STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	1	Add Flow / Climate Change (%)	0
M5-60 (mm)	18.000	Minimum Backdrop Height (m)	0.200
Ratio R	0.400	Maximum Backdrop Height (m)	1.500
Maximum Rainfall (mm/hr)	50	Min Design Depth for Optimisation (m)	1.200
Maximum Time of Concentration (mins)	30	Min Vel for Auto Design only (m/s)	1.00
Foul Sewage (l/s/ha)	0.000	Min Slope for Optimisation (1:X)	500
Volumetric Runoff Coeff.	0.750		

Designed with Level Soffits

Time Area Diagram for Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.366	4-8	0.025

Total Area Contributing (ha) = 0.391

Total Pipe Volume (m^3) = 164.071

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PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	o	225	1	139.094	137.669	1.200	Open Manhole	1200
1.001	o	225	2	138.332	136.907	1.200	Open Manhole	1200
1.002	ooo	-47	3	136.569	132.423	3.246	Open Manhole	1800
2.000	ooo	-47	4	134.569	132.388	1.281	Open Manhole	1800
3.000	[]	-48	5	135.200	133.085	1.315	Open Manhole	3000
3.001	o	225	5	135.000	133.055	1.720	Open Manhole	3000
1.003	ooo	-47	5	134.431	132.358	1.173	Open Manhole	1800
1.004	o	225	6	134.291	132.303	1.763	Open Manhole	3000

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	8.406	11.0	2	138.332	136.907	1.200	Open Manhole	1200
1.001	17.175	4.5	3	136.569	133.098	3.246	Open Manhole	1800
1.002	26.000	400.0	5	134.431	132.358	1.173	Open Manhole	1800
2.000	12.000	400.0	5	134.431	132.358	1.173	Open Manhole	1800
3.000	12.000	400.0	5	135.000	133.055	1.145	Open Manhole	3000
3.001	8.678	394.5	5	134.431	133.033	1.173	Open Manhole	1800
1.003	22.000	400.0	6	134.291	132.303	1.088	Open Manhole	3000
1.004	4.982	79.1		134.210	132.240	1.745	Open Manhole	1200

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.004		134.210	132.240	0.000	1200	0

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Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	132.842	0.539	5.0	77.9	O K
30 min Summer	132.946	0.643	5.0	101.0	O K
60 min Summer	133.035	0.732	5.0	120.0	O K
120 min Summer	133.117	0.814	5.0	136.0	O K
180 min Summer	133.139	0.836	5.0	140.0	O K
240 min Summer	133.128	0.825	5.0	138.1	O K
360 min Summer	133.085	0.782	5.0	130.0	O K
480 min Summer	133.048	0.745	5.0	122.6	O K
600 min Summer	133.018	0.715	5.0	116.5	O K
720 min Summer	132.990	0.687	5.0	110.6	O K
960 min Summer	132.938	0.635	5.0	99.3	O K
1440 min Summer	132.846	0.543	5.0	78.6	O K
2160 min Summer	132.729	0.426	5.0	52.9	O K
2880 min Summer	132.638	0.335	4.9	34.1	O K
4320 min Summer	132.515	0.212	4.6	13.2	O K
5760 min Summer	132.445	0.142	4.1	5.2	O K
7200 min Summer	132.413	0.110	3.6	2.9	O K
8640 min Summer	132.398	0.095	3.1	2.1	O K
10080 min Summer	132.388	0.085	2.7	1.7	O K
15 min Winter	132.888	0.585	5.0	88.2	O K
30 min Winter	133.009	0.706	5.0	114.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.281	0.0	83.1	20
30 min Summer	75.158	0.0	110.0	34
60 min Summer	47.182	0.0	136.7	64
120 min Summer	28.693	0.0	167.7	122
180 min Summer	21.198	0.0	186.5	182
240 min Summer	17.014	0.0	199.4	240
360 min Summer	12.387	0.0	217.9	300
480 min Summer	9.861	0.0	231.3	354
600 min Summer	8.268	0.0	242.5	418
720 min Summer	7.157	0.0	251.9	486
960 min Summer	5.695	0.0	267.2	618
1440 min Summer	4.121	0.0	290.0	880
2160 min Summer	2.977	0.0	314.3	1252
2880 min Summer	2.361	0.0	332.4	1588
4320 min Summer	1.701	0.0	359.2	2252
5760 min Summer	1.347	0.0	379.2	2944
7200 min Summer	1.123	0.0	395.2	3648
8640 min Summer	0.968	0.0	408.7	4352
10080 min Summer	0.853	0.0	420.3	5136
15 min Winter	114.281	0.0	93.4	20
30 min Winter	75.158	0.0	123.4	34

