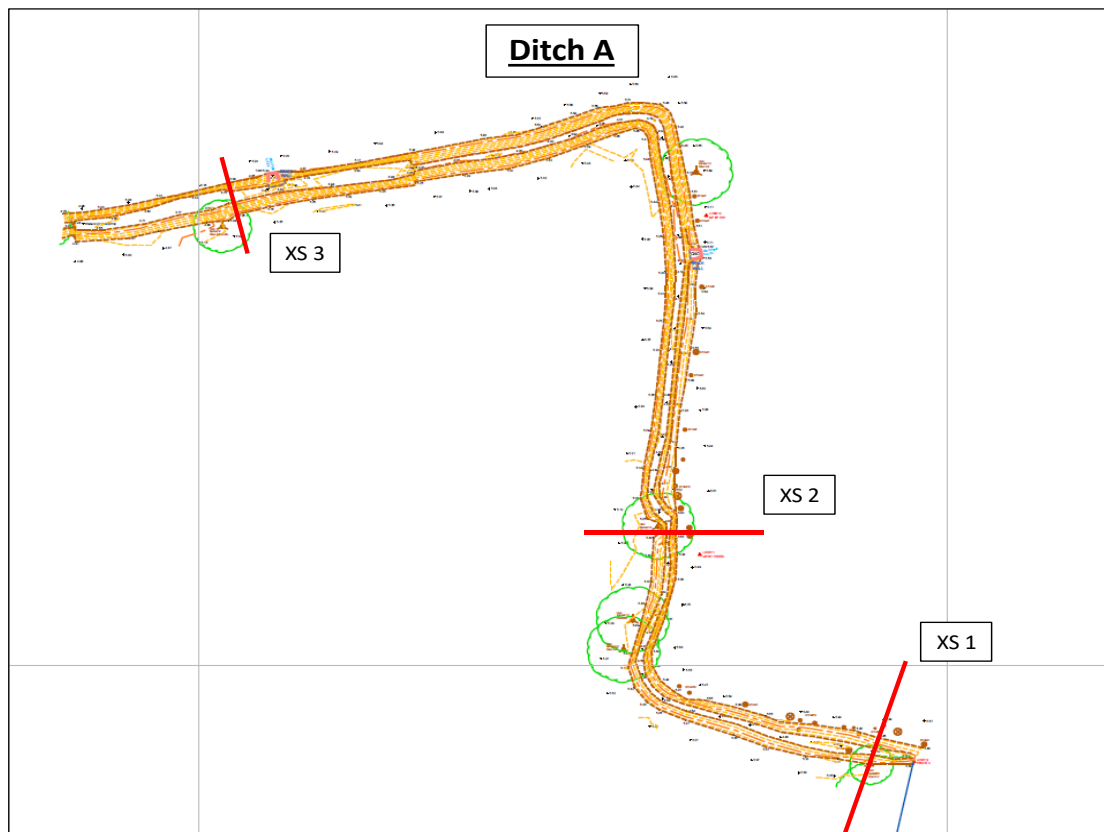
R 2.82
 $R^{2/3}$ 2.00

Area

Depth 0.48
Width 2.63
= 0.63

Flow

Q= 4.58 m³/s



A18

(p.3 of 6)

$k_s = 0.60 \text{ mm}$
 $S = 0.00100 \text{ to } 0.00300$

Water (or sewage) at 15°C ;
 full bore conditions.

