STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FEH Rainfall Model

Return Period (years)	2
FEH Rainfall Version	1999
Site Location	GB 528900 324900 TF 28900 24900
C (1km)	-0.023
D1 (1km)	0.319
D2 (1km)	0.274
D3 (1km)	0.232
E (1km)	0.316
F (1km)	2.482
Maximum Rainfall (mm/hr)	100
Maximum Time of Concentration (mins)	100
Foul Sewage (l/s/ha)	0.000
Volumetric Runoff Coeff.	0.750
PIMP (%)	100
Add Flow / Climate Change (%)	0
Minimum Backdrop Height (m)	0.200
Maximum Backdrop Height (m)	1.500
Min Design Depth for Optimisation (m)	1.200
Min Vel for Auto Design only (m/s)	1.00
Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for Storm at outfall (pipe 1.002)

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.054	4-8	0.004

Total Area Contributing (ha) = 0.057

Total Pipe Volume (m^3) = 14.902

Time Area Diagram at outfall (pipe 3.002)

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.056	4-8	0.002

Total Area Contributing (ha) = 0.058

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Time Area Diagram at outfall (pipe 3.002)

Total Pipe Volume (m^3) = 15.337

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
1.000	18.008	0.036	500.2	0.009	4.00	0.0	0.600	oo	450	Double Pipe	
2.000	12.923	0.026	497.0	0.000	4.00	0.0	0.600	o	450	Pipe/Conduit	
1.001	21.989#	0.044	499.8	0.000	0.00	0.0	0.600	oo	450	Double Pipe	
1.002	7.003	0.045	155.6	0.049	0.00	0.0	0.600	o	150	Pipe/Conduit	
3.000	18.250	0.037	493.2	0.008	4.00	0.0	0.600	oo	450	Double Pipe	
4.000	10.525	0.021	501.2	0.000	4.00	0.0	0.600	o	450	Pipe/Conduit	
3.001	24.549	0.049	501.0	0.000	0.00	0.0	0.600	oo	450	Double Pipe	
3.002	2.768#	0.019	145.7	0.050	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	93.01	4.33	1.735	0.009	0.0	0.0	0.0	0.90	287.0	2.2
2.000	94.45	4.24	1.725	0.000	0.0	0.0	0.0	0.91	144.0	0.0
1.001	87.38	4.74	1.699	0.009	0.0	0.0	0.0	0.90	287.1	2.2
1.002	85.56	4.88	1.655	0.057	0.0	0.0	0.0	0.80	14.2	13.3
3.000	92.98	4.33	1.975	0.008	0.0	0.0	0.0	0.91	289.0	2.1
4.000	95.13	4.19	1.959	0.000	0.0	0.0	0.0	0.90	143.3	0.0
3.001	86.75	4.79	1.938	0.008	0.0	0.0	0.0	0.90	286.7	2.1
3.002	86.05	4.84	1.889	0.058	0.0	0.0	0.0	0.83	14.7	13.5

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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	3.075	1.340	Open Manhole	1500 x 900	1.000	1.735	450				
2	2.913	1.188	Open Manhole	900 x 900	2.000	1.725	450				
3	2.925	1.226	Open Manhole	1500 x 900	1.001	1.699	450	1.000	1.699	450	
								2.000	1.699	450	
4	2.775	1.120	Open Manhole	1500 x 2400	1.002	1.655	150	1.001	1.655	450	
	2.825	1.215	Open Manhole	0		OUTFALL		1.002	1.610	150	
6	3.113	1.138	Open Manhole	1500 x 900	3.000	1.975	450				
7	3.050	1.091	Open Manhole	900 x 900	4.000	1.959	450				
8	3.013	1.075	Open Manhole	1500 x 900	3.001	1.938	450	3.000	1.938	450	
								4.000	1.938	450	
9	2.933	1.044	Open Manhole	1500 x 2400	3.002	1.889	150	3.001	1.889	450	
	2.950	1.080	Open Manhole	0		OUTFALL		3.002	1.870	150	

