



Consulting Civil Engineers

## **SuDS Maintenance and Management Plan**

**283-285a Chichester Road, Bognor Regis**

**For**

**Mr Jason Weller**

Rev -

Reference **C1113**

Date **6<sup>th</sup> November 2019**

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## 1. Introduction

CGS Civils Ltd have been appointed to undertake a drainage design using sustainable techniques for a proposed development in Chichester Road, Bognor Regis.

The site will consist of the development of a new block of flats which is to be constructed in an existing courtyard. The new block of flats will consist of 6 no. 2 bedroom flats and 2 no. 1 bedroom flats. A new access road is to be constructed, which will replace the existing access road. Car parking areas and foot access is to be constructed also.

## 2. Sustainable Drainage Systems (SuDS)

The surface water management strategy has been developed using best practice Sustainable Drainage Systems (SuDS) techniques. Guidance on suitable techniques and methods has been obtained from the EA, and the SuDS manual (CIRIA C753).

The National Planning Policy Framework (NPPF) recognises that flood risk and other environmental damage can be managed by minimising changes in the volume and rate of surface runoff from development sites and recommends that priority is given to the use of Sustainable Drainage Systems (SuDS) in new development.

The overall philosophy of SuDS is to replicate, as closely as possible, the natural drainage process of a site prior to development to mitigate the adverse effect of storm water runoff on the environment. SuDS not only provide the ability to control surface water flows, but also improve water quality, amenity and bio-diversity within the development.

The Building Regulations Requirement H3 stipulates that rainwater from roofs and paved areas is carried away from the surface to discharge to one of the following, listed in order of priority:

- 1- Discharge into the ground
- 2- Discharge to a surface water body
- 3- Discharge to a surface water sewer

The client will employ a maintenance company to carry out the below tasks to the schedule that is specified. The eventual users/occupants of the buildings will then take on the responsibility of employing the company. This information will be made available at an appropriate time during the scheme but before occupation.

### **3. SuDS at Chichester Road, Bognor Regis**

The British Geological Survey confirms that the bedrock of the site to be Lambeth Group and local boreholes confirm the site to be underlain by Clay and dense sand.

Intrusive ground investigation works on site confirm the presence of clays along with poor soakage test results and high ground water. Infiltration therefore will not work on site. It is therefore proposed to connect the runoff from the roof and external areas into the existing surface water sewer at a restricted rate of 2l/s which is the generally agreed practical minimum. The drainage system will incorporate a geocellular attenuation tank to cater for the 1 in 100-year storm +40%.

Foul water will be discharged into the local foul sewer and this connection and the surface water sewer will require approval from Southern Water prior to construction.

### **4. Managing SuDS**

The SuDS have been designed for easy maintenance and comprise:

- Regular day-to-day care – litter collection, regular gardening to control vegetation growth and checking inlets where water enters the SuDS feature
- Occasional tasks – checking the SUDS feature and removing any silt that builds up in the SuDS feature
- Remedial work – repairing damage where necessary

## 5. SuDS Drainage Maintenance Specification

### 5.1. Attenuation Tank

In order to maintain the functioning of the attenuation tanks, the following maintenance requirements should be adhered to:

**TABLE 21.3** Operation and maintenance requirements for attenuation storage tanks

| Maintenance schedule | Required action                                                                                                                                                                                        | Typical frequency                   |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| Regular maintenance  | Inspect and identify any areas that are not operating correctly. If required, take remedial action                                                                                                     | Monthly for 3 months, then annually |
|                      | Remove debris from the catchment surface (where it may cause risks to performance)                                                                                                                     | Monthly                             |
|                      | For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary. | Annually                            |
|                      | Remove sediment from pre-treatment structures and/or internal forebays                                                                                                                                 | Annually, or as required            |
| Remedial actions     | Repair/rehabilitate inlets, outlet, overflows and vents                                                                                                                                                | As required                         |
| Monitoring           | Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed                                                                             | Annually                            |
|                      | Survey inside of tank for sediment build-up and remove if necessary                                                                                                                                    | Every 5 years or as required        |