ie hydraulic gradient =
 1 in 1000 to 1 in 333

velocities in ms^{-1}
 discharges in litres/sec

Gradient

(Equivalent) Pipe diameters in mm

	150	200	225	250	275	300	350	375	400	450	500	525	600	630
0.00100	0.309	0.374	0.404	0.433	0.461	0.488	0.539	0.563	0.587	0.633	0.677	0.698	0.760	0.784
1/ 1000	5.4531	11.743	16.063	21.251	27.366	34.464	51.833	62.207	73.776	100.69	132.95	151.20	214.93	244.38
0.00105	0.316	0.383	0.414	0.444	0.472	0.500	0.552	0.577	0.602	0.649	0.694	0.716	0.779	0.804
1/ 952	5.5929	12.043	16.472	21.791	28.060	35.337	53.143	63.778	75.638	103.23	136.30	155.00	220.33	250.52
0.00110	0.324	0.393	0.424	0.455	0.484	0.512	0.566	0.591	0.616	0.665	0.711	0.733	0.798	0.823
1/ 909	5.7294	12.335	16.871	22.318	28.737	36.190	54.422	65.313	77.456	105.70	139.56	158.72	225.61	256.52
0.00115	0.332	0.402	0.434	0.465	0.495	0.524	0.579	0.605	0.631	0.680	0.727	0.750	0.816	0.842
1/ 870	5.8628	12.621	17.261	22.833	29.400	37.023	55.673	66.812	79.233	108.13	142.76	162.35	230.76	262.37
0.00120	0.339	0.411	0.444	0.475	0.506	0.535	0.591	0.618	0.644	0.695	0.743	0.766	0.834	0.860
1/ 833	5.9934	12.900	17.643	23.337	30.048	37.839	56.897	68.280	80.972	110.50	145.89	165.90	235.81	268.11
0.00125	0.346	0.419	0.453	0.485	0.517	0.547	0.604	0.631	0.658	0.709	0.759	0.782	0.851	0.878
1/ 800	6.1213	13.174	18.017	23.831	30.683	38.638	58.096	69.718	82.676	112.82	148.95	169.38	240.75	273.72
0.00130	0.353	0.428	0.462	0.495	0.527	0.558	0.616	0.644	0.671	0.724	0.774	0.798	0.869	0.896
1/ 769	6.2467	13.443	18.384	24.315	31.306	39.421	59.271	71.127	84.346	115.10	151.95	172.79	245.59	279.23
0.00135	0.360	0.436	0.471	0.505	0.537	0.569	0.628	0.657	0.684	0.738	0.789	0.814	0.885	0.913
1/ 741	6.3697	13.706	18.743	24.790	31.917	40.189	60.424	72.509	85.984	117.33	154.89	176.14	250.34	284.63
0.00140	0.367	0.445	0.480	0.515	0.547	0.579	0.640	0.669	0.697	0.751	0.804	0.829	0.902	0.930
1/ 714	6.4905	13.965	19.096	25.257	32.516	40.943	61.556	73.866	87.592	119.52	157.78	179.42	255.00	289.93
0.00145	0.374	0.453	0.489	0.524	0.557	0.590	0.651	0.681	0.710	0.765	0.818	0.844	0.918	0.947
1/ 690	6.6092	14.219	19.443	25.715	33.105	41.684	62.668	75.199	89.172	121.67	160.62	182.65	259.58	295.13
0.00150	0.381	0.461	0.498	0.533	0.567	0.600	0.663	0.693	0.722	0.778	0.832	0.858	0.934	0.963
1/ 667	6.7258	14.469	19.784	26.165	33.684	42.412	63.761	76.510	90.724	123.79	163.41	185.82	264.09	300.25
0.00160	0.393	0.476	0.514	0.551	0.586	0.620	0.685	0.716	0.746	0.804	0.860	0.887	0.965	0.995
1/ 625	6.9535	14.956	20.450	27.044	34.814	43.833	65.893	79.067	93.754	127.92	168.86	192.01	272.87	310.24
0.00170	0.406	0.491	0.531	0.568	0.605	0.640	0.706	0.738	0.769	0.829	0.887	0.915	0.995	1.026
