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)	100	PIMP (%)	100
M5-60 (mm)	19.000	Add Flow / Climate Change (%)	0
Ratio R	0.350	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.344	4-8	0.270

Total Area Contributing (ha) = 0.614

Total Pipe Volume (m³) = 29.239

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.000	147.600	0.738	200.0	0.214	5.00	0.0	0.600	o	375	Pipe/Conduit	
1.001	29.300	0.293	100.0	0.100	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.002	11.050	0.134	82.5	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	6.93	146.600	0.214	0.0	0.0	0.0	1.28	141.1	29.0
1.001	50.00	7.20	146.283	0.314	0.0	0.0	0.0	1.81	200.1	42.5
1.002	50.00	7.29	145.990	0.314	0.0	0.0	0.0	2.00	220.5	42.5

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Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
2.000	23.800	1.117	21.3	0.026	5.00	0.0	0.600	o	150	Pipe/Conduit	
1.003	4.400	0.044	100.0	0.044	0.00	0.0	0.600	o	375	Pipe/Conduit	
3.000	57.200	0.572	100.0	0.230	5.00	0.0	0.600	o	300	Pipe/Conduit	
3.001	23.500	0.235	100.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
3.002	3.600	0.036	100.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.004	1.500	0.008	187.5	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.005	2.700	0.027	100.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.006	17.800	0.371	48.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
2.000	50.00	5.18	147.000	0.026	0.0	0.0	0.0	2.19	38.7	3.5
1.003	50.00	7.33	145.880	0.384	0.0	0.0	0.0	1.81	200.1	52.0
3.000	50.00	5.61	146.700	0.230	0.0	0.0	0.0	1.57	111.1	31.1
3.001	50.00	5.86	146.128	0.230	0.0	0.0	0.0	1.57	111.1	31.1
3.002	50.00	5.89	145.893	0.230	0.0	0.0	0.0	1.57	111.1	31.1
1.004	50.00	7.35	145.400	0.614	0.0	0.0	0.0	1.32	145.8	83.1
1.005	50.00	7.38	145.392	0.614	0.0	0.0	0.0	1.57	111.1	83.1
1.006	50.00	7.51	145.365	0.614	0.0	0.0	0.0	2.28	160.8	83.1

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Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	Pipe Out PN	Pipe Out Invert Level (m)	Pipe Out Diameter (mm)	Pipes In PN	Pipes In Invert Level (m)	Pipes In Diameter (mm)	Backdrop (mm)
1	147.600	1.000	Open Manhole	1350	1.000	146.600	375				
2	147.760	1.898	Open Manhole	1350	1.001	146.283	375	1.000	145.862	375	
3	147.520	1.530	Open Manhole	1350	1.002	145.990	375	1.001	145.990	375	
4	147.950	0.950	Open Manhole	1200	2.000	147.000	150				
5	147.600	1.744	Open Manhole	1350	1.003	145.880	375	1.002	145.856	375	
								2.000	145.883	150	
6	147.500	0.800	Open Manhole	1200	3.000	146.700	300				
7	147.400	1.272	Open Manhole	1200	3.001	146.128	300	3.000	146.128	300	
8	147.550	1.657	Open Manhole	1200	3.002	145.893	300	3.001	145.893	300	
9	147.800	2.400	Open Manhole	1350	1.004	145.400	375	1.003	145.836	375	436
								3.002	145.857	300	382
10	147.650	2.258	Open Manhole	1350	1.005	145.392	300	1.004	145.392	375	
11	147.600	2.235	Open Manhole	1200	1.006	145.365	300	1.005	145.365	300	
	146.020	1.026	Open Manhole	0		OUTFALL		1.006	144.994	300	

No coordinates have been specified, layout information cannot be produced.

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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	375	1	147.600	146.600	0.625	Open Manhole	1350
1.001	o	375	2	147.760	146.283	1.102	Open Manhole	1350
1.002	o	375	3	147.520	145.990	1.155	Open Manhole	1350
2.000	o	150	4	147.950	147.000	0.800	Open Manhole	1200
1.003	o	375	5	147.600	145.880	1.345	Open Manhole	1350
3.000	o	300	6	147.500	146.700	0.500	Open Manhole	1200
3.001	o	300	7	147.400	146.128	0.972	Open Manhole	1200
3.002	o	300	8	147.550	145.893	1.357	Open Manhole	1200
1.004	o	375	9	147.800	145.400	2.025	Open Manhole	1350
1.005	o	300	10	147.650	145.392	1.958	Open Manhole	1350
1.006	o	300	11	147.600	145.365	1.935	Open Manhole	1200