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PIPELINE SCHEDULES for Storm

Upstream Manhole

- Indicates pipe length does not match coordinates

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	oo	450	1	3.075	1.735	0.890	Open Manhole	1500 x 900
2.000	o	450	2	2.913	1.725	0.738	Open Manhole	900 x 900
1.001	oo	450	3	2.925	1.699	0.776	Open Manhole	1500 x 900
1.002	o	150	4	2.775	1.655	0.970	Open Manhole	1500 x 2400
3.000	oo	450	6	3.113	1.975	0.688	Open Manhole	1500 x 900
4.000	o	450	7	3.050	1.959	0.641	Open Manhole	900 x 900
3.001	oo	450	8	3.013	1.938	0.625	Open Manhole	1500 x 900
3.002	o	150	9	2.933	1.889	0.894	Open Manhole	1500 x 2400

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	18.008	500.2	3	2.925	1.699	0.776	Open Manhole	1500 x 900
2.000	12.923	497.0	3	2.925	1.699	0.776	Open Manhole	1500 x 900
1.001	21.989#	499.8	4	2.775	1.655	0.670	Open Manhole	1500 x 2400
1.002	7.003	155.6		2.825	1.610	1.065	Open Manhole	0
3.000	18.250	493.2	8	3.013	1.938	0.625	Open Manhole	1500 x 900
4.000	10.525	501.2	8	3.013	1.938	0.625	Open Manhole	1500 x 900
3.001	24.549	501.0	9	2.933	1.889	0.594	Open Manhole	1500 x 2400
3.002	2.768#	145.7		2.950	1.870	0.930	Open Manhole	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)
1.002		2.825	1.610	1.608	0	0

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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)
3.002		2.950	1.870	1.870	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 2	Number of Storage Structures 0	Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	1999
Site Location	GB 528900 324900 TF 28900 24900
C (1km)	-0.023
D1 (1km)	0.319
D2 (1km)	0.274
D3 (1km)	0.232
E (1km)	0.316
F (1km)	2.482
Summer Storms	Yes
Winter Storms	No
Cv (Summer)	0.750
Cv (Winter)	0.840
Storm Duration (mins)	30

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: 4, DS/PN: 1.002, Volume (m³): 10.5

Unit Reference	MD-SHE-0093-4000-1125-4000
Design Head (m)	1.125
Design Flow (l/s)	4.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	93
Invert Level (m)	1.655
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.125	4.0	Kick-Flo®	0.696	3.2
Flush-Flo™	0.331	4.0	Mean Flow over Head Range	-	3.5

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	2.9	1.200	4.1	3.000	6.3	7.000	9.4
0.200	3.8	1.400	4.4	3.500	6.8	7.500	9.7
0.300	4.0	1.600	4.7	4.000	7.2	8.000	10.0
0.400	4.0	1.800	5.0	4.500	7.6	8.500	10.3
0.500	3.9	2.000	5.2	5.000	8.0	9.000	10.6
0.600	3.7	2.200	5.5	5.500	8.4	9.500	10.9
0.800	3.4	2.400	5.7	6.000	8.8		
1.000	3.8	2.600	5.9	6.500	9.1		

Hydro-Brake® Optimum Manhole: 9, DS/PN: 3.002, Volume (m³): 11.1

Unit Reference	MD-SHE-0094-4000-1042-4000
Design Head (m)	1.042
Design Flow (l/s)	4.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	94
Invert Level (m)	1.889
Minimum Outlet Pipe Diameter (mm)	150

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Hydro-Brake® Optimum Manhole: 9, DS/PN: 3.002, Volume (m³): 11.1

Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.042	4.0	Kick-Flo®	0.652	3.2
Flush-Flo™	0.307	4.0	Mean Flow over Head Range	-	3.5