1/ 588	7.1741	15.429	21.094	27.895	35.909	45.211	67.960	81.545	96.691	131.92	174.14	198.01	281.39	319.92
0.00180	0.418	0.506	0.546	0.585	0.622	0.659	0.727	0.760	0.792	0.854	0.913	0.942	1.024	1.056
1/ 556	7.3884	15.888	21.721	28.723	36.973	46.548	69.967	83.952	99.543	135.81	179.26	203.84	289.66	329.31
0.00190	0.430	0.520	0.562	0.602	0.640	0.677	0.748	0.781	0.814	0.878	0.938	0.968	1.053	1.086
1/ 526	7.5969	16.334	22.330	29.527	38.007	47.849	71.919	86.293	102.32	139.59	184.25	209.51	297.71	338.46
0.00200	0.441	0.534	0.577	0.617	0.657	0.695	0.767	0.802	0.836	0.901	0.963	0.993	1.081	1.114
1/ 500	7.8000	16.769	22.923	30.311	39.015	49.116	73.821	88.573	105.02	143.27	189.10	215.03	305.54	347.36
0.00210	0.453	0.547	0.591	0.633	0.673	0.712	0.787	0.822	0.857	0.923	0.987	1.018	1.108	1.142
1/ 476	7.9981	17.193	23.502	31.075	39.998	50.352	75.676	90.797	107.65	146.86	193.84	220.41	313.18	356.05
0.00220	0.464	0.560	0.605	0.648	0.690	0.729	0.805	0.842	0.877	0.945	1.011	1.042	1.134	1.169
1/ 455	8.1915	17.607	24.068	31.822	40.957	51.559	77.487	92.968	110.23	150.37	198.47	225.67	320.64	364.53
0.00230	0.474	0.573	0.619	0.663	0.705	0.746	0.824	0.861	0.897	0.967	1.034	1.066	1.160	1.196
1/ 435	8.3806	18.012	24.620	32.551	41.895	52.739	79.258	95.091	112.74	153.80	202.99	230.81	327.94	372.82
0.00240	0.485	0.586	0.633	0.678	0.721	0.762	0.842	0.880	0.917	0.988	1.056	1.089	1.185	1.222
1/ 417	8.5657	18.408	25.161	33.265	42.814	53.894	80.990	97.169	115.20	157.15	207.41	235.83	335.08	380.93
0.00250	0.495	0.598	0.646	0.692	0.736	0.778	0.859	0.898	0.936	1.009	1.078	1.112	1.210	1.247
1/ 400	8.7470	18.796	25.690	33.965	43.713	55.025	82.687	99.203	117.62	160.44	211.74	240.76	342.07	388.87
0.00260	0.505	0.610	0.659	0.706	0.751	0.794	0.877	0.916	0.955	1.029	1.100	1.134	1.234	1.272
1/ 385	8.9247	19.176	26.210	34.650	44.594	56.133	84.351	101.20	119.98	163.66	215.99	245.59	348.92	396.66
0.00270	0.515	0.622	0.672	0.720	0.765	0.810	0.894	0.934	0.973	1.049	1.121	1.156	1.258	1.297
1/ 370	9.0990	19.549	26.719	35.323	45.459	57.221	85.983	103.15	122.30	166.82	220.16	250.32	355.64	404.30
0.00280	0.525	0.634	0.685	0.733	0.780	0.825	0.910	0.951	0.991	1.068	1.142	1.178	1.281	1.321
1/ 357	9.2701	19.916	27.219	35.983	46.308	58.288	87.584	105.07	124.57	169.92	224.25	254.97	362.24	411.80
0.00290	0.534	0.645	0.697	0.746	0.794	0.839	0.927	0.968	1.009	1.088	1.163	1.199	1.304	1.345
1/ 345	9.4383	20.276	27.710	36.631	47.141	59.337	89.158	106.96	126.81	172.96	228.26	259.54	368.72	419.16
0.00300	0.543	0.657	0.709	0.759	0.807	0.854	0.943	0.985	1.027	1.106	1.183	1.220	1.327	1.368
1/ 333	9.6035	20.629	28.193	37.269	47.961	60.368	90.705	108.82	129.01	175.96	232.21	264.02	375.09	426.41
0.77	0.78	0.79	0.79	0.79	0.80	0.81	0.81	0.81	0.82	0.83	0.83	0.84	0.84	