## 6. General Drainage Maintenance Specification

### 6.1. Inlet Structures and Inspection Chambers

- Inlet structures such as rain water downpipes, road gullies and channel drains should be free from obstruction at all times to allow free flow through the SuDS.
- Inspection Chambers and rodding eyes are used on bends or where pipes come together. They allow access and cleaning to the system if necessary.

| <b>Inlet Structures and Inspection Chambers</b>                                                                                                                                                                                                                                |                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>Regular Maintenance</b>                                                                                                                                                                                                                                                     | <b>Frequency</b> |
| <b>Inlet Structures</b><br><br>Inspect rainwater downpipes, channel drains and road gullies, removing obstructions and silt as necessary. Check that there is no physical damage.<br><br>Trim vegetation 1m min surround to structures and keep area free from silt and debris | Monthly          |
| <b>Inspections Chambers and below ground control chambers</b><br><br>Remove cover and inspect, ensuring that the water is flowing freely and that the exit route for water is unobstructed. Remove debris and silt.<br><br>Undertake inspection after leaf fall in Autumn      | Annually         |
| <b>Occasional Maintenance</b><br><br>Check topsoil levels are 20mm above edges of chambers to avoid mower damage.                                                                                                                                                              | As necessary     |
| <b>Remedial Work</b><br><br>Repair physical damage if necessary                                                                                                                                                                                                                | As required      |

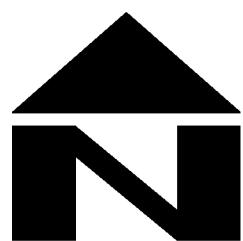
## 6.2. Below ground drainage pipes

- Below ground drainage pipes convey water to the SuDS system. They should always be free from obstruction to allow free flow.

| <b>Below Ground Drainage Pipes</b>                                                                           |                                    |
|--------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>Regular Maintenance</b>                                                                                   | <b>Frequency</b>                   |
| Inspect and identify any areas that are not operating correctly. If required take remedial action.           | Monthly for 3 months then annually |
| Remove debris from the catchment surface (where it may cause risks to performance)                           | Monthly                            |
| Remove sediment from pre-treatment inlet structures and inspection chambers.                                 | Annually or as required            |
| Maintain vegetation to designed limits within the vicinity of below ground drainage pipes and tanks to avoid | Monthly or as required             |
| <b>Remedial Work</b>                                                                                         |                                    |
| Repair physical damage if necessary                                                                          | As required                        |
| <b>Monitoring</b>                                                                                            |                                    |
| Inspect all inlets, outlets and vents to ensure that they are in good conditions and operating as designed.  | Annually                           |
| Survey inside of pipe runs for sediment build up and remove if necessary.                                    | Every 5 years or as required       |

## **Appendix A**

### **Drainage Strategy**



INFORMATIVE

Foul and surface water connection  
subject to approval from Southern  
Water under S106 application

## Drainage Legend (1:100)

### EXISTING FEATURES

- Existing foul water sewer/drain and manhole
- Existing surface water sewer/drain and manhole
- Existing foul/surface water sewer/drain and manhole to be abandoned
- Proposed Features
  - Storm water sewer/drain
  - Channel drain (Hauraton Monotec Type 230 C250)
  - Rainwater pipe
  - Road gully
  - Storm water access chamber (300Ø)
  - Storm water inspection chamber (450Ø)
  - Storm water manhole
  - Storm water vortex flow control chamber
  - Foul water sewer/drain
  - Pipe crossing - Thick line denotes pipe above
  - Soil stack (type TBC by architect/m&e engineer)
  - Foul water access chamber (300Ø)
  - Foul water inspection chamber (450Ø)
  - Foul water trapped gully
  - Finished floor level
  - PIPE INFO - DIAMETER, LENGTH, GRADIENT, BEDDING TYPE
  - ABBREVIATIONS
    - CP - CATCHPIT
    - MH - MANHOLE
    - IC - INSPECTION CHAMBER
    - AC - ACCESS CHAMBER
    - RE - RODDING EYE
    - IL - INVERT LEVEL
    - SL - SUMP LEVEL
    - CL - COVER LEVEL
  - Backdrop
    - High level IL
    - Low level IL

