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	0.317	Minimum Backdrop Height (m)	0.000
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	0.419	4-8	0.074

Total Area Contributing (ha) = 0.493

Total Pipe Volume (m³) = 9.424

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	35.269	2.350	15.0	0.085	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	38.672	2.500	15.5	0.210	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.002	9.367	0.550	17.0	0.167	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.003	11.044	0.900	12.3	0.031	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.004	9.566	0.900	10.6	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.005	10.580	0.050	211.6	0.000	0.00	0.0	0.600	o	600	Pipe/Conduit	
1.006	10.071	0.140	71.9	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)
1.000	50.00	5.17	115.375	0.085	0.0	0.0	0.0	3.40	135.0	11.5
1.001	50.00	5.33	112.950	0.295	0.0	0.0	0.0	4.02	284.0	39.9
1.002	50.00	5.37	110.450	0.462	0.0	0.0	0.0	3.83	270.6	62.6
1.003	50.00	5.42	109.900	0.493	0.0	0.0	0.0	4.51	319.0	66.8
1.004	50.00	5.45	109.000	0.493	0.0	0.0	0.0	4.85	342.8	66.8
1.005	50.00	5.55	107.000	0.493	0.0	0.0	0.0	1.67	472.2	66.8
1.006	50.00	5.70	106.900	0.493	0.0	0.0	0.0	1.19	21.0«	66.8

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)
2	116.800	1.425	Open Manhole	1200	1.000	115.375	225				
3	115.050	2.100	Open Manhole	1200	1.001	112.950	300	1.000	113.025	225	
4	112.250	1.800	Open Manhole	1200	1.002	110.450	300	1.001	110.450	300	
5	111.450	1.550	Open Manhole	1200	1.003	109.900	300	1.002	109.900	300	
6	110.750	1.750	Open Manhole	1200	1.004	109.000	300	1.003	109.000	300	
7	110.800	3.800	Open Manhole	1500	1.005	107.000	600	1.004	108.100	300	800
8	110.200	3.300	Open Manhole	1500	1.006	106.900	150	1.005	106.950	600	500
	111.340	4.580	Open Manhole	0		OUTFALL		1.006	106.760	150	

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	2	116.800	115.375	1.200	Open Manhole	1200
1.001	o	300	3	115.050	112.950	1.800	Open Manhole	1200
1.002	o	300	4	112.250	110.450	1.500	Open Manhole	1200
1.003	o	300	5	111.450	109.900	1.250	Open Manhole	1200
1.004	o	300	6	110.750	109.000	1.450	Open Manhole	1200
1.005	o	600	7	110.800	107.000	3.200	Open Manhole	1500
1.006	o	150	8	110.200	106.900	3.150	Open Manhole	1500

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	35.269	15.0	3	115.050	113.025	1.800	Open Manhole	1200
1.001	38.672	15.5	4	112.250	110.450	1.500	Open Manhole	1200
1.002	9.367	17.0	5	111.450	109.900	1.250	Open Manhole	1200
1.003	11.044	12.3	6	110.750	109.000	1.450	Open Manhole	1200
1.004	9.566	10.6	7	110.800	108.100	2.400	Open Manhole	1500
1.005	10.580	211.6	8	110.200	106.950	2.650	Open Manhole	1500
1.006	10.071	71.9		111.340	106.760	4.430	Open Manhole	0

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	2	225	1.200	1.800	Unclassified	1200	0	1.200	Unclassified
1.001	3	300	1.500	1.800	Unclassified	1200	0	1.800	Unclassified
1.002	4	300	1.250	1.500	Unclassified	1200	0	1.500	Unclassified
1.003	5	300	1.250	1.450	Unclassified	1200	0	1.250	Unclassified
1.004	6	300	1.450	2.400	Unclassified	1200	0	1.450	Unclassified
1.005	7	600	2.650	3.200	Unclassified	1500	0	3.200	Unclassified
1.006	8	150	3.150	4.430	Unclassified	1500	0	3.150	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		111.340	106.760	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	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 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	0.317		

Online Controls for Storm

Hydro-Brake® Optimum Manhole: 8, DS/PN: 1.006, Volume (m³): 8.4

Unit Reference	MD-SHE-0081-5000-3300-5000
Design Head (m)	3.300
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	81
Invert Level (m)	106.900
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)	3.300	5.0	Kick-Flo®	0.723	2.5
Flush-Flo™	0.349	3.1	Mean Flow over Head Range	-	3.6