$V_{r(0.5)\text{medial}}$ for half-full circular pipes.

$k_s = 0.60 \text{ mm}$

$S = 0.00100 \text{ to } 0.00300$

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(p.5 of 6)

$k_s = 0.60 \text{ mm}$
 $S = 0.01000 \text{ to } 0.03000$

Water (or sewage) at 15°C ;
 full bore conditions.

ie hydraulic gradient =
 1 in 100 to 1 in 33.3

velocities in ms^{-1}
 discharges in litres/sec

Gradient	(Equivalent) Pipe diameters in mm													
	150	200	225	250	275	300	350	375	400	450	500	525	600	630
0.01000	1.003	1.210	1.306	1.398	1.486	1.571	1.733	1.810	1.886	2.032	2.171	2.239	2.434	2.509
1/ 100	17.729	38.018	51.924	68.604	88.246	111.03	166.72	199.95	237.00	323.12	426.27	484.59	688.17	782.20
0.01050	1.028	1.240	1.339	1.432	1.523	1.610	1.776	1.855	1.933	2.082	2.225	2.294	2.494	2.572
1/ 95	18.173	38.968	53.220	70.315	90.446	113.80	170.87	204.93	242.90	331.16	436.87	496.64	705.27	801.63
0.01100	1.053	1.270	1.370	1.466	1.559	1.648	1.818	1.899	1.979	2.132	2.278	2.349	2.553	2.632
1/ 91	18.607	39.895	54.486	71.986	92.594	116.50	174.92	209.79	248.65	339.00	447.22	508.40	721.96	820.60
0.01150	1.077	1.299	1.401	1.500	1.594	1.685	1.859	1.943	2.024	2.180	2.329	2.402	2.611	2.692
1/ 87	19.031	40.802	55.723	73.620	94.694	119.14	178.89	214.54	254.28	346.67	457.33	519.90	738.28	839.15
0.01200	1.100	1.327	1.432	1.532	1.629	1.722	1.900	1.985	2.067	2.227	2.380	2.454	2.668	2.750
1/ 83	19.445	41.689	56.934	75.219	96.749	121.72	182.76	219.19	259.79	354.18	467.23	531.15	754.25	857.30
0.01250	1.123	1.355	1.462	1.564	1.663	1.758	1.939	2.026	2.110	2.273	2.429	2.505	2.723	2.807
1/ 80	19.851	42.558	58.120	76.784	98.762	124.26	186.56	223.74	265.19	361.53	476.92	542.16	769.89	875.07
0.01300	1.146	1.382	1.491	1.595	1.696	1.793	1.978	2.066	2.152	2.318	2.477	2.554	2.777	2.863
1/ 77	20.249	43.410	59.282	78.319	100.73	126.74	190.28	228.21	270.47	368.74	486.43	552.96	785.22	892.49
0.01350	1.168	1.408	1.520	1.626	1.729	1.827	2.016	2.106	2.194	2.363	2.525	2.603	2.830	2.918
1/ 74	20.640	44.245	60.422	79.824	102.67	129.17	193.94	232.59	275.66	375.81	495.75	563.56	800.26	909.58
0.01400	1.190	1.434	1.548	1.656	1.761	1.861	2.053	2.145	2.234	2.407	2.571	2.651	2.883	2.972
1/ 71	21.023	45.065	61.541	81.302	104.57	131.56	197.52	236.88	280.75	382.74	504.90	573.96	815.02	926.35
0.01450	1.211	1.460	1.575	1.686	1.792	1.894	2.090	2.183	2.274	2.449	2.617	2.699	2.934	3.025
1/ 69	21.400	45.871	62.641	82.753	106.44	133.91	201.04	241.10	285.76	389.56	513.89	584.17	829.52	942.83
0.01500	1.232	1.485	1.603	1.715	1.823	1.927	2.126	2.221	2.313	2.492	2.662	2.745	2.984	3.077
1/ 67	21.770	46.663	63.721	84.180	108.27	136.21	204.50	245.25	290.67	396.26	522.72	594.21	843.77	959.03
0.01600	1.273	1.535	1.656	1.772	1.883	1.991	2.196	2.294	2.389	2.574	2.750	2.835	3.083	3.178
1/ 63	22.492	48.208	65.830	86.964	111.85	140.71	211.25	253.35	300.27	409.33	539.96	613.81	871.58	990.63
