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)	2	PIMP (%)	100
M5-60 (mm)	18.400	Add Flow / Climate Change (%)	0
Ratio R	0.354	Minimum Backdrop Height (m)	0.650
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)	Time (mins)	Area (ha)
0-4	0.310	4-8	0.448	8-12	0.003

Total Area Contributing (ha) = 0.761

Total Pipe Volume (m³) = 29.461

Network Design Table for Storm

« - Indicates pipe capacity < flow

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	21.364	0.140	152.6	0.000	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	18.702	0.080	233.8	0.042	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.002	28.000	0.120	233.3	0.073	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.003	11.132	0.050	222.6	0.054	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.004	20.000	0.090	222.2	0.042	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)
1.000	50.00	5.34	130.625	0.000	0.0	0.0	0.0	1.06	42.0	0.0
1.001	50.00	5.64	130.410	0.042	0.0	0.0	0.0	1.02	72.4	5.7
1.002	50.00	6.10	130.330	0.115	0.0	0.0	0.0	1.02	72.5	15.6
1.003	50.00	6.27	130.210	0.169	0.0	0.0	0.0	1.05	74.2	22.9
1.004	50.00	6.59	130.160	0.211	0.0	0.0	0.0	1.05	74.3	28.6

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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
1.005	36.401	0.160	227.5	0.053	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.006	10.900	0.050	218.0	0.036	0.00	0.0	0.600	o	300	Pipe/Conduit	
2.000	8.608	0.140	61.5	0.046	5.00	0.0	0.600	o	150	Pipe/Conduit	
2.001	6.829	0.120	56.9	0.005	0.00	0.0	0.600	o	150	Pipe/Conduit	
2.002	13.000	0.830	15.7	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
2.003	9.844	2.000	4.9	0.006	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.007	15.727	0.070	224.7	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.008	13.422	0.060	223.7	0.049	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.009	37.035	0.160	231.5	0.120	0.00	0.0	0.600	o	300	Pipe/Conduit	
3.000	28.615	2.205	13.0	0.029	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.010	23.856	0.100	238.6	0.069	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.011	27.968	0.150	186.5	0.015	0.00	0.0	0.600	o	375	Pipe/Conduit	
4.000	22.198	0.800	27.7	0.026	5.00	0.0	0.600	o	150	Pipe/Conduit	
5.000	22.019	0.300	73.4	0.047	5.00	0.0	0.600	o	150	Pipe/Conduit	
4.001	30.000	0.300	100.0	0.000	0.00	0.0	0.600	o	150	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)
1.005	50.00	7.18	130.070	0.264	0.0	0.0	0.0	1.04	73.4	35.7
1.006	50.00	7.35	129.910	0.300	0.0	0.0	0.0	1.06	75.0	40.6
2.000	50.00	5.11	134.450	0.046	0.0	0.0	0.0	1.28	22.7	6.2
2.001	50.00	5.20	134.310	0.051	0.0	0.0	0.0	1.34	23.6	6.9
2.002	50.00	5.28	134.190	0.051	0.0	0.0	0.0	2.56	45.2	6.9
2.003	50.00	5.32	133.360	0.057	0.0	0.0	0.0	4.57	80.8	7.7
1.007	50.00	7.60	129.860	0.357	0.0	0.0	0.0	1.04	73.9	48.3
1.008	49.79	7.81	129.790	0.406	0.0	0.0	0.0	1.05	74.0	54.7
1.009	48.03	8.41	129.730	0.526	0.0	0.0	0.0	1.03	72.7	68.4
3.000	50.00	5.13	131.975	0.029	0.0	0.0	0.0	3.65	145.2	3.9
1.010	47.09	8.75	129.495	0.624	0.0	0.0	0.0	1.17	129.1	79.6
1.011	46.16	9.10	129.395	0.639	0.0	0.0	0.0	1.32	146.2	79.9
4.000	50.00	5.19	131.950	0.026	0.0	0.0	0.0	1.92	33.9	3.5
5.000	50.00	5.31	131.450	0.047	0.0	0.0	0.0	1.17	20.8	6.4
4.001	50.00	5.81	131.150	0.073	0.0	0.0	0.0	1.00	17.8	9.9