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	3.0	1.200	4.3	3.000	6.5	7.000	9.8
0.200	3.9	1.400	4.6	3.500	7.0	7.500	10.1
0.300	4.0	1.600	4.9	4.000	7.5	8.000	10.4
0.400	3.9	1.800	5.2	4.500	7.9	8.500	10.7
0.500	3.8	2.000	5.4	5.000	8.3	9.000	11.0
0.600	3.5	2.200	5.7	5.500	8.7	9.500	11.3
0.800	3.5	2.400	5.9	6.000	9.1		
1.000	3.9	2.600	6.1	6.500	9.4		

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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	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 2 Number of Storage Structures 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.400
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 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Summer and Winter
Duration(s) (mins)	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)
1.000	1	60 Summer	1	+0%					1.765
2.000	2	60 Summer	1	+0%					1.763
1.001	3	60 Summer	1	+0%					1.763
1.002	4	60 Summer	1	+0%	30/60 Summer				1.763
3.000	6	60 Summer	1	+0%					2.001
4.000	7	60 Summer	1	+0%					1.997
3.001	8	60 Summer	1	+0%					1.998
3.002	9	60 Summer	1	+0%	30/60 Summer				1.997

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.420	0.000	0.00		0.7	OK	

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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 (m^3)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
2.000	2	-0.412	0.000	0.00		0.1	OK	
1.001	3	-0.386	0.000	0.00		0.8	OK	
1.002	4	-0.042	0.000	0.26		3.1	OK	
3.000	6	-0.424	0.000	0.00		0.7	OK	
4.000	7	-0.412	0.000	0.00		0.1	OK	
3.001	8	-0.390	0.000	0.00		0.8	OK	
3.002	9	-0.042	0.000	0.29		3.1	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	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 2 Number of Storage Structures 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.400
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 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Summer and Winter
Duration(s) (mins)	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)
1.000	1	60 Winter	30	+0%					1.887
2.000	2	60 Winter	30	+0%					1.887
1.001	3	60 Winter	30	+0%					1.887
1.002	4	60 Winter	30	+0%	30/60 Summer				1.887
3.000	6	60 Winter	30	+0%					2.122
4.000	7	60 Winter	30	+0%					2.122
3.001	8	60 Winter	30	+0%					2.122
3.002	9	60 Winter	30	+0%	30/60 Summer				2.122

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.298	0.000	0.01		1.3	OK	

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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 (m^3)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
2.000	2	-0.288	0.000	0.00		0.1	OK	
1.001	3	-0.262	0.000	0.01		1.9	OK	
1.002	4	0.082	0.000	0.32		3.9	SURCHARGED	
3.000	6	-0.303	0.000	0.01		1.2	OK	
4.000	7	-0.287	0.000	0.00		0.1	OK	
3.001	8	-0.266	0.000	0.01		1.7	OK	
3.002	9	0.083	0.000	0.36		3.9	SURCHARGED	

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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	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 2 Number of Storage Structures 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.400
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 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Summer and Winter
Duration(s) (mins)	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)
1.000	1	60 Winter	100	+40%					2.104
2.000	2	60 Winter	100	+40%					2.104
1.001	3	60 Winter	100	+40%					2.104
1.002	4	60 Winter	100	+40%	30/60 Summer				2.104
3.000	6	60 Winter	100	+40%					2.338
4.000	7	60 Winter	100	+40%					2.337
3.001	8	60 Winter	100	+40%					2.338
3.002	9	60 Winter	100	+40%	30/60 Summer				2.338

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.081	0.000	0.01		2.3	OK	

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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 (m^3)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
2.000	2	-0.071	0.000	0.00		0.1	OK	
1.001	3	-0.045	0.000	0.01		2.3	OK	
1.002	4	0.299	0.000	0.33		4.0	SURCHARGED	
3.000	6	-0.087	0.000	0.01		2.1	OK	
4.000	7	-0.072	0.000	0.00		0.1	OK	
3.001	8	-0.050	0.000	0.01		2.2	OK	
3.002	9	0.299	0.000	0.37		4.0	SURCHARGED	

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