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	147.600	200.0	2	147.760	145.862	1.523	Open Manhole	1350
1.001	29.300	100.0	3	147.520	145.990	1.155	Open Manhole	1350
1.002	11.050	82.5	5	147.600	145.856	1.369	Open Manhole	1350
2.000	23.800	21.3	5	147.600	145.883	1.567	Open Manhole	1350
1.003	4.400	100.0	9	147.800	145.836	1.589	Open Manhole	1350
3.000	57.200	100.0	7	147.400	146.128	0.972	Open Manhole	1200
3.001	23.500	100.0	8	147.550	145.893	1.357	Open Manhole	1200
3.002	3.600	100.0	9	147.800	145.857	1.643	Open Manhole	1350
1.004	1.500	187.5	10	147.650	145.392	1.883	Open Manhole	1350
1.005	2.700	100.0	11	147.600	145.365	1.935	Open Manhole	1200
1.006	17.800	48.0		146.020	144.994	0.726	Open Manhole	0

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Network Classifications for Storm

PN	USMH Name	Pipe Dia (mm)	Min Cover Depth (m)	Max Cover Depth (m)	Pipe Type	MH Dia (mm)	MH Width (mm)	MH Ring Depth (m)	MH Type
1.000	1	375	0.625	1.523	Unclassified	1350	0	0.625	Unclassified
1.001	2	375	1.102	1.155	Unclassified	1350	0	1.102	Unclassified
1.002	3	375	1.155	1.369	Unclassified	1350	0	1.155	Unclassified
2.000	4	150	0.800	1.567	Unclassified	1200	0	0.800	Unclassified
1.003	5	375	1.345	1.589	Unclassified	1350	0	1.345	Unclassified
3.000	6	300	0.500	0.972	Unclassified	1200	0	0.500	Unclassified
3.001	7	300	0.972	1.357	Unclassified	1200	0	0.972	Unclassified
3.002	8	300	1.357	1.643	Unclassified	1200	0	1.357	Unclassified
1.004	9	375	1.883	2.025	Unclassified	1350	0	2.025	Unclassified
1.005	10	300	1.935	1.958	Unclassified	1350	0	1.958	Unclassified
1.006	11	300	0.726	1.935	Unclassified	1200	0	1.935	Unclassified

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)
1.006		146.020	144.994	0.000	0	0

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	2.000
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 Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	1	Number of Storage Structures	1	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)	19.000	Storm Duration (mins)	30
Ratio R	0.350		

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: 10, DS/PN: 1.005, Volume (m³): 3.2

Unit Reference	MD-SHE-0075-3100-1600-3100
Design Head (m)	1.600
Design Flow (l/s)	3.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	75
Invert Level (m)	145.392
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.600	3.1	Kick-Flo®	0.673	2.1
Flush-Flo™	0.332	2.6	Mean Flow over Head Range	-	2.5

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	2.1	1.200	2.7	3.000	4.1	7.000	6.2
0.200	2.5	1.400	2.9	3.500	4.4	7.500	6.4
0.300	2.6	1.600	3.1	4.000	4.7	8.000	6.6
0.400	2.6	1.800	3.3	4.500	5.0	8.500	6.8
0.500	2.5	2.000	3.4	5.000	5.3	9.000	6.9
0.600	2.3	2.200	3.6	5.500	5.5	9.500	7.1
0.800	2.3	2.400	3.7	6.000	5.7		
1.000	2.5	2.600	3.9	6.500	6.0		

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Storage Structures for Storm

Cellular Storage Manhole: 9, DS/PN: 1.004

Invert Level (m) 145.400 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	250.0	250.0	1.700	0.0	362.0
1.600	250.0	362.0			

Manhole Headloss for Storm

PN	US/MH Name	US/MH Headloss
1.000	1	0.500
1.001	2	0.500
1.002	3	0.500
2.000	4	0.500
1.003	5	0.500
3.000	6	0.500
3.001	7	0.500
3.002	8	0.500
1.004	9	0.500
1.005	10	0.500
1.006	11	0.500

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1 year Return Period 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	2.000
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 Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	1	Number of Storage Structures	1	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.361
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	19.000	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	ON
Inertia Status	ON

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

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 Winter	1	+0%	100/15 Summer				146.714
1.001	2	15 Winter	1	+0%	100/15 Winter				146.386
1.002	3	15 Winter	1	+0%	100/15 Summer				146.106
2.000	4	15 Winter	1	+0%					147.030
1.003	5	15 Winter	1	+0%	100/15 Summer				146.028
3.000	6	15 Winter	1	+0%	100/15 Summer				146.808
3.001	7	15 Winter	1	+0%	100/15 Summer				146.238
3.002	8	15 Winter	1	+0%	30/15 Summer				146.037
1.004	9	480 Winter	1	+0%	30/30 Summer				145.705
1.005	10	960 Winter	1	+0%	1/240 Winter				145.717
1.006	11	480 Winter	1	+0%					145.391

