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)	16.000	Add Flow / Climate Change (%)	0
Ratio R	0.269	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

Network Design Table for Storm

- Indicates pipe length does not match coordinates

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
S1.000	11.950	0.350	34.1	0.010	5.00	0.0	0.600	o	100	Pipe/Conduit	
S2.000	24.252	0.850	28.5	0.020	5.00	0.0	0.600	o	100	Pipe/Conduit	
S2.001	11.135	0.300	37.1	0.014	0.00	0.0	0.600	o	100	Pipe/Conduit	
S3.000	30.081	0.800	37.6	0.028	5.00	0.0	0.600	o	100	Pipe/Conduit	
S3.001	10.946	0.150	73.0	0.000	0.00	0.0	0.600	o	100	Pipe/Conduit	
S2.002	5.789	0.100	57.9	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.001	20.310	0.500	40.6	0.035	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.002	4.183	0.100	41.8	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.003	14.336	0.050	286.7	0.016	0.00	0.0	0.600	o	375	Pipe/Conduit	
S4.000	14.943	0.049	305.0	0.000	5.00	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)
S1.000	45.32	5.15	10.700	0.010	0.0	0.0	0.0	1.32	10.4	1.2
S2.000	44.91	5.28	11.600	0.020	0.0	0.0	0.0	1.45	11.4	2.4
S2.001	44.45	5.42	10.750	0.034	0.0	0.0	0.0	1.27	10.0	4.1
S3.000	44.54	5.40	11.400	0.028	0.0	0.0	0.0	1.26	9.9	3.4
S3.001	43.92	5.60	10.600	0.028	0.0	0.0	0.0	0.90	7.1	3.4
S2.002	43.70	5.67	10.400	0.062	0.0	0.0	0.0	1.32	23.4	7.3
S1.001	43.08	5.89	10.300	0.107	0.0	0.0	0.0	1.58	28.0	12.5
S1.002	42.95	5.93	9.800	0.107	0.0	0.0	0.0	1.56	27.6	12.5
S1.003	42.32	6.16	9.475	0.123	0.0	0.0	0.0	1.06	117.6	14.1
S4.000	44.91	5.28	9.500	0.000	0.0	0.0	0.0	0.90	63.3	0.0

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
S4.001	7.129#	0.026	274.2	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
S1.004	3.732	0.375	10.0	0.018	0.00	0.0	0.600	o	375	Pipe/Conduit	
S5.000	23.019	0.250	92.1	0.024	5.00	0.0	0.600	o	150	Pipe/Conduit	
S6.000	11.111	0.150	74.1	0.012	5.00	0.0	0.600	o	100	Pipe/Conduit	
S6.001	5.651	0.100	56.5	0.010	0.00	0.0	0.600	o	100	Pipe/Conduit	
S5.001	11.719	0.150	78.1	0.010	0.00	0.0	0.600	o	150	Pipe/Conduit	
S5.002	9.605	0.100	96.1	0.005	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.005	3.993	0.045	88.7	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)
S4.001	44.51	5.40	9.451	0.000	0.0	0.0	0.0	0.94	66.8	0.0
S1.004	42.30	6.17	9.425	0.141	0.0	0.0	0.0	5.77	637.5	16.2
S5.000	44.63	5.37	9.550	0.024	0.0	0.0	0.0	1.05	18.5	2.9
S6.000	45.14	5.21	9.600	0.012	0.0	0.0	0.0	0.90	7.0	1.5
S6.001	44.85	5.30	9.450	0.022	0.0	0.0	0.0	1.03	8.1	2.7
S5.001	44.10	5.54	9.300	0.056	0.0	0.0	0.0	1.14	20.1	6.7
S5.002	43.64	5.69	9.150	0.061	0.0	0.0	0.0	1.03	18.1	7.2
S1.005	42.20	6.20	9.050	0.202	0.0	0.0	0.0	1.92	212.5	23.1