0.01700	1.312	1.582	1.707	1.827	1.942	2.052	2.264	2.365	2.463	2.653	2.835	2.923	3.178	3.276
1/ 59	23.192	49.706	67.874	89.663	115.32	145.08	217.80	261.20	309.56	422.00	556.66	632.80	898.53	1021.3
0.01800	1.351	1.628	1.757	1.880	1.998	2.112	2.330	2.434	2.535	2.731	2.918	3.008	3.270	3.372
1/ 56	23.872	51.160	69.858	92.283	118.69	149.31	224.15	268.82	318.59	434.30	572.89	651.23	924.70	1051.0
0.01900	1.388	1.673	1.805	1.932	2.053	2.171	2.394	2.501	2.605	2.806	2.998	3.091	3.360	3.464
1/ 53	24.533	52.574	71.788	94.831	121.96	153.43	230.34	276.23	327.37	446.27	588.67	669.17	950.16	1079.9
0.02000	1.425	1.717	1.853	1.982	2.107	2.227	2.457	2.566	2.673	2.879	3.076	3.172	3.448	3.555
1/ 50	25.177	53.952	73.668	97.313	125.15	157.44	236.36	283.45	335.93	457.92	604.03	686.63	974.95	1108.1
0.02100	1.460	1.760	1.899	2.032	2.160	2.283	2.518	2.630	2.740	2.951	3.153	3.251	3.534	3.643
1/ 47.6	25.805	55.295	75.501	99.734	128.27	161.36	242.23	290.48	344.27	469.29	619.02	703.67	999.13	1135.6
0.02200	1.495	1.802	1.944	2.080	2.211	2.337	2.577	2.692	2.804	3.020	3.227	3.327	3.617	3.729
1/ 45.5	26.418	56.607	77.292	102.10	131.30	165.18	247.96	297.36	352.41	480.39	633.66	720.30	1022.7	1162.4
0.02300	1.529	1.843	1.988	2.127	2.261	2.390	2.636	2.753	2.868	3.089	3.300	3.403	3.699	3.813
1/ 43.5	27.017	57.890	79.042	104.41	134.27	168.92	253.57	304.08	360.37	491.24	647.96	736.57	1045.8	1188.6
0.02400	1.562	1.883	2.031	2.173	2.310	2.441	2.693	2.813	2.930	3.155	3.371	3.476	3.779	3.895
1/ 41.7	27.604	59.145	80.754	106.67	137.18	172.57	259.05	310.65	368.16	501.85	661.96	752.48	1068.4	1214.3
0.02500	1.595	1.922	2.073	2.218	2.358	2.492	2.748	2.871	2.990	3.221	3.441	3.548	3.857	3.976
1/ 40.0	28.178	60.374	82.432	108.88	140.03	176.15	264.42	317.09	375.79	512.25	675.67	768.06	1090.5	1239.4
0.02600	1.626	1.960	2.115	2.262	2.405	2.542	2.803	2.928	3.050	3.285	3.510	3.619	3.934	4.055
1/ 38.5	28.742	61.578	84.076	111.05	142.82	179.66	269.69	323.41	383.27	522.44	689.11	783.33	1112.2	1264.1
0.02700	1.658	1.998	2.155	2.306	2.451	2.590	2.857	2.984	3.108	3.348	3.577	3.688	4.009	4.133
1/ 37.0	29.294	62.760	85.688	113.18	145.56	183.10	274.85	329.60	390.61	532.44	702.29	798.32	1133.5	1288.3
0.02800	1.688	2.035	2.195	2.348	2.496	2.638	2.909	3.039	3.166	3.409	3.643	3.756	4.083	4.209
1/ 35.7	29.836	63.920	87.271	115.27	148.24	186.48	279.92	335.68	397.81	542.25	715.24	813.03	1154.3	1312.0
0.02900	1.719	2.071	2.234	2.390	2.540	2.685	2.961	3.093	3.222	3.470	3.707	3.822	4.155	4.284
1/ 34.5	30.369	65.060	88.826	117.33	150.88	189.80	284.90	341.65	404.89	551.89	727.95	827.47	1174.9	1335.3
0.03000	1.748	2.107	2.272	2.431	2.584	2.731	3.012	3.146	3.277	3.530	3.771	3.888	4.226	4.357
1/ 33.3	30.892	66.180	90.355	119.35	153.48	193.06	289.79	347.51	411.84	561.37	740.44	841.67	1195.0	1358.2
	0.77	0.79	0.79	0.80	0.80	0.80	0.81	0.82	0.82	0.82	0.83	0.83	0.84	0.84