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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
4.002	4.681	0.200	23.4	0.015	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.012	18.410	0.100	184.1	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.013	5.881	0.495	11.9	0.034	0.00	0.0	0.600	o	375	Pipe/Conduit	
6.000	18.000	0.000	0.0	0.000	5.00	0.0	0.600	o	300	Pipe/Conduit	
6.001	18.000	0.000	0.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.014	15.806	0.150	105.4	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.015	7.534	0.420	17.9	0.000	0.00	0.0	0.600	o	225	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)
4.002	50.00	5.85	130.850	0.088	0.0	0.0	0.0	2.09	36.9	11.9
1.012	45.58	9.33	129.245	0.727	0.0	0.0	0.0	1.33	147.1	89.7
1.013	45.53	9.35	129.145	0.761	0.0	0.0	0.0	5.28	583.3	93.8
6.000	50.00	7.01	128.650	0.000	0.0	0.0	0.0	0.15	10.5	0.0
6.001	46.35	9.03	128.650	0.000	0.0	0.0	0.0	0.15	10.5	0.0
1.014	45.03	9.56	128.650	0.761	0.0	0.0	0.0	1.27	50.6«	93.8
1.015	44.93	9.60	128.500	0.761	0.0	0.0	0.0	3.10	123.4	93.8

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)
1.015	SEWER CONNECTION	131.180	128.080	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 Storage Structures	3
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

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Simulation Criteria for Storm

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	2	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.400	Storm Duration (mins)	30
Ratio R	0.354		

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: S15-HB, DS/PN: 1.014, Volume (m³): 11.8

Unit Reference	MD-SHE-0077-3800-2300-3800
Design Head (m)	2.300
Design Flow (l/s)	3.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	77
Invert Level (m)	128.650
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.300	3.8
Flush-Flo™	0.338	2.7
Kick-Flo®	0.684	2.2
Mean Flow over Head Range	-	2.8

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	2.2	1.200	2.8	3.000	4.3	7.000	6.4
0.200	2.6	1.400	3.0	3.500	4.6	7.500	6.6
0.300	2.7	1.600	3.2	4.000	4.9	8.000	6.8
0.400	2.7	1.800	3.4	4.500	5.2	8.500	7.0
0.500	2.6	2.000	3.6	5.000	5.4	9.000	7.2
0.600	2.5	2.200	3.7	5.500	5.7	9.500	7.4
0.800	2.3	2.400	3.9	6.000	5.9		
1.000	2.6	2.600	4.0	6.500	6.2		

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Storage Structures for Storm

Cellular Storage Manhole: S1, DS/PN: 1.000

Invert Level (m) 130.625 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	30.0	30.0	1.300	0.0	41.0
0.100	30.0	32.2	1.400	0.0	41.0
0.200	30.0	34.4	1.500	0.0	41.0
0.300	30.0	36.6	1.600	0.0	41.0
0.400	30.0	38.8	1.700	0.0	41.0
0.500	30.0	41.0	1.800	0.0	41.0
0.501	0.0	41.0	1.900	0.0	41.0
0.700	0.0	41.0	2.000	0.0	41.0
0.800	0.0	41.0	2.100	0.0	41.0
0.900	0.0	41.0	2.200	0.0	41.0
1.000	0.0	41.0	2.300	0.0	41.0
1.100	0.0	41.0	2.400	0.0	41.0
1.200	0.0	41.0	2.500	0.0	41.0

Cellular Storage Manhole: S27, DS/PN: 6.001

Invert Level (m) 128.950 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	110.0	110.0	2.600	0.0	193.9
0.200	110.0	118.4	2.800	0.0	193.9
0.400	110.0	126.8	3.000	0.0	193.9
0.600	110.0	135.2	3.200	0.0	193.9
0.800	110.0	143.6	3.400	0.0	193.9
1.000	110.0	152.0	3.600	0.0	193.9
1.200	110.0	160.3	3.800	0.0	193.9
1.400	110.0	168.7	4.000	0.0	193.9
1.600	110.0	177.1	4.200	0.0	193.9
1.800	110.0	185.5	4.400	0.0	193.9
2.000	110.0	193.9	4.600	0.0	193.9
2.001	0.0	193.9	4.800	0.0	193.9
2.400	0.0	193.9	5.000	0.0	193.9

Cellular Storage Manhole: S15-HB, DS/PN: 1.014

Invert Level (m) 128.700 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

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Cellular Storage Manhole: S15-HB, DS/PN: 1.014

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	96.0	96.0	2.600	0.0	174.4
0.200	96.0	103.8	2.800	0.0	174.4
0.400	96.0	111.7	3.000	0.0	174.4
0.600	96.0	119.5	3.200	0.0	174.4
0.800	96.0	127.4	3.400	0.0	174.4
1.000	96.0	135.2	3.600	0.0	174.4
1.200	96.0	143.0	3.800	0.0	174.4
1.400	96.0	150.9	4.000	0.0	174.4
1.600	96.0	158.7	4.200	0.0	174.4
1.800	96.0	166.5	4.400	0.0	174.4
2.000	96.0	174.4	4.600	0.0	174.4
2.001	0.0	174.4	4.800	0.0	174.4
2.400	0.0	174.4	5.000	0.0	174.4

