## 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) | 20.600 | Add Flow / Climate Change (%) | 0 |
| Ratio R | 0.437 | 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 | 0.133 | 4-8 | 0.054 |

Total Area Contributing (ha) = 0.187

Total Pipe Volume (m³) = 3.855

### 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 | 9.000 | 0.113 | 80.0 | 0.011 | 5.00 | 0.0 | 0.600 | o | 100 | Pipe/Conduit | |
| 1.001 | 10.000 | 0.125 | 80.0 | 0.006 | 0.00 | 0.0 | 0.600 | o | 150 | Pipe/Conduit | |
| 1.002 | 10.000 | 0.125 | 80.0 | 0.003 | 0.00 | 0.0 | 0.600 | o | 150 | Pipe/Conduit | |
| 1.003 | 9.500 | 0.119 | 80.0 | 0.013 | 0.00 | 0.0 | 0.600 | o | 150 | Pipe/Conduit | |
| 1.004 | 15.500 | 0.194 | 79.9 | 0.025 | 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 | 30.645 | 0.011 | 0.0 | 0.0 | 0.0 | 0.86 | 6.8 | 1.5 |
| 1.001 | 50.00 | 5.32 | 30.483 | 0.017 | 0.0 | 0.0 | 0.0 | 1.12 | 19.9 | 2.3 |
| 1.002 | 50.00 | 5.47 | 30.358 | 0.020 | 0.0 | 0.0 | 0.0 | 1.12 | 19.9 | 2.7 |
| 1.003 | 50.00 | 5.61 | 30.233 | 0.033 | 0.0 | 0.0 | 0.0 | 1.12 | 19.9 | 4.5 |
| 1.004 | 50.00 | 5.84 | 30.114 | 0.058 | 0.0 | 0.0 | 0.0 | 1.13 | 19.9 | 7.9 |

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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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.000 | 21.500 | 0.215 | 100.0 | 0.027 | 5.00 | 0.0 | 0.600 | o | 150 | Pipe/Conduit | |
| 2.001 | 20.000 | 0.123 | 162.0 | 0.024 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 2.002 | 3.000 | 0.015 | 200.0 | 0.000 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 1.005 | 11.500 | 0.058 | 200.0 | 0.025 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 1.006 | 9.500 | 0.048 | 200.0 | 0.012 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 1.007 | 2.000 | 0.010 | 200.0 | 0.000 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 1.008 | 10.000 | 0.020 | 500.0 | 0.012 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 1.009 | 2.700 | 0.027 | 100.0 | 0.000 | 0.00 | 0.0 | 0.600 | o | 225 | Pipe/Conduit | |
| 3.000 | 10.600 | 0.177 | 60.0 | 0.008 | 5.00 | 0.0 | 0.600 | o | 100 | Pipe/Conduit | |
| 3.001 | 6.500 | 0.325 | 20.0 | 0.021 | 0.00 | 0.0 | 0.600 | o | 100 | Pipe/Conduit | |
| 1.010 | 8.000 | 0.080 | 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.000 | 50.00 | 5.36 | 30.273 | 0.027 | 0.0 | 0.0 | 0.0 | 1.00 | 17.8 | 3.7 |
| 2.001 | 50.00 | 5.68 | 29.983 | 0.051 | 0.0 | 0.0 | 0.0 | 1.02 | 40.7 | 6.9 |
| 2.002 | 50.00 | 5.74 | 29.860 | 0.051 | 0.0 | 0.0 | 0.0 | 0.92 | 36.6 | 6.9 |
| 1.005 | 50.00 | 6.05 | 29.845 | 0.134 | 0.0 | 0.0 | 0.0 | 0.92 | 36.6 | 18.1 |
| 1.006 | 50.00 | 6.22 | 29.787 | 0.146 | 0.0 | 0.0 | 0.0 | 0.92 | 36.6 | 19.8 |
| 1.007 | 50.00 | 6.26 | 29.740 | 0.146 | 0.0 | 0.0 | 0.0 | 0.92 | 36.6 | 19.8 |
| 1.008 | 50.00 | 6.55 | 29.730 | 0.158 | 0.0 | 0.0 | 0.0 | 0.58 | 23.0 | 21.4 |
| 1.009 | 50.00 | 6.58 | 29.710 | 0.158 | 0.0 | 0.0 | 0.0 | 1.31 | 52.0 | 21.4 |
| 3.000 | 50.00 | 5.18 | 30.184 | 0.008 | 0.0 | 0.0 | 0.0 | 1.00 | 7.8 | 1.1 |
| 3.001 | 50.00 | 5.24 | 30.007 | 0.029 | 0.0 | 0.0 | 0.0 | 1.73 | 13.6 | 3.9 |
| 1.010 | 50.00 | 6.71 | 0.000 | 0.187 | 0.0 | 0.0 | 0.0 | 1.00 | 17.8« | 25.3 |

## 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) |
|---|---|---|---|---|---|---|
| 1.010 | | 31.390 | -0.080 | 0.000 | 0 | 0 |

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## 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 | 2 |
| 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) | 2 | Cv (Summer) | 0.750 |
| Region | England and Wales | Cv (Winter) | 0.840 |
| M5-60 (mm) | 20.600 | Storm Duration (mins) | 30 |
| Ratio R | 0.437 | | |

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## Online Controls for Storm