00.000

100Ø 4.5m 1:100

Z BED

CONSTRUCTION WARNING

High groundwater up to 0.5m bgl and running sand recorded during site investigations. Contractor to take necessary precautions to ensure trench stability

AT1  
Attenuation Tank using Polytype Polystorm-R units wrapped in impermeable geomembrane  
5x7x0.8m DP  
Total 28m³ storage for 1 in 100 year + 40% peak storm event  
CL 5.55  
TOTL 4.90  
BOTL 4.10  
Min 500mm cover to units

CONSTRUCTION WARNING

Polytype to undertake floatation calculations prior to construction

## PRELIMINARY NOT FOR CONSTRUCTION

|     |          |                   |    |     |     |
|-----|----------|-------------------|----|-----|-----|
| P.  | 04.11.19 | PRELIMINARY ISSUE | LH | CS  | CS  |
| REV | DATE     | DESCRIPTION       | BY | CHK | APP |

|                                                                                                                     |          |            |       |             |     |
|---------------------------------------------------------------------------------------------------------------------|----------|------------|-------|-------------|-----|
| <br>Consulting Civil Engineers |          |            |       |             |     |
| CLIENT<br>MR JASON WELLER                                                                                           |          |            |       |             |     |
| ARCHITECT<br>ADM ARCHITECTS                                                                                         |          |            |       |             |     |
| JOB TITLE<br>283-285a CHICHESTER ROAD<br>BOGNOR REGIS                                                               |          |            |       |             |     |
| DRAWING TITLE<br>DRAINAGE LAYOUT                                                                                    |          |            |       |             |     |
| DRAWN                                                                                                               | LH       | ENGINEER   | CS    | CHECKED     | CS  |
| DATE                                                                                                                | OCT 2019 | SCALE @ A1 | 1:100 |             |     |
| JOB NO.                                                                                                             | C1113    | STATUS     | P     | DRAWING NO. | 100 |
|                                                                                                                     |          | REV.       | P-    |             |     |

