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	PIMP (%)	100
M5-60 (mm)	18.000	Add Flow / Climate Change (%)	0
Ratio R	0.352	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	0.163	4-8	0.155

Total Area Contributing (ha) = 0.318

Total Pipe Volume (m³) = 4.822

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
S1.000	22.741	1.137	20.0	0.060	5.00	0.0	0.600	o	225	Pipe/Conduit	
S1.001	31.689	0.158	200.0	0.040	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.002	31.689	0.158	200.0	0.109	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.003	7.891	0.079	100.0	0.109	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.004	17.455	0.175	100.0	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.005	5.902	0.059	100.0	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.006	38.577	0.386	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)
S1.000	45.79	5.13	52.220	0.060	0.0	0.0	0.0	2.94	116.9	7.4
S1.001	43.74	5.70	51.083	0.100	0.0	0.0	0.0	0.92	36.6	11.8
S1.002	41.90	6.28	50.925	0.209	0.0	0.0	0.0	0.92	36.6	23.7
S1.003	45.78	5.13	50.766	0.000	5.0	0.0	0.0	1.00	17.8	5.0
S1.004	44.72	5.42	50.687	0.000	5.0	0.0	0.0	1.00	17.8	5.0
S1.005	44.38	5.52	50.513	0.000	5.0	0.0	0.0	1.00	17.8	5.0
S1.006	42.27	6.16	50.454	0.000	5.0	0.0	0.0	1.00	17.8	5.0

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
S1.007	9.299	0.093	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)
S1.007	41.79	6.31	50.068	0.000	5.0	0.0	0.0	1.00	17.8	5.0

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)
S1.007	S	53.700	49.975	50.000	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	1
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)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.352		

Online Controls for Storm

Hydro-Brake® Optimum Manhole: S4, DS/PN: S1.003, Volume (m³): 6.3

Unit Reference	MD-SHE-0100-5000-1350-5000
Design Head (m)	1.350
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	100
Invert Level (m)	50.766
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.350	5.0
Flush-Flo™	0.400	5.0
Kick-Flo®	0.829	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	4.7	3.000	7.3	7.000	10.9
0.200	4.6	1.400	5.1	3.500	7.8	7.500	11.2
0.300	4.9	1.600	5.4	4.000	8.3	8.000	11.6
0.400	5.0	1.800	5.7	4.500	8.8	8.500	11.9
0.500	5.0	2.000	6.0	5.000	9.2	9.000	12.2
0.600	4.8	2.200	6.3	5.500	9.7	9.500	12.6
0.800	4.2	2.400	6.5	6.000	10.1		
1.000	4.4	2.600	6.8	6.500	10.5		

Storage Structures for Storm

Infiltration Trench Manhole: S4, DS/PN: S1.003

Infiltration Coefficient Base (m/hr)	0.00000	Trench Width (m)	10.0
Infiltration Coefficient Side (m/hr)	0.00000	Trench Length (m)	106.0
Safety Factor	2.0	Slope (1:X)	175.0
Porosity	0.30	Cap Volume Depth (m)	0.000
Invert Level (m)	50.766	Cap Infiltration Depth (m)	0.600

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 Storage Structures	1
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 0.352
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	ON
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)	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)
S1.000	S1	15 Winter	1	+0%	100/15 Summer				52.258
S1.001	S2	15 Winter	1	+0%	30/15 Summer				51.172
S1.002	S3	15 Winter	1	+0%	30/15 Summer				51.055
S1.003	S4	60 Winter	1	+0%	1/15 Summer				51.017
S1.004	S5	60 Winter	1	+0%					50.742
S1.005	S6	60 Winter	1	+0%					50.571
S1.006	S7	60 Winter	1	+0%					50.508
S1.007	S8	60 Winter	1	+0%					50.125

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
S1.000	S1	-0.187	0.000	0.07			7.2	OK	
S1.001	S2	-0.136	0.000	0.32			11.1	OK	
S1.002	S3	-0.094	0.000	0.63			21.5	OK	

1 year Return Period 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
S1.003	S4	0.101	0.000	0.31		44	4.8	SURCHARGED	
S1.004	S5	-0.095	0.000	0.29			4.8	OK	
S1.005	S6	-0.091	0.000	0.33			4.8	OK	
S1.006	S7	-0.096	0.000	0.28			4.8	OK	
S1.007	S8	-0.093	0.000	0.31			4.8	OK	

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 Storage Structures	1
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 0.352
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	ON
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)	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)
S1.000	S1	15 Winter	30	+0%	100/15 Summer				52.281
S1.001	S2	15 Winter	30	+0%	30/15 Summer				51.605
S1.002	S3	15 Winter	30	+0%	30/15 Summer				51.498
S1.003	S4	120 Winter	30	+0%	1/15 Summer				51.235
S1.004	S5	480 Winter	30	+0%					50.743
S1.005	S6	360 Winter	30	+0%					50.573
S1.006	S7	360 Winter	30	+0%					50.509
S1.007	S8	480 Summer	30	+0%					50.126

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
S1.000	S1	-0.164	0.000	0.16			17.5	OK	
S1.001	S2	0.297	0.000	0.81			27.8	SURCHARGED	
S1.002	S3	0.349	0.000	1.66			56.9	SURCHARGED	

30 year Return Period 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
S1.003	S4	0.319	0.000	0.32		110	5.0	SURCHARGED	
S1.004	S5	-0.094	0.000	0.30			5.0	OK	
S1.005	S6	-0.090	0.000	0.34			5.0	OK	
S1.006	S7	-0.095	0.000	0.29			5.0	OK	
S1.007	S8	-0.092	0.000	0.32			5.0	OK	

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 Storage Structures	1
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	0.352
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	ON
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)	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)
S1.000	S1	15 Winter	100	+40%	100/15 Summer				52.793
S1.001	S2	15 Winter	100	+40%	30/15 Summer				52.717
S1.002	S3	15 Winter	100	+40%	30/15 Summer				52.423
S1.003	S4	240 Winter	100	+40%	1/15 Summer				51.500
S1.004	S5	960 Winter	100	+40%					50.743
S1.005	S6	2160 Summer	100	+40%					50.573
S1.006	S7	2160 Summer	100	+40%					50.509
S1.007	S8	2160 Summer	100	+40%					50.126

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
S1.000	S1	0.348	0.000	0.30			31.9	FLOOD RISK	
S1.001	S2	1.409	0.000	1.39			47.7	SURCHARGED	
S1.002	S3	1.274	0.000	2.79			95.6	SURCHARGED	
S1.003	S4	0.583	0.000	0.32			5.0	SURCHARGED	
S1.004	S5	-0.094	0.000	0.30			5.0	OK	
S1.005	S6	-0.090	0.000	0.34			5.0	OK	
S1.006	S7	-0.095	0.000	0.29			5.0	OK	
S1.007	S8	-0.092	0.000	0.32			5.0	OK	