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
S1.000	SP02	100	0.530	0.580	Unclassified	450	0	0.530	Unclassified
S2.000	SRE2	100	0.460	0.580	Unclassified	100	0	0.460	Unclassified
S2.001	SP03	100	0.580	0.730	Unclassified	450	0	0.580	Unclassified
S3.000	SP04	100	0.550	0.675	Unclassified	1200	0	0.675	Unclassified
S3.001	SP05	100	0.550	0.730	Unclassified	1200	0	0.550	Unclassified
S2.002	SP06	150	0.580	0.730	Unclassified	600	0	0.730	Unclassified
S1.001	SP07	150	0.580	0.600	Unclassified	600	0	0.580	Unclassified
S1.002	SP08	150	0.600	0.750	Unclassified	600	0	0.600	Unclassified
S1.003	SW01	375	0.670	0.750	Unclassified	600	0	0.750	Unclassified
S4.000	SW ATT	300	0.899	1.000	Unclassified	600	0	1.000	Unclassified
S4.001	SW04	300	0.745	0.899	Unclassified	1200	0	0.899	Unclassified
S1.004	SW02	375	0.670	0.895	Unclassified	600	0	0.670	Unclassified
S5.000	SRE3	150	0.600	1.000	Unclassified	150	0	0.600	Unclassified
S6.000	SP09	100	0.890	1.140	Unclassified	450	0	0.890	Unclassified
S6.001	SP10	100	1.000	1.140	Unclassified	450	0	1.140	Unclassified
S5.001	SP11	150	1.000	1.150	Unclassified	600	0	1.000	Unclassified
S5.002	SP12	150	1.120	1.150	Unclassified	1500	0	1.150	Unclassified
S1.005	SW03	375	0.895	1.195	Unclassified	1500	0	0.895	Unclassified

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 6	Number of Real Time Controls 0

Synthetic Rainfall Details

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)	16.000	Storm Duration (mins)	30
Ratio R	0.257		

Online Controls for Storm

Hydro-Brake® Optimum Manhole: SW03, DS/PN: S1.005, Volume (m³): 2.7

Unit Reference	MD-SHE-0075-2700-1200-2700
Design Head (m)	1.200
Design Flow (l/s)	2.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	75
Invert Level (m)	9.050
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)	1.200	2.7	Kick-Flo®	0.670	2.1
Flush-Flo™	0.330	2.6	Mean Flow over Head Range	-	2.3

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)	Depth (m)	Flow (l/s)
0.100	2.1	0.800	2.2	2.000	3.4	4.000	4.7	7.000	6.1
0.200	2.5	1.000	2.5	2.200	3.6	4.500	5.0	7.500	6.3
0.300	2.6	1.200	2.7	2.400	3.7	5.000	5.2	8.000	6.5
0.400	2.5	1.400	2.9	2.600	3.9	5.500	5.5	8.500	6.7
0.500	2.5	1.600	3.1	3.000	4.1	6.000	5.7	9.000	6.9
0.600	2.3	1.800	3.2	3.500	4.4	6.500	5.9	9.500	7.1

Storage Structures for Storm

Porous Car Park Manhole: SP07, DS/PN: S1.001

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.4
Membrane Percolation (mm/hr)	1000	Length (m)	11.1
Max Percolation (l/s)	16.7	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	10.470	Membrane Depth (mm)	0

Porous Car Park Manhole: SP08, DS/PN: S1.002

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.5
Membrane Percolation (mm/hr)	1000	Length (m)	16.8
Max Percolation (l/s)	25.7	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	9.980	Membrane Depth (mm)	0

Tank or Pond Manhole: SW ATT, DS/PN: S4.000

Invert Level (m) 9.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	85.5	0.600	85.5	0.601	0.0

Porous Car Park Manhole: SP11, DS/PN: S5.001

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.4
Membrane Percolation (mm/hr)	1000	Length (m)	21.8
Max Percolation (l/s)	32.7	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	9.740	Membrane Depth (mm)	0