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	2.4	0.800	2.6	2.000	4.0	4.000	5.5	7.000	7.1
0.200	3.0	1.000	2.9	2.200	4.1	4.500	5.8	7.500	7.4
0.300	3.1	1.200	3.1	2.400	4.3	5.000	6.1	8.000	7.6
0.400	3.1	1.400	3.4	2.600	4.5	5.500	6.4	8.500	7.8
0.500	3.0	1.600	3.6	3.000	4.8	6.000	6.6	9.000	8.0
0.600	2.9	1.800	3.8	3.500	5.1	6.500	6.9	9.500	8.2

Storage Structures for Storm

Tank or Pond Manhole: 7, DS/PN: 1.005

Invert Level (m) 107.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	170.0	2.500	170.0	2.501	0.0

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	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 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	M5-60 (mm) 19.000	Cv (Summer) 0.750
Region	England and Wales	Ratio R 0.317	Cv (Winter) 0.850

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760
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)	Surcharged Depth (m)
1.000	2	15 Winter	1	+30%					115.424	-0.176
1.001	3	15 Winter	1	+30%					113.031	-0.219
1.002	4	15 Winter	1	+30%	30/15 Summer				110.573	-0.177
1.003	5	15 Winter	1	+30%	100/15 Summer				110.011	-0.189
1.004	6	15 Winter	1	+30%	100/15 Summer				109.111	-0.189
1.005	7	360 Winter	1	+30%	30/30 Winter				107.418	-0.182
1.006	8	360 Winter	1	+30%	1/15 Summer				107.466	0.416

PN	US/MH Name	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	2	0.000	0.11		13.7	OK	
1.001	3	0.000	0.16		42.3	OK	
1.002	4	0.000	0.35		64.7	OK	
1.003	5	0.000	0.29		68.9	OK	
1.004	6	0.000	0.29		69.3	OK	
1.005	7	0.000	0.05		16.1	OK	
1.006	8	0.000	0.17		3.1	SURCHARGED	

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	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 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	M5-60 (mm) 19.000	Cv (Summer) 0.750
Region	England and Wales	Ratio R 0.317	Cv (Winter) 0.850

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760
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)	Surcharged Depth (m)
1.000	2	15 Winter	30	+30%					115.454	-0.146
1.001	3	15 Winter	30	+30%					113.094	-0.156
1.002	4	15 Winter	30	+30%	30/15 Summer				110.777	0.027
1.003	5	15 Winter	30	+30%	100/15 Summer				110.116	-0.084
1.004	6	15 Winter	30	+30%	100/15 Summer				109.215	-0.085
1.005	7	480 Winter	30	+30%	30/30 Winter				108.259	0.659
1.006	8	360 Winter	30	+30%	1/15 Summer				108.424	1.374

PN	US/MH Name	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	2	0.000	0.26		33.5	OK	
1.001	3	0.000	0.46		121.7	OK	
1.002	4	0.000	1.03		191.2	SURCHARGED	
1.003	5	0.000	0.86		203.4	OK	
1.004	6	0.000	0.85		202.3	OK	
1.005	7	0.000	0.03		9.2	SURCHARGED	
1.006	8	0.000	0.17		3.2	SURCHARGED	

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	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 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	M5-60 (mm) 19.000	Cv (Summer) 0.750
Region	England and Wales	Ratio R 0.317	Cv (Winter) 0.850

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760
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)	Surcharged Depth (m)
1.000	2	15 Winter	100	+30%					115.466	-0.134
1.001	3	15 Winter	100	+30%					113.118	-0.132
1.002	4	15 Winter	100	+30%	30/15 Summer				111.370	0.620
1.003	5	15 Winter	100	+30%	100/15 Summer				110.431	0.231
1.004	6	15 Winter	100	+30%	100/15 Summer				109.396	0.096
1.005	7	600 Winter	100	+30%	30/30 Winter				108.713	1.113
1.006	8	720 Winter	100	+30%	1/15 Summer				108.837	1.787

PN	US/MH Name	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	2	0.000	0.34		43.3	OK	
1.001	3	0.000	0.60		157.2	OK	
1.002	4	0.000	1.29		239.3	SURCHARGED	
1.003	5	0.000	1.06		252.4	SURCHARGED	
1.004	6	0.000	1.06		252.6	SURCHARGED	
1.005	7	0.000	0.03		8.1	SURCHARGED	
1.006	8	0.000	0.20		3.7	SURCHARGED	