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Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	133.131	0.828	5.0	138.6	O K
120 min Winter	133.272	0.969	5.0	158.0	O K
180 min Winter	133.495	1.192	5.0	163.5	O K
240 min Winter	133.657	1.354	5.0	163.6	O K
360 min Winter	133.260	0.957	5.0	157.0	O K
480 min Winter	133.180	0.877	5.0	146.7	O K
600 min Winter	133.123	0.820	5.0	137.1	O K
720 min Winter	133.075	0.772	5.0	128.0	O K
960 min Winter	132.988	0.685	5.0	110.3	O K
1440 min Winter	132.843	0.540	5.0	78.0	O K
2160 min Winter	132.672	0.369	4.9	41.0	O K
2880 min Winter	132.551	0.248	4.7	18.6	O K
4320 min Winter	132.424	0.121	3.9	3.6	O K
5760 min Winter	132.399	0.096	3.1	2.1	O K
7200 min Winter	132.385	0.082	2.6	1.6	O K
8640 min Winter	132.377	0.074	2.3	1.3	O K
10080 min Winter	132.371	0.068	2.0	1.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	47.182	0.0	154.8	62
120 min Winter	28.693	0.0	188.5	120
180 min Winter	21.198	0.0	208.7	178
240 min Winter	17.014	0.0	223.5	232
360 min Winter	12.387	0.0	244.1	342
480 min Winter	9.861	0.0	259.1	432
600 min Winter	8.268	0.0	271.6	464
720 min Winter	7.157	0.0	282.1	536
960 min Winter	5.695	0.0	299.3	676
1440 min Winter	4.121	0.0	324.8	942
2160 min Winter	2.977	0.0	352.0	1300
2880 min Winter	2.361	0.0	372.3	1616
4320 min Winter	1.701	0.0	402.3	2196
5760 min Winter	1.347	0.0	424.7	2904
7200 min Winter	1.123	0.0	442.7	3608
8640 min Winter	0.968	0.0	457.7	4312
10080 min Winter	0.853	0.0	470.8	5096

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Pipe Network

Volume in Pipe Network (m^3)	2	Dia of Outfall Pipe (m)	0.2
Slope of Outfall Pipe (1:X)	80	Roughness of Outfall Pipe (mm)	0.600

Time Area Diagram

Total Area (ha) 0.391

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.366	4	8	0.025

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Model Details

Storage is Online Cover Level (m) 134.291

Pipe Structure

Diameter (m) Conduit Section Length (m) 85.000
Slope (1:X) 400.000 Invert Level (m) 132.303

Section Number -1 Minor Dimn (mm) 900 4 * Hyd Radius (mm) 0.900
Conduit Type ooo Side Slope (Deg) XSect Area (m²) 1.909
Major Dimn (mm) 2700 Corner Splay (mm)

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0099-5000-1410-5000
Design Head (m)	1.410
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	99
Invert Level (m)	132.303
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.410	5.0
Flush-Flo™	0.421	5.0
Kick-Flo®	0.861	4.0
Mean Flow over Head Range	-	4.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.3	1.200	4.6	3.000	7.1	7.000	10.6
0.200	4.5	1.400	5.0	3.500	7.6	7.500	10.9
0.300	4.9	1.600	5.3	4.000	8.1	8.000	11.3
0.400	5.0	1.800	5.6	4.500	8.6	8.500	11.6
0.500	4.9	2.000	5.9	5.000	9.0	9.000	11.9
0.600	4.8	2.200	6.1	5.500	9.4	9.500	12.2
0.800	4.3	2.400	6.4	6.000	9.8		
1.000	4.2	2.600	6.6	6.500	10.2		

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Existing Network Details for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	k (mm)	HYD SECT	DIA (mm)
1.000	8.406	0.762	11.0	0.040	2.00	0.600	o	225
1.001	17.175	3.809	4.5	0.106	0.00	0.600	o	225
1.002	26.000	0.065	400.0	0.015	0.00	0.600	ooo	-47
2.000	12.000	0.030	400.0	0.137	2.00	0.600	ooo	-47
3.000	12.000	0.030	400.0	0.000	2.00	0.600	[]	-48
3.001	8.678	0.022	394.5	0.000	0.00	0.600	o	225
1.003	22.000	0.055	400.0	0.093	0.00	0.600	ooo	-47
1.004	4.982	0.063	79.1	0.000	0.00	0.600	o	225