Porous Car Park Manhole: SP12, DS/PN: S5.002

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.2
Membrane Percolation (mm/hr)	1000	Length (m)	11.0
Max Percolation (l/s)	15.9	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	9.890	Membrane Depth (mm)	0

Porous Car Park Manhole: SW03, DS/PN: S1.005

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.1
Membrane Percolation (mm/hr)	1000	Length (m)	5.5
Max Percolation (l/s)	7.8	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	10.020	Membrane Depth (mm)	0

500 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 6 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	M5-60 (mm) 16.000	Cv (Summer) 0.750
Region	England and Wales	Ratio R 0.269	Cv (Winter) 0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	ON
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)	500
Climate Change (%)	0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
S1.000	SP02	15 Winter	500	+0%					10.746	-0.054
S2.000	SRE2	15 Winter	500	+0%	500/15 Winter				11.702	0.002
S2.001	SP03	15 Winter	500	+0%	500/15 Summer				11.290	0.440
S3.000	SP04	15 Winter	500	+0%	500/15 Summer				11.678	0.178
S3.001	SP05	15 Winter	500	+0%	500/15 Summer				11.007	0.307
S2.002	SP06	15 Winter	500	+0%	500/15 Summer				10.752	0.202
S1.001	SP07	15 Winter	500	+0%	500/15 Summer				10.650	0.200
S1.002	SP08	240 Winter	500	+0%	500/15 Summer				10.298	0.348
S1.003	SW01	240 Winter	500	+0%	500/15 Summer				10.295	0.445
S4.000	SW ATT	240 Winter	500	+0%	500/15 Winter				10.294	0.494
S4.001	SW04	240 Winter	500	+0%	500/15 Summer				10.294	0.543
S1.004	SW02	240 Winter	500	+0%	500/15 Summer				10.294	0.494
S5.000	SRE3	240 Winter	500	+0%	500/15 Summer	500/240 Winter			10.300	0.600
S6.000	SP09	240 Winter	500	+0%	500/15 Summer				10.302	0.602
S6.001	SP10	240 Winter	500	+0%	500/15 Summer				10.300	0.750
S5.001	SP11	240 Winter	500	+0%	500/15 Summer				10.299	0.849
S5.002	SP12	240 Winter	500	+0%	500/15 Summer				10.296	0.996
S1.005	SW03	240 Winter	500	+0%	500/15 Summer				10.294	0.869

PN	US/MH Name	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
S1.000	SP02	0.000	0.43			4.2	OK	
S2.000	SRE2	0.000	0.73			8.1	SURCHARGED	
S2.001	SP03	0.000	1.37			12.8	FLOOD RISK	
S3.000	SP04	0.000	0.94			9.1	SURCHARGED	
S3.001	SP05	0.000	1.35			8.9	FLOOD RISK	
S2.002	SP06	0.000	1.05			20.4	SURCHARGED	
S1.001	SP07	0.000	1.04		5	27.4	SURCHARGED	
S1.002	SP08	0.000	0.60		80	11.9	FLOOD RISK	
S1.003	SW01	0.000	0.15			13.6	SURCHARGED	

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

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
S4.000	SW ATT	0.000	0.08			4.1	SURCHARGED	
S4.001	SW04	0.000	0.07			3.5	SURCHARGED	
S1.004	SW02	0.000	0.02			5.3	FLOOD RISK	
S5.000	SRE3	0.001	0.15			2.6	FLOOD	1
S6.000	SP09	0.000	0.20			1.3	FLOOD RISK	
S6.001	SP10	0.000	0.33			2.4	SURCHARGED	
S5.001	SP11	0.000	0.28		169	5.1	FLOOD RISK	
S5.002	SP12	0.000	0.34		153	5.5	FLOOD RISK	
S1.005	SW03	0.000	0.03		175	2.7	FLOOD RISK	