PRELIMINARY

### STANDARD DRAINAGE NOTES

- DO NOT SCALE FROM THIS DRAWING. REFER TO FIGURED DIMENSIONS ONLY. THE CONTRACTOR SHOULD CHECK ALL DIMENSIONS ON SITE.
- ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS ARE IN METERS UNLESS NOTED OTHERWISE.
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ARCHITECT AND ENGINEERING DETAILS, DRAWINGS AND SPECIFICATIONS.
- ANY DISCREPANCIES SHOULD BE REPORTED TO THE ARCHITECT AND/OR ENGINEER IMMEDIATELY, SO THAT CLARIFICATION CAN BE SOUGHT PRIOR TO THE COMMENCEMENT OF WORK.
- BEFORE COMMENCING CONSTRUCTION THE CONTRACTOR MUST CHECK THE INVERT LEVELS OF EXISTING SEWERS TO WHICH CONNECTIONS ARE MADE. IN ADDITION THE CONTRACTOR MUST LOCATE AND DETERMINE INVERT LEVELS OF THE EXISTING SPURS TO WHICH CONNECTIONS ARE PROPOSED. ANY DISCREPANCIES ARE TO BE NOTIFIED TO THE ENGINEER IMMEDIATELY, PRIOR TO CONSTRUCTION.
- ALL DRAINAGE WORKS SHOULD COMMENCE AT THE PROPOSED DOWNSTREAM CONNECTION POINT, THE WORKS CONTINUING UPSTREAM FOLLOWING CONFIRMATION OF THE TIE-IN INVERT LEVELS TO THE ENGINEER. CONNECTIONS TO MANHOLES OR LARGER SIZED PIPES ETC. SHOULD BE SOFFIT TO SOFFIT UNLESS OTHERWISE INSTRUCTED BY THE ENGINEER. IF THIS IS NOT POSSIBLE INFORM THE ENGINEER IMMEDIATELY.
- COVER LEVELS SHOWN ARE APPROXIMATE. COVERS AND FRAMES SHALL BE SET TO FINISHED GROUND LEVELS AND FALLS.
- ALL UN-REFERENCED PIPES ARE ASSUMED TO BE 100mm DIA
- ALL PIPES TO BE ADOPTED, OR CONNECTING TO ADOPTED SEWERS, TO BE VITRIFIED CLAY TO BS EN 295 AND BS65 (SWS ONLY), OR CONCRETE PIPES TO BE EN 1916 AND BS5911-PART 1.
- ROAD GULLY OUTLET PIPES ARE TO BE 150mm DIA. WITH CONCRETE SURROUND AND FLEXIBLE JOINTS. ALL GULLIES SHALL BE FITTED WITH GRADE D400 GRATINGS AND FRAMES TO BS EN124, UNLESS OTHERWISE STATED.
- ALL ADOPTABLE SEWERS SHALL BE CONSTRUCTED TO THE STANDARDS AND SPECIFICATION LAID DOWN DOWN IN 'SEWERS FOR ADOPTION' 8th EDITION, WITH A VIEW TO ADOPTION UPON COMPLETION OF WORKS.
- ALL PRIVATE DRAINAGE TO BE IN ACCORDANCE WITH THE BUILDING REGULATIONS APPROVED DOCUMENT PART-H, AND TO THE SATISFACTION OF THE BUILDING CONTROL INSPECTOR.
- THE CONTRACTOR IS TO KEEP A RECORD OF ANY VARIATIONS MADE ON SITE, INCLUDING THE RELOCATION OF SEWERS OR DRAINS, SO THAT AN AS CONSTRUCTED DRAWING CAN BE PREPARED UPON COMPLETION OF THE PROJECT.
- STUB CONNECTIONS TO ADOPTABLE MANHOLES SHALL BE MADE FROM VITRIFIED CLAY AND CONSIST OF TWO ROCKER PIPES LAID AT THE SAME GRADIENT AS THE UP OR DOWNSTREAM PIPE.
- IF ANY SUB SOIL DRAINAGE SYSTEMS ARE UNCOVERED DURING THE WORKS CONTACT THE ENGINEER FOR INSTRUCTIONS. SUB SOIL DRAINS ARE TO BE DIVERTED AROUND NEW WORKS AND CONNECTED INTO THE SURFACE WATER. NO PRIVATE AREAS ARE TO DRAIN ONTO ADOPTABLE AREAS AND VICE VERSA.
- ALL EXISTING MANHOLE COVER'S, GULLIES, ETC. ARE TO BE RAISED/LOWERED TO SUIT NEW LEVELS.

DESIGN SUBJECT TO THE APPROVAL OF:  
PLANNING AUTHORITY  
BUILDING CONTROL  
SOUTHERN WATER

DESIGN SUBJECT TO THE CONFIRMATION OF:  
RWP POSITIONS

## **Appendix B**

### **Surface Water Drainage Calculations**

### Design Settings

|                       |                   |                                      |               |
|-----------------------|-------------------|--------------------------------------|---------------|
| Rainfall Methodology  | FSR               | Maximum Time of Concentration (mins) | 30.00         |
| Return Period (years) | 2                 | Maximum Rainfall (mm/hr)             | 50.0          |
| Additional Flow (%)   | 0                 | Minimum Velocity (m/s)               | 1.00          |
| FSR Region            | England and Wales | Connection Type                      | Level Soffits |
| M5-60 (mm)            | 20.000            | Minimum Backdrop Height (m)          | 0.200         |
| Ratio-R               | 0.350             | Preferred Cover Depth (m)            | 0.500         |
| CV                    | 0.750             | Include Intermediate Ground          | ✓             |
| Time of Entry (mins)  | 5.00              | Enforce best practice design rules   | ✓             |