$V_{r(0.5)medial}$ for half-full circular pipes.

$k_s = 0.60 \text{ mm}$ $S = 0.01000 \text{ to } 0.03000$

Appendix E

Hydrological Analysis

Calculated by:	John Easton
Site name:	196790
Site location:	Pagham

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	50.77994° N
Longitude:	0.74085° W
Reference:	3765018434
Date:	Nov 04 2019 10:46

Runoff estimation approach

IH124

Site characteristics

Total site area (ha):	38
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Methodology

Q _{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics

	Default	Edited
SAAR (mm):	693	693
Hydrological region:	7	7
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 30 years:	2.3	2.3
Growth curve factor 100 years:	3.19	3.19
Growth curve factor 200 years:	3.74	3.74

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q _{BAR} (l/s):	107.89	107.89
1 in 1 year (l/s):	91.71	91.71
1 in 30 years (l/s):	248.14	248.14
1 in 100 years (l/s):	344.17	344.17
1 in 200 years (l/s):	403.5	403.5

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

Appendix

Catchment descriptors *

Name	Value	User-defined value used?
Area (km ²)	0.38 [0.69]	Yes
ALTBAR	5	No
ASPBAR	106	No
ASPVAR	0.74	No
BFIHOST	0.69	No
DPLBAR (km)	0.64	No
DPSBAR (mkm ⁻¹)	3.8	No
FARL	1	No
LDP	1.52	No
PROPWET (mm)	0.34	No
RMED1H	9.3	No
RMED1D	32.1	No
RMED2D	40.4	No
SAAR (mm)	694	No
SAAR4170 (mm)	732	No
SPRHOST	29.84	No
Urbext2000	0.05 [0]	Yes
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
DDF parameter C	-0.03	No
DDF parameter D1	0.4	No
DDF parameter D2	0.26	No
DDF parameter D3	0.39	No
DDF parameter E	0.31	No
DDF parameter F	2.28	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.4	No
DDF parameter D2 (1km grid value)	0.26	No
DDF parameter D3 (1km grid value)	0.4	No
DDF parameter E (1km grid value)	0.31	No
DDF parameter F (1km grid value)	2.28	No

Values in square brackets are the original values loaded from the FEH Web Service or FEH CD-ROM

UK Design Flood Estimation

Generated on 03 December 2019 13:53:44 by JEaston

Printed from the ReFH2 Flood Modelling software package, version 3.0.7257.24553

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details

Checksum: 48F4-3477

Site name: FEH_Catchment_Descriptors_486650_98250

Easting: 486650

Northing: 98250

Country: England, Wales or Northern Ireland

Catchment Area (km²): 0.38 [0.69]*

Using plot scale calculations: No

Model: ReFH2.2

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH 2013 model (mm):	62.67	Total runoff (ML):	4.09
Total Rainfall (mm):	60.82	Total flow (ML):	10.35
Peak Rainfall (mm):	18.81	Peak flow (m ³ /s):	0.20

Parameters

Where the user has overridden a system-generated value, this original value is shown in square brackets after the value used.

* Indicates that the user locked the duration/timestep

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	05:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.99	No
ARF (Areal reduction factor)	0.98	No
Seasonality	Summer [Winter]	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	79.96	No
Cmax (mm)	672.6	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No
Use seasonal Cini for equations	No [Yes]	Yes

Routing model parameters

UK Design Flood Estimation

Generated on 03 December 2019 13:51:36 by JEaston

Printed from the ReFH2 Flood Modelling software package, version 3.0.7257.24553

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details

Checksum: 6621-57C4

Site name: FEH_Catchment_Descriptors_486650_98250

Easting: 486650

Northing: 98250

Country: England, Wales or Northern Ireland

Catchment Area (km²): 0.38 [0.69]*

Using plot scale calculations: No

Model: ReFH2.2

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH 2013 model (mm):	62.67	Total runoff (ML):	2.65
Total Rainfall (mm):	42.62	Total flow (ML):	6.68
Peak Rainfall (mm):	9.68	Peak flow (m ³ /s):	0.13

Parameters

Where the user has overridden a system-generated value, this original value is shown in square brackets after the value used.

* Indicates that the user locked the duration/timestep

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	05:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.69	No
ARF (Areal reduction factor)	0.98	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	79.96	No
Cmax (mm)	672.6	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No
Use seasonal Cini for equations	No [Yes]	Yes

Routing model parameters