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

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.261	0.000	0.17			23.7	OK	
1.001	2	-0.272	0.000	0.17			29.4	OK	
1.002	3	-0.259	0.000	0.21			29.8	OK	
2.000	4	-0.120	0.000	0.09			3.3	OK	
1.003	5	-0.227	0.000	0.33			34.9	OK	
3.000	6	-0.192	0.000	0.27			28.7	OK	
3.001	7	-0.190	0.000	0.29			28.6	OK	
3.002	8	-0.156	0.000	0.46			28.5	OK	
1.004	9	-0.070	0.000	0.04		326	3.1	OK	
1.005	10	0.025	0.000	0.04			2.6	SURCHARGED	
1.006	11	-0.274	0.000	0.02			2.6	OK	

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30 year Return Period 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	2.000
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 Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	1	Number of Storage Structures	1	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.361
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	19.000	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	ON
Inertia Status	ON

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

WARNING: Half Drain Time has not been calculated as the structure is too full.

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 Winter	30	+0%	100/15 Summer				146.786
1.001	2	15 Winter	30	+0%	100/15 Winter				146.467
1.002	3	480 Winter	30	+0%	100/15 Summer				146.243
2.000	4	15 Winter	30	+0%					147.048
1.003	5	480 Winter	30	+0%	100/15 Summer				146.243
3.000	6	15 Winter	30	+0%	100/15 Summer				146.884
3.001	7	15 Winter	30	+0%	100/15 Summer				146.333
3.002	8	480 Winter	30	+0%	30/15 Summer				146.242
1.004	9	480 Winter	30	+0%	30/30 Summer				146.242
1.005	10	480 Winter	30	+0%	1/240 Winter				146.218
1.006	11	1440 Summer	30	+0%					145.391

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30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.189	0.000	0.42			58.0	OK	
1.001	2	-0.191	0.000	0.47			82.9	OK	
1.002	3	-0.122	0.000	0.08			11.9	OK	
2.000	4	-0.102	0.000	0.22			8.1	OK	
1.003	5	-0.012	0.000	0.14			14.6	OK	
3.000	6	-0.116	0.000	0.67			70.4	OK	
3.001	7	-0.095	0.000	0.70			69.4	OK	
3.002	8	0.049	0.000	0.14			8.8	SURCHARGED	
1.004	9	0.467	0.000	0.03			3.0	SURCHARGED	
1.005	10	0.526	0.000	0.04			2.6	SURCHARGED	
1.006	11	-0.274	0.000	0.02			2.6	OK	

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100 year Return Period 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 2.000
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 Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 1 Number of Storage Structures 1 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.361
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 19.000 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0
Analysis Timestep 2.5 Second Increment (Extended)
DTS Status OFF
DVD Status ON
Inertia Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 40

WARNING: Half Drain Time has not been calculated as the structure is too full.

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 Winter	100	+40%	100/15 Summer				147.135
1.001	2	960 Winter	100	+40%	100/15 Winter				147.026
1.002	3	960 Winter	100	+40%	100/15 Summer				147.025
2.000	4	15 Winter	100	+40%					147.066
1.003	5	960 Winter	100	+40%	100/15 Summer				147.024
3.000	6	15 Winter	100	+40%	100/15 Summer				147.288
3.001	7	960 Winter	100	+40%	100/15 Summer				147.026
3.002	8	960 Winter	100	+40%	30/15 Summer				147.024
1.004	9	960 Winter	100	+40%	30/30 Summer				147.024
1.005	10	960 Winter	100	+40%	1/240 Winter				147.007
1.006	11	960 Winter	100	+40%					145.396

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100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	0.160	0.000	0.73			100.2	SURCHARGED	
1.001	2	0.368	0.000	0.07			12.6	SURCHARGED	
1.002	3	0.660	0.000	0.09			12.5	SURCHARGED	
2.000	4	-0.084	0.000	0.40			14.7	OK	
1.003	5	0.769	0.000	0.14			15.3	SURCHARGED	
3.000	6	0.288	0.000	1.07			113.1	FLOOD RISK	
3.001	7	0.598	0.000	0.09			9.0	SURCHARGED	
3.002	8	0.831	0.000	0.15			8.9	SURCHARGED	
1.004	9	1.249	0.000	0.04			3.1	SURCHARGED	
1.005	10	1.315	0.000	0.05			3.1	SURCHARGED	
1.006	11	-0.269	0.000	0.02			3.1	OK	

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