### Nodes

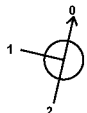
| Name | Area (ha) | T of E (mins) | Cover Level (m) | Diameter (mm) | Easting (m) | Northing (m) | Depth (m) |
|------|-----------|---------------|-----------------|---------------|-------------|--------------|-----------|
| S1   | 0.006     | 5.00          | 5.750           | 450           | 492385.678  | 100451.881   | 0.740     |
| S2   | 0.003     | 5.00          | 5.650           | 450           | 492393.000  | 100456.293   | 0.750     |
| S3   | 0.003     | 5.00          | 5.570           | 450           | 492394.842  | 100464.157   | 0.780     |
| S4   | 0.008     | 5.00          | 5.610           | 450           | 492388.525  | 100467.859   | 0.907     |
| S5   | 0.030     | 5.00          | 5.580           | 1200          | 492389.684  | 100472.808   | 1.500     |
| S6   | 0.013     | 5.00          | 5.150           | 1200          | 492395.820  | 100499.744   | 1.250     |
| S7   |           |               | 4.840           | 1200          | 492388.657  | 100508.148   | 1.050     |
| S8   | 0.006     | 5.00          | 5.650           | 300           | 492371.526  | 100465.117   | 0.600     |
| S9   | 0.006     | 5.00          | 5.650           | 450           | 492374.179  | 100476.440   | 0.796     |

### Links

| Name  | US Node | DS Node | Length (m) | ks (mm) / n | US IL (m) | DS IL (m) | Fall (m) | Slope (1:X) | Dia (mm) | T of C (mins) | Rain (mm/hr) |
|-------|---------|---------|------------|-------------|-----------|-----------|----------|-------------|----------|---------------|--------------|
| 1.000 | S1      | S2      | 8.549      | 0.600       | 5.010     | 4.900     | 0.110    | 77.7        | 100      | 5.16          | 50.0         |
| 1.001 | S2      | S3      | 8.077      | 0.600       | 4.900     | 4.790     | 0.110    | 73.4        | 100      | 5.31          | 50.0         |
| 1.002 | S3      | S4      | 7.322      | 0.600       | 4.790     | 4.703     | 0.087    | 84.2        | 100      | 5.46          | 50.0         |
| 1.003 | S4      | S5      | 5.083      | 0.600       | 4.703     | 4.650     | 0.053    | 95.9        | 100      | 5.57          | 50.0         |
| 1.004 | S5      | S6      | 27.626     | 0.600       | 4.080     | 3.900     | 0.180    | 153.5       | 225      | 6.00          | 50.0         |
| 1.005 | S6      | S7      | 11.042     | 0.600       | 3.900     | 3.790     | 0.110    | 100.0       | 225      | 6.14          | 50.0         |
| 2.000 | S8      | S9      | 11.630     | 0.600       | 5.050     | 4.854     | 0.196    | 59.3        | 100      | 5.19          | 50.0         |
| 2.001 | S9      | S5      | 15.925     | 0.600       | 4.854     | 4.536     | 0.318    | 50.1        | 100      | 5.44          | 50.0         |

| Name  | Vel (m/s) | Cap (l/s) | Flow (l/s) | US Depth (m) | DS Depth (m) | Σ Area (ha) | Σ Add Inflow (l/s) | Pro Depth (mm) | Pro Velocity (m/s) |
|-------|-----------|-----------|------------|--------------|--------------|-------------|--------------------|----------------|--------------------|
| 1.000 | 0.874     | 6.9       | 0.8        | 0.640        | 0.650        | 0.006       | 0.0                | 23             | 0.581              |
| 1.001 | 0.899     | 7.1       | 1.2        | 0.650        | 0.680        | 0.009       | 0.0                | 29             | 0.677              |
| 1.002 | 0.839     | 6.6       | 1.6        | 0.680        | 0.807        | 0.012       | 0.0                | 34             | 0.696              |
| 1.003 | 0.785     | 6.2       | 2.7        | 0.807        | 0.830        | 0.020       | 0.0                | 46             | 0.761              |
| 1.004 | 1.053     | 41.9      | 8.4        | 1.275        | 1.025        | 0.062       | 0.0                | 68             | 0.826              |
| 1.005 | 1.307     | 52.0      | 10.2       | 1.025        | 0.825        | 0.075       | 0.0                | 67             | 1.019              |
| 2.000 | 1.002     | 7.9       | 0.8        | 0.500        | 0.696        | 0.006       | 0.0                | 21             | 0.639              |
| 2.001 | 1.091     | 8.6       | 1.6        | 0.696        | 0.944        | 0.012       | 0.0                | 29             | 0.835              |