PN	US/MH Name	US/CL (m)	US/IL (m)	US C.Depth (m)	DS/CL (m)	DS/IL (m)	DS C.Depth (m)	Ctrl	US/MH (mm)
1.000	1	139.094	137.669	1.200	138.332	136.907	1.200		1200
1.001	2	138.332	136.907	1.200	136.569	133.098	3.246		1200
1.002	3	136.569	132.423	3.246	134.431	132.358	1.173		1800
2.000	4	134.569	132.388	1.281	134.431	132.358	1.173		1800
3.000	5	135.200	133.085	1.315	135.000	133.055	1.145		3000
3.001	5	135.000	133.055	1.720	134.431	133.033	1.173		3000
1.003	5	134.431	132.358	1.173	134.291	132.303	1.088		1800
1.004	6	134.291	132.303	1.763	134.210	132.240	1.745	Hydro-Brake®	3000

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PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	o	225	1	139.094	137.669	1.200	Open Manhole	1200
1.001	o	225	2	138.332	136.907	1.200	Open Manhole	1200
1.002	ooo	-47	3	136.569	132.423	3.246	Open Manhole	1800
2.000	ooo	-47	4	134.569	132.388	1.281	Open Manhole	1800
3.000	[]	-48	5	135.200	133.085	1.315	Open Manhole	3000
3.001	o	225	5	135.000	133.055	1.720	Open Manhole	3000
1.003	ooo	-47	5	134.431	132.358	1.173	Open Manhole	1800
1.004	o	225	6	134.291	132.303	1.763	Open Manhole	3000

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	8.406	11.0	2	138.332	136.907	1.200	Open Manhole	1200
1.001	17.175	4.5	3	136.569	133.098	3.246	Open Manhole	1800
1.002	26.000	400.0	5	134.431	132.358	1.173	Open Manhole	1800
2.000	12.000	400.0	5	134.431	132.358	1.173	Open Manhole	1800
3.000	12.000	400.0	5	135.000	133.055	1.145	Open Manhole	3000
3.001	8.678	394.5	5	134.431	133.033	1.173	Open Manhole	1800
1.003	22.000	400.0	6	134.291	132.303	1.088	Open Manhole	3000
1.004	4.982	79.1		134.210	132.240	1.745	Open Manhole	1200

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.004		134.210	132.240	0.000	1200	0

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Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	0.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Storage Structures	0
Number of Online Controls	1	Number of Time/Area Diagrams	0
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.400		

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Online Controls for Storm

Hydro-Brake Optimum® Manhole: 6, DS/PN: 1.004, Volume (m³): 51.5

Unit Reference	MD-SHE-0099-5000-1410-5000
Design Head (m)	1.410
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	99
Invert Level (m)	132.303
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.410	5.0
Flush-Flo™	0.421	5.0
Kick-Flo®	0.861	4.0
Mean Flow over Head Range	-	4.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.3	1.200	4.6	3.000	7.1	7.000	10.6
0.200	4.5	1.400	5.0	3.500	7.6	7.500	10.9
0.300	4.9	1.600	5.3	4.000	8.1	8.000	11.3
0.400	5.0	1.800	5.6	4.500	8.6	8.500	11.6
0.500	4.9	2.000	5.9	5.000	9.0	9.000	11.9
0.600	4.8	2.200	6.1	5.500	9.4	9.500	12.2
0.800	4.3	2.400	6.4	6.000	9.8		
1.000	4.2	2.600	6.6	6.500	10.2		

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Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	0.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Storage Structures	0
Number of Online Controls	1	Number of Time/Area Diagrams	0
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR	Ratio R 0.400
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	18.000	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	OFF		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	30, 30, 30

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.000	1	15 Summer	100	+30%					137.741
1.001	2	15 Summer	100	+30%					137.004
1.002	3	240 Winter	100	+30%	100/60 Winter				133.752
2.000	4	240 Winter	100	+30%	100/60 Summer				133.752
3.000	5	240 Winter	100	+30%					133.751
3.001	5	240 Winter	100	+30%	100/60 Summer				133.751
1.003	5	240 Winter	100	+30%	100/30 Winter				133.752
1.004	6	240 Winter	100	+30%	1/15 Summer				133.753

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.153	0.000	0.22		27.7	OK	
1.001	2	-0.128	0.000	0.38		84.3	OK	
1.002	3	0.429	0.000	0.01		15.5	SURCHARGED	
2.000	4	0.464	0.000	0.01		13.0	SURCHARGED	
3.000	5	-0.134	0.000	0.00		0.7	OK	
3.001	5	0.471	0.000	0.30		5.4	SURCHARGED	
1.003	5	0.494	0.000	0.01		17.3	SURCHARGED	

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Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.004	6	1.225	0.000	0.14		5.0	SURCHARGED	

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