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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	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 Storage Structures	3
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 0.357
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
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, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	100
Climate Change (%)	30

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	S1	15 Winter	100	+30%	100/15 Summer				131.618
1.001	S2	15 Winter	100	+30%	100/15 Summer				131.631
1.002	S3	15 Winter	100	+30%	100/15 Summer				131.753
1.003	S4	15 Winter	100	+30%	100/15 Summer				131.829
1.004	S5	15 Winter	100	+30%	100/15 Summer				131.845
1.005	S6	15 Winter	100	+30%	100/15 Summer				131.835
1.006	S7	15 Winter	100	+30%	100/15 Summer				131.758
2.000	S17	15 Winter	100	+30%	100/15 Summer				134.709
2.001	S18	15 Winter	100	+30%	100/15 Summer				134.526
2.002	S19	15 Winter	100	+30%					134.275
2.003	S20	15 Winter	100	+30%					133.425
1.007	S8	15 Winter	100	+30%	100/15 Summer				131.692
1.008	S9	15 Winter	100	+30%	100/15 Summer				131.564
1.009	S10	15 Winter	100	+30%	100/15 Summer				131.380
3.000	S21	15 Winter	100	+30%					132.024

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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)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	S1	0.768	0.000	0.84		9	32.2	FLOOD RISK	
1.001	S2	0.921	0.000	0.55			34.3	SURCHARGED	
1.002	S3	1.123	0.000	0.55			35.9	SURCHARGED	
1.003	S4	1.319	0.000	0.67			39.9	SURCHARGED	
1.004	S5	1.385	0.000	0.75			48.4	SURCHARGED	
1.005	S6	1.465	0.000	0.85			57.8	SURCHARGED	
1.006	S7	1.548	0.000	1.11			66.4	SURCHARGED	
2.000	S17	0.109	0.000	1.12			22.3	SURCHARGED	
2.001	S18	0.066	0.000	1.24			24.9	SURCHARGED	
2.002	S19	-0.065	0.000	0.60			24.9	OK	
2.003	S20	-0.085	0.000	0.38			27.6	OK	
1.007	S8	1.532	0.000	1.41			88.0	SURCHARGED	
1.008	S9	1.474	0.000	1.75			106.8	SURCHARGED	
1.009	S10	1.350	0.000	2.27			152.6	SURCHARGED	
3.000	S21	-0.176	0.000	0.11			14.3	OK	

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

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.010	S11	720 Winter	100	+30%	100/15 Summer				130.943
1.011	S12	720 Winter	100	+30%	100/15 Summer				130.941
4.000	S22	15 Winter	100	+30%	100/15 Winter				132.189
5.000	S25	15 Winter	100	+30%	100/15 Summer				132.409
4.001	S23	15 Winter	100	+30%	100/15 Summer				132.098
4.002	S24	15 Winter	100	+30%	100/15 Summer				131.122
1.012	S13	720 Winter	100	+30%	100/15 Summer				130.939
1.013	S14	720 Winter	100	+30%	100/15 Summer				130.936
6.000	S26	720 Winter	100	+30%	100/15 Summer				130.935
6.001	S27	720 Winter	100	+30%	100/15 Summer				130.935
1.014	S15-HB	720 Winter	100	+30%	100/15 Summer				130.935
1.015	S16	720 Winter	100	+30%					128.529

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.010	S11	1.073	0.000	0.22			24.4	SURCHARGED	
1.011	S12	1.171	0.000	0.19			24.9	SURCHARGED	
4.000	S22	0.089	0.000	0.39			12.5	SURCHARGED	
5.000	S25	0.809	0.000	1.00			19.7	SURCHARGED	
4.001	S23	0.798	0.000	1.78			30.4	SURCHARGED	
4.002	S24	0.122	0.000	1.27			35.6	SURCHARGED	
1.012	S13	1.319	0.000	0.23			28.6	SURCHARGED	
1.013	S14	1.416	0.000	0.11			29.9	SURCHARGED	
6.000	S26	1.985	0.000	0.00			0.0	SURCHARGED	
6.001	S27	1.985	0.000	0.12			2.5	SURCHARGED	
1.014	S15-HB	2.060	0.000	0.08			3.8	SURCHARGED	
1.015	S16	-0.196	0.000	0.04			3.8	OK	

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