**Manhole Schedule**

| Node | Easting<br>(m) | Northing<br>(m) | CL<br>(m) | Depth<br>(m) | Dia<br>(mm) | Connections                                                                          | Link | IL<br>(m) | Dia<br>(mm) |     |
|------|----------------|-----------------|-----------|--------------|-------------|--------------------------------------------------------------------------------------|------|-----------|-------------|-----|
| S1   | 492385.678     | 100451.881      | 5.750     | 0.740        | 450         |    | 0    | 1.000     | 5.010       | 100 |
| S2   | 492393.000     | 100456.293      | 5.650     | 0.750        | 450         |    | 1    | 1.000     | 4.900       | 100 |
| S3   | 492394.842     | 100464.157      | 5.570     | 0.780        | 450         |    | 1    | 1.001     | 4.790       | 100 |
| S4   | 492388.525     | 100467.859      | 5.610     | 0.907        | 450         |    | 0    | 1.002     | 4.790       | 100 |
| S5   | 492389.684     | 100472.808      | 5.580     | 1.500        | 1200        |   | 1    | 2.001     | 4.536       | 100 |
| S6   | 492395.820     | 100499.744      | 5.150     | 1.250        | 1200        |   | 2    | 1.003     | 4.650       | 100 |
| S7   | 492388.657     | 100508.148      | 4.840     | 1.050        | 1200        |  | 0    | 1.004     | 4.080       | 225 |
| S8   | 492371.526     | 100465.117      | 5.650     | 0.600        | 300         |  | 1    | 1.004     | 3.900       | 225 |
| S9   | 492374.179     | 100476.440      | 5.650     | 0.796        | 450         |  | 0    | 2.000     | 5.050       | 100 |
|      |                |                 |           |              |             |  | 1    | 2.000     | 4.854       | 100 |
|      |                |                 |           |              |             |  | 0    | 2.001     | 4.854       | 100 |

**Simulation Settings**

|                      |                   |                            |        |
|----------------------|-------------------|----------------------------|--------|
| Rainfall Methodology | FSR               | Analysis Speed             | Normal |
| FSR Region           | England and Wales | Skip Steady State          | x      |
| M5-60 (mm)           | 20.000            | Drain Down Time (mins)     | 240    |
| Ratio-R              | 0.350             | Additional Storage (m³/ha) | 20.0   |
| Summer CV            | 0.750             | Check Discharge Rate(s)    | x      |
| Winter CV            | 0.840             | Check Discharge Volume     | x      |

**Storm Durations**

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

| Return Period<br>(years) | Climate Change<br>(CC %) | Additional Area<br>(A %) | Additional Flow<br>(Q %) |
|--------------------------|--------------------------|--------------------------|--------------------------|
| 1                        | 0                        | 0                        | 0                        |
| 30                       | 0                        | 0                        | 0                        |
| 100                      | 40                       | 0                        | 0                        |

#### Node S6 Online Hydro-Brake® Control

|                          |       |                         |                                |
|--------------------------|-------|-------------------------|--------------------------------|
| Flap Valve               | x     | Objective               | (HE) Minimise upstream storage |
| Replaces Downstream Link | ✓     | Sump Available          | ✓                              |
| Invert Level (m)         | 3.900 | Product Number          | CTL-SHE-0067-2000-1029-2000    |
| Design Depth (m)         | 1.029 | Min Outlet Diameter (m) | 0.100                          |
| Design Flow (l/s)        | 2.0   | Min Node Diameter (mm)  | 1200                           |

#### Node S5 Depth/Area Storage Structure

|                             |         |               |      |                           |       |
|-----------------------------|---------|---------------|------|---------------------------|-------|
| Base Inf Coefficient (m/hr) | 0.00000 | Safety Factor | 2.0  | Invert Level (m)          | 4.080 |
| Side Inf Coefficient (m/hr) | 0.00000 | Porosity      | 0.95 | Time to half empty (mins) | 192   |

| Depth<br>(m) | Area<br>(m²) | Inf Area<br>(m²) | Depth<br>(m) | Area<br>(m²) | Inf Area<br>(m²) | Depth<br>(m) | Area<br>(m²) | Inf Area<br>(m²) |
|--------------|--------------|------------------|--------------|--------------|------------------|--------------|--------------|------------------|
| 0.000        | 35.0         | 0.0              | 0.800        | 35.0         | 0.0              | 0.801        | 0.0          | 0.0              |

