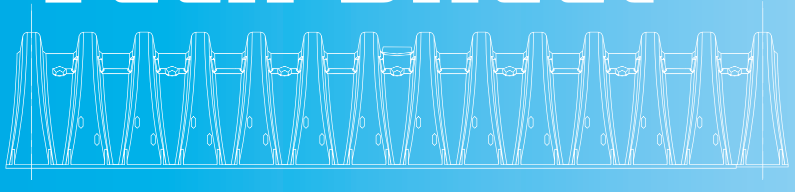

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Detention • Retention • Water Quality

Manifold Sizing Guidance for StormTech Chamber Systems

Tech Sheet # 7
August, 2012

General:

The design of subsurface chambers systems, as part of a site design, involves many site-specific and regulatory constraints that necessarily leave overall design responsibility with the consulting engineer. However StormTech offers assistance to the design engineer for the layout of chamber systems and the manifolds that connect the chambers to the drainage system. This summarizes methods StormTech uses for calculating the size and configuration of manifolds for the StormTech chamber system.

StormTech manifolds are comprised of smooth interior HDPE pipes, fittings and prefabricated manifold sections that align with proper spacing of the chamber rows. The use of common pipe components enables the engineer to apply simple equations of hydraulics to size the manifold system. Available prefabricated manifolds are shown in Table 1.

	Trunk in. (mm)	SC-310 & RC-310 Manifolds									
Stub in. (mm)	48 (1200)	42 (1050)	36 (900)	30 (750)	24 (600)	18 (450)	15 (375)	12 (300)	10 (250)	8 (200)	6 (150)
12 (300)	NA	NA	NA	NA	Avail	Avail	Avail	Avail	NA	NA	NA
10 (250)	NA	NA	NA	NA	Avail	Avail	Avail	Avail	Avail	NA	NA
8 (200)	NA	NA	NA	NA	Avail	Avail	Avail	Avail	Avail	Avail	NA
6 (150)	NA	NA	NA	NA	Avail	Avail	Avail	Avail	Avail	Avail	Avail

	Trunk in. (mm)	SC-740, DC-780 & RC-750 Manifolds									
Stub in. (mm)	48 (1200)	42 (1050)	36 (900)	30 (750)	24 (600)	18 (450)	15 (375)	12 (300)	10 (250)	8 (200)	6 (150)
24 (600)	Avail	Avail	Avail	Avail	Avail	NA	NA	NA	NA	NA	NA
18 (450)	Avail	Avail	Avail	Avail	Avail	Avail	NA	NA	NA	NA	NA
15 (375)	Avail	Avail	Avail	Avail	Avail	Avail	Avail	NA	NA	NA	NA
12 (300)	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	NA	NA	NA
10 (250)	NA	NA	NA	NA	Avail	Avail	Avail	Avail	Avail	NA	NA
8 (200)	NA	NA	NA	NA	Avail	Avail	Avail	Avail	Avail	Avail	NA
6 (150)	NA	NA	NA	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail

	Trunk in. (mm)	MC-3500 & MC-4500 Manifolds									
Stub in. (mm)	48 (1200)	42 (1050)	36 (900)	30 (750)	24 (600)	18 (450)	15 (375)	12 (300)	10 (250)	8 (200)	6 (150)
24 (600)	Avail	Avail	Avail	Avail	Avail	NA	NA	NA	NA	NA	NA
18 (450)	Avail	Avail	Avail	Avail	Avail	Avail	NA	NA	NA	NA	NA
15 (375)	Avail	Avail	Avail	Avail	Avail	Avail	Avail	NA	NA	NA	NA
12 (300)	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	NA	NA	NA

Table 1 Standard Manifolds Manufactured by ADS (special sizes available)

The primary manifold design objectives are; 1) to convey the peak flows to and from the chamber system without causing an unacceptable backwater and 2) to preclude scour of structural stone under the chamber system. StormTech assumes the maximum allowable water surface elevation is at full storage (top of open graded stone). The design engineer may choose to design for a higher maximum water surface elevation. Since the relationship between the inflow hydrographs, outlet control, time to peak and accumulated storage are site specific and complex, StormTech assumes that the peak inlet flow occurs when there is no water in the chambers. This is the worst case condition for scour. StormTech assumes that the chambers are full when the peak outlet flow occurs.

Inlet Manifolds:

Inlet manifold sizing is broken down into two parts: 1) sizing the main trunk and 2) determining the size and number of stubs required. The following guidance includes how to determine main trunk size and a sufficient number of properly sized stub connections.

Inlet Trunk Sizing:

StormTech manifold systems are generally laid level. The analysis of the trunk can be performed by looking at the trunk as an orifice of a short tube and submerged at peak flow. The premise is that the length between the manhole and first stub is relatively short. Thus the orifice of a short tube can be looked at as the length of main trunk to the first inlet stub. The short tube is the constriction.

Flow in the main trunk is reduced after each stub and headlosses in the balance of the trunk do not control.

The equation for an orifice of a short tube[1] is:

$$Q = Ca\sqrt{2gh}$$

With the variables defined as follows:

Q = maximum flow rate cresting the weir (cfs)
C = 0.75
a = area of manifold trunk (ft^2) (to be determined)
g = 32.2 (ft/s^2)
h = head over center of orifice (ft) (figure 1)

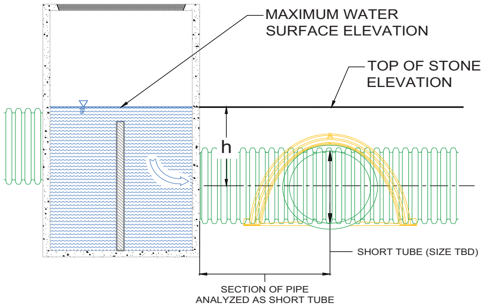

Figure 1 Orifice of a Short Tube

This analysis is used to determine the area of the orifice required to pass the flow rate. A pipe is selected with at least this area.

The design engineer may apply a greater value for “h” if it is not limited by the maximum water surface elevation at the top of stone.

Inlet Stub Sizing:

The number and size of the stubs can be determined by analyzing each inlet stub as a broad crested weir. Weir analysis is dependant upon whether a tailwater condition exists inside the chambers. Unless otherwise determined by the inlet hydrograph, no tail water is used for the analysis (worst case scenario).

The equation for a broad crested weir [1] is:

$$Q = CLH^{3/2}$$

With the variables defined as follows:

Q = flow rate in the stub (cfs)
C = discharge coefficient
L= width of weir (ft)
H = height of water over weir (ft)
b = Length of weir (ft) *(used to determine C)*

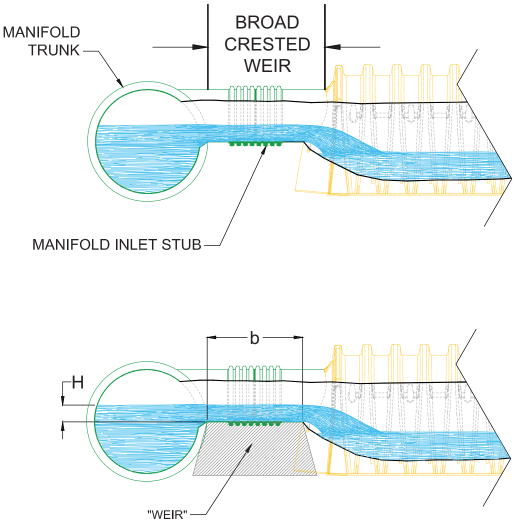

Figure 2 Broad Crested Weir

These parameters are defined in figure 2. When performing the analysis on the weir, the first step is to determine the maximum allowable flow rate through the stubs into the chambers. Table 2 shows the maximum velocities based on scour analysis and pipe size. Specifying scour protection fabric allows higher velocities to be tolerated. **Note: the velocity from Table 2 cannot be multiplied by the area of the pipe to determine the allowable flow rate through the pipe stubs.**

Inlet Pipe Diameter in. (mm)	Maximum Inlet Pipe Velocities ft/s (m/s)
4 (100)	2.43 (0.74)
6 (150)	2.61 (0.80)
8 (200)	2.73 (0.83)
10 (250)	2.44 (0.74)
12 (300)	2.19 (0.67)
15 (375)	2.00 (0.61)
18 (450)	1.88 (0.57)
24 (600)	1.74 (0.53)

Table 2: Maximum inlet velocities for various pipes

When sizing the stubs for a “size on size” manifold, there is no weir formed by the stub. A conservative approach to determine the number of stubs required is to assume an eccentric manifold with the desired stub size and an oversized trunk. Thus if a 24” x 24” manifold is desired then size a 30” x 24” manifold to determine the number of 24” stubs required and use this number of stubs for the 24” x 24” manifold.

Outlet Manifolds:

The purpose of the outlet manifold “hard-pipe connection(s)” is to ensure that there are free-flooding conditions between the StormTech chambers and the outlet control structure. The outlet manifold must be able to pass the design peak outlet flow rate from the chamber system to the outlet control structure and the outlet control structure must in-fact control the flow.

The premise for the StormTech sizing approach is that the outlet control structure has caused the chambers to be full when the peak outlet flow occurs. Essentially, the outlet control structure has impeded flow and caused a backwater in the StormTech chambers. This premise is appropriate for most flow attenuation systems and also simplifies the design. Since the chambers are assumed to be full, the allowable flow through the chamber row is the full chamber flow area multiplied by the acceptable scour velocity. However, when the design intent is to maximize storage in the chambers, the outlet structure would cause a high tailwater and driving head would be small. Under the low driving head scenario, pipe flow is more constricting than chamber row flow.

The outlet manifold sizing then becomes full pipe flow which is dependent upon driving head, headlosses at the pipe entrance, friction losses in the pipes, fitting losses (if a manifold) and exit losses. This is solved by a simple application of the energy equation and the Darcy Weisbach equation for piping connecting two reservoirs; the upstream reservoir elevation being the maximum water surface elevation in the chamber system and the downstream reservoir elevation being the water surface elevation caused by the outlet control (see figure 3).

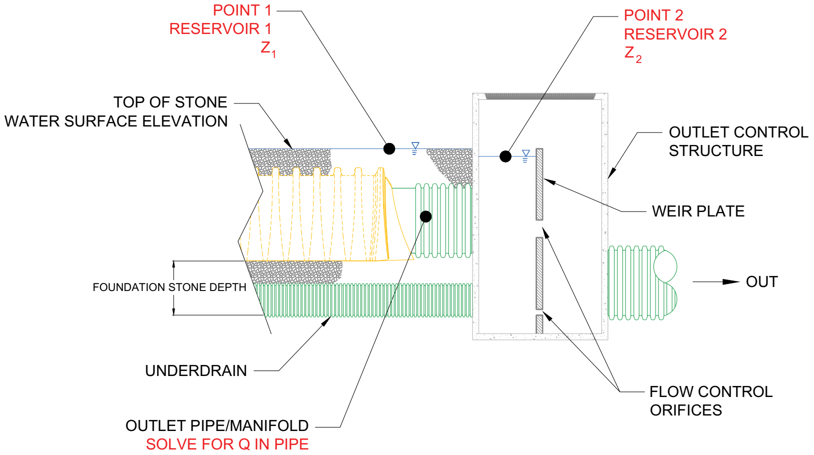

Figure 3, Outlet connections (reservoir-to-reservoir connection)

The formulas to be used are:
Energy Equation [2]:

$$\frac{p_1}{\gamma} + \alpha_1 \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \alpha_2 \frac{v_2^2}{2g} + z_2 + h_L$$

Where:

p/γ = pressure head

$\alpha v^2/2g$ = velocity head

α = kinetic energy correction factor (typically set to 1)

z = elevation

h_L = head loss between sections 1 and 2

Darcy-Weisbach formula[2]:

$$h_f = f \frac{L}{D}\frac{V^2}{2g}$$

Where:

h_f = headloss in pipe

$V^2/2g$ = velocity head

L = length of pipe

D = pipe diameter

f = resistance coefficient

Colebrook formula[3]:

$$\frac{1}{\sqrt{f}} = 2.0 \log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$$

Where:

f = headloss in pipe

ε/D = equivalent relative roughness

D = pipe diameter

ε = equivalent absolute roughness

Re = Reynolds number

Note: Most hydraulics textbooks contain a copy of the Moody Chart that can be used to calculate f instead of the Colebrook formula.

Headloss in transitions and fitting can be calculated using the formula [2]:

$$h_L = K \frac{V^2}{2g}$$

Where:
$K_e = 0.5$ for a square edged inlet pipe [2]
$K_E = 1.0$ for a re-entrant (pipe into outlet control structure) [2]
$K_L = 2.0$ for a branched tee (manifold tee) [4]

StormTech has solved the energy equation and the Darcy Weisbach equation based on a driving head of 0.25 ft, losses that include: 1 square edge inlet, 1 tee, 1 outlet and ≤ 50 ft of pipe and suggests maximum flow rates for stub and manifold sizes as shown in table 3. When the pipe required is larger than the maximum sized pipe that can be inlet into the chamber the pipe size calculated is specified as the main manifold trunk (see table 3). The number of stubs required for the manifold is obtained by dividing the outlet flow rate by the maximum flow rate from table 3 for the desired stub size. For example, with an outlet flow rate of 6 cfs a 24 in manifold trunk is required for the SC-310 chamber (maximum pipe size is 12 in). To size a 24” x 12” outlet manifold the 6 cfs is divided by 2.0 cfs (maximum outlet flow rate for 12 inch pipe) for a total of three 12 inch stubs required.

Manifold Configuration:
As well as conveying the design flow rates and preventing scour of the foundation stone, the manifold must also disperse the water across the chamber bed and ensure that peak flows readily reach to the outlet control structure. For wide beds with many rows, the manifold stubs should be spread out so that large areas of the bed are not dependent upon flow through stone to fill.

Figure 4 shows an example of a “limiting row” that requires nearly half the chamber bed to be filled via the stone permeability. The flow to the remainder of the bed and to the outlet control structure is limited by the flow through the stone of only one chamber row. Based on the inlet hydrograph and the permeability of the stone this limiting row may cause a backwater condition. In figure 4 there are 9 chambers that will laterally feed the remainder of the bed consisting of 54 chambers.

Outlet Pipe Diameter in. (mm)	Maximum Outlet Pipe Flow Rates cfs (l/s)
6 (150)	0.4 (11.3)
8 (200)	0.7 (19.8)
10 (250)	1.0 (28.3)
12 (300)	2.0 (56.6)
15 (375)	2.7 (76.5)
18 (450)	4.0 (113.3)
24 (600)	7.0 (198.2)
30 (750)	11.0 (311.5)
36 (400)	16.0 (453.1)
42 (1050)	22.0 (623.0)
48 (1200)	28.0 (792.9)

Max. SC-310 pipe connection

Max. SC-740 pipe connection

Table 3: Maximum outlet flow rate for various pipes