### Hydro-Brake® Optimum Manhole: 16, DS/PN: 1.010, Volume (m³): 35.6

| | |
|---|---|
| Unit Reference | MD-SHE-0078-2600-0900-2600 |
| Design Head (m) | 0.900 |
| Design Flow (l/s) | 2.6 |
| Flush-Flo™ | Calculated |
| Objective | Minimise upstream storage |
| Application | Surface |
| Sump Available | Yes |
| Diameter (mm) | 78 |
| Invert Level (m) | 29.682 |
| Minimum Outlet Pipe Diameter (mm) | 100 |
| Suggested Manhole Diameter (mm) | 1200 |

| Control Points | Head (m) | Flow (l/s) |
|---|---|---|
| Design Point (Calculated) | 0.900 | 2.6 |
| Flush-Flo™ | 0.271 | 2.6 |
| Kick-Flo® | 0.569 | 2.1 |
| 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) |
|---|---|---|---|---|---|---|---|
| 0.100 | 2.2 | 1.200 | 3.0 | 3.000 | 4.5 | 7.000 | 6.8 |
| 0.200 | 2.6 | 1.400 | 3.2 | 3.500 | 4.9 | 7.500 | 7.0 |
| 0.300 | 2.6 | 1.600 | 3.4 | 4.000 | 5.2 | 8.000 | 7.2 |
| 0.400 | 2.5 | 1.800 | 3.6 | 4.500 | 5.5 | 8.500 | 7.4 |
| 0.500 | 2.4 | 2.000 | 3.8 | 5.000 | 5.8 | 9.000 | 7.6 |
| 0.600 | 2.2 | 2.200 | 3.9 | 5.500 | 6.0 | 9.500 | 7.8 |
| 0.800 | 2.5 | 2.400 | 4.1 | 6.000 | 6.3 | | |
| 1.000 | 2.7 | 2.600 | 4.2 | 6.500 | 6.5 | | |

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## Storage Structures for Storm

### Cellular Storage Manhole: 8, DS/PN: 2.002

Invert Level (m) 29.860 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 | 78.0 | 78.0 | 0.900 | 0.0 | 111.0 |
| 0.800 | 78.0 | 111.0 | | | |

### Cellular Storage Manhole: 13, DS/PN: 1.009

Invert Level (m) 29.710 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 | 56.3 | 56.3 | 0.900 | 0.0 | 83.5 |
| 0.800 | 56.3 | 83.5 | | | |

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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 2
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 0.437
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 20.600 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) 100
Climate Change (%) 45

| 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 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.960 |
| 1.001 | 2 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.861 |
| 1.002 | 3 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.830 |
| 1.003 | 4 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.792 |
| 1.004 | 5 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.686 |
| 2.000 | 6 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.454 |
| 2.001 | 7 | 360 Winter | 100 | +45% | 100/30 Winter | | | | 30.351 |
| 2.002 | 8 | 360 Winter | 100 | +45% | 100/15 Summer | | | | 30.349 |
| 1.005 | 9 | 360 Winter | 100 | +45% | 100/15 Summer | | | | 30.349 |
| 1.006 | 10 | 360 Winter | 100 | +45% | 100/15 Summer | | | | 30.347 |
| 1.007 | 11 | 360 Winter | 100 | +45% | 100/15 Summer | | | | 30.344 |
| 1.008 | 12 | 360 Winter | 100 | +45% | 100/15 Summer | | | | 30.343 |
| 1.009 | 13 | 360 Winter | 100 | +45% | 100/15 Winter | | | | 30.341 |
| 3.000 | 14 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.508 |
| 3.001 | 15 | 15 Winter | 100 | +45% | 100/15 Summer | | | | 30.428 |
| 1.010 | 16 | 360 Winter | 100 | +45% | 100/15 Summer | | | | 30.349 |

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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 |
|---|---|---|---|---|---|---|---|---|---|
| 1.000 | 1 | 0.215 | 0.000 | 1.00 | | | 6.3 | SURCHARGED | |
| 1.001 | 2 | 0.228 | 0.000 | 0.56 | | | 9.8 | SURCHARGED | |
| 1.002 | 3 | 0.323 | 0.000 | 0.70 | | | 12.4 | SURCHARGED | |
| 1.003 | 4 | 0.410 | 0.000 | 1.02 | | | 17.9 | SURCHARGED | |
| 1.004 | 5 | 0.422 | 0.000 | 1.67 | | | 30.7 | SURCHARGED | |
| 2.000 | 6 | 0.031 | 0.000 | 1.07 | | | 18.0 | SURCHARGED | |
| 2.001 | 7 | 0.143 | 0.000 | 0.12 | | | 4.4 | SURCHARGED | |
| 2.002 | 8 | 0.265 | 0.000 | 0.11 | | 275 | 2.9 | SURCHARGED | |
| 1.005 | 9 | 0.279 | 0.000 | 0.29 | | | 9.0 | SURCHARGED | |
| 1.006 | 10 | 0.335 | 0.000 | 0.33 | | | 9.9 | SURCHARGED | |
| 1.007 | 11 | 0.380 | 0.000 | 0.34 | | | 9.7 | SURCHARGED | |
| 1.008 | 12 | 0.388 | 0.000 | 0.71 | | | 10.6 | SURCHARGED | |
| 1.009 | 13 | 0.406 | 0.000 | 0.31 | | 338 | 9.3 | SURCHARGED | |
| 3.000 | 14 | 0.224 | 0.000 | 0.80 | | | 5.8 | SURCHARGED | |
| 3.001 | 15 | 0.321 | 0.000 | 1.40 | | | 17.2 | SURCHARGED | |
| 1.010 | 16 | 30.199 | 0.000 | 0.17 | | | 2.6 | SURCHARGED | |

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