**Results for 1 year Critical Storm Duration. Lowest mass balance: 99.72%**

| Node Event       | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status     |
|------------------|---------|-------------|-----------|-----------|--------------|---------------|------------|------------|
| 15 minute winter | S1      | 11          | 5.033     | 0.023     | 0.8          | 0.0074        | 0.0000     | OK         |
| 15 minute winter | S2      | 11          | 4.928     | 0.028     | 1.2          | 0.0067        | 0.0000     | OK         |
| 15 minute winter | S3      | 11          | 4.824     | 0.034     | 1.6          | 0.0079        | 0.0000     | OK         |
| 15 minute winter | S4      | 11          | 4.752     | 0.049     | 2.6          | 0.0163        | 0.0000     | OK         |
| 60 minute winter | S5      | 45          | 4.165     | 0.085     | 5.3          | 2.9662        | 0.0000     | OK         |
| 60 minute winter | S6      | 44          | 4.172     | 0.272     | 4.4          | 0.3636        | 0.0000     | SURCHARGED |
| 15 minute summer | S7      | 1           | 3.790     | 0.000     | 1.9          | 0.0000        | 0.0000     | OK         |
| 15 minute winter | S8      | 11          | 5.072     | 0.022     | 0.8          | 0.0058        | 0.0000     | OK         |
| 15 minute winter | S9      | 11          | 4.884     | 0.030     | 1.6          | 0.0092        | 0.0000     | OK         |

| Link Event (Upstream Depth) | US Node | Link         | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|-----------------------------|---------|--------------|---------|---------------|----------------|----------|---------------|--------------------|
| 15 minute winter            | S1      | 1.000        | S2      | 0.8           | 0.508          | 0.117    | 0.0135        |                    |
| 15 minute winter            | S2      | 1.001        | S3      | 1.2           | 0.588          | 0.170    | 0.0165        |                    |
| 15 minute winter            | S3      | 1.002        | S4      | 1.6           | 0.527          | 0.242    | 0.0223        |                    |
| 15 minute winter            | S4      | 1.003        | S5      | 2.6           | 0.724          | 0.425    | 0.0184        |                    |
| 60 minute winter            | S5      | 1.004        | S6      | 3.4           | 0.203          | 0.082    | 0.7397        |                    |
| 60 minute winter            | S6      | Hydro-Brake® | S7      | 1.9           |                |          |               | 7.9                |
| 15 minute winter            | S8      | 2.000        | S9      | 0.8           | 0.507          | 0.102    | 0.0186        |                    |
| 15 minute winter            | S9      | 2.001        | S5      | 1.6           | 0.827          | 0.186    | 0.0307        |                    |

**Results for 30 year Critical Storm Duration. Lowest mass balance: 99.72%**

| Node Event       | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status     |
|------------------|---------|-------------|-----------|-----------|--------------|---------------|------------|------------|
| 15 minute winter | S1      | 10          | 5.047     | 0.037     | 2.0          | 0.0120        | 0.0000     | OK         |
| 15 minute winter | S2      | 10          | 4.947     | 0.047     | 3.0          | 0.0111        | 0.0000     | OK         |
| 15 minute winter | S3      | 11          | 4.845     | 0.055     | 3.9          | 0.0129        | 0.0000     | OK         |
| 15 minute winter | S4      | 11          | 4.807     | 0.104     | 6.4          | 0.0349        | 0.0000     | SURCHARGED |
| 60 minute winter | S5      | 60          | 4.424     | 0.344     | 11.9         | 11.9621       | 0.0000     | SURCHARGED |
| 60 minute winter | S6      | 60          | 4.423     | 0.523     | 4.8          | 0.7001        | 0.0000     | SURCHARGED |
| 15 minute summer | S7      | 1           | 3.790     | 0.000     | 1.9          | 0.0000        | 0.0000     | OK         |
| 15 minute winter | S8      | 10          | 5.084     | 0.034     | 2.0          | 0.0093        | 0.0000     | OK         |
| 15 minute winter | S9      | 10          | 4.903     | 0.049     | 4.0          | 0.0151        | 0.0000     | OK         |

| Link Event (Upstream Depth) | US Node | Link         | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|-----------------------------|---------|--------------|---------|---------------|----------------|----------|---------------|--------------------|
| 15 minute winter            | S1      | 1.000        | S2      | 2.0           | 0.634          | 0.288    | 0.0267        |                    |
| 15 minute winter            | S2      | 1.001        | S3      | 2.9           | 0.733          | 0.412    | 0.0321        |                    |
| 15 minute winter            | S3      | 1.002        | S4      | 3.8           | 0.610          | 0.583    | 0.0447        |                    |
| 15 minute winter            | S4      | 1.003        | S5      | 6.3           | 0.842          | 1.025    | 0.0372        |                    |
| 60 minute winter            | S5      | 1.004        | S6      | 3.3           | 0.204          | 0.080    | 1.0987        |                    |
| 60 minute winter            | S6      | Hydro-Brake® | S7      | 1.9           |                |          |               | 19.2               |
| 15 minute winter            | S8      | 2.000        | S9      | 2.0           | 0.644          | 0.251    | 0.0358        |                    |
| 15 minute winter            | S9      | 2.001        | S5      | 3.9           | 1.047          | 0.453    | 0.0591        |                    |

**Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.72%**

| Node Event        | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status     |
|-------------------|---------|-------------|-----------|-----------|--------------|---------------|------------|------------|
| 15 minute winter  | S1      | 12          | 5.084     | 0.074     | 3.6          | 0.0239        | 0.0000     | OK         |
| 15 minute winter  | S2      | 12          | 5.067     | 0.167     | 5.4          | 0.0398        | 0.0000     | SURCHARGED |
| 15 minute winter  | S3      | 12          | 5.013     | 0.223     | 6.0          | 0.0527        | 0.0000     | SURCHARGED |
| 180 minute winter | S4      | 168         | 4.975     | 0.272     | 3.1          | 0.0910        | 0.0000     | SURCHARGED |
| 180 minute winter | S5      | 168         | 4.974     | 0.894     | 9.4          | 27.9856       | 0.0000     | SURCHARGED |
| 180 minute winter | S6      | 168         | 4.974     | 1.074     | 2.6          | 1.4378        | 0.0000     | FLOOD RISK |
| 15 minute summer  | S7      | 1           | 3.790     | 0.000     | 1.9          | 0.0000        | 0.0000     | OK         |
| 15 minute winter  | S8      | 10          | 5.097     | 0.047     | 3.6          | 0.0128        | 0.0000     | OK         |
| 180 minute winter | S9      | 168         | 4.975     | 0.121     | 1.8          | 0.0375        | 0.0000     | SURCHARGED |

| Link Event (Upstream Depth) | US Node | Link         | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|-----------------------------|---------|--------------|---------|---------------|----------------|----------|---------------|--------------------|
| 15 minute winter            | S1      | 1.000        | S2      | 3.6           | 0.711          | 0.520    | 0.0601        |                    |
| 15 minute winter            | S2      | 1.001        | S3      | 4.4           | 0.748          | 0.630    | 0.0632        |                    |
| 15 minute winter            | S3      | 1.002        | S4      | 6.0           | 0.762          | 0.904    | 0.0573        |                    |
| 180 minute winter           | S4      | 1.003        | S5      | 3.1           | 0.753          | 0.503    | 0.0398        |                    |
| 180 minute winter           | S5      | 1.004        | S6      | 2.0           | 0.205          | 0.049    | 1.0987        |                    |
| 180 minute winter           | S6      | Hydro-Brake® | S7      | 2.0           |                |          |               | 43.9               |
| 15 minute winter            | S8      | 2.000        | S9      | 3.6           | 0.731          | 0.453    | 0.0564        |                    |
| 180 minute winter           | S9      | 2.001        | S5      | 1.8           | 0.855          | 0.210    | 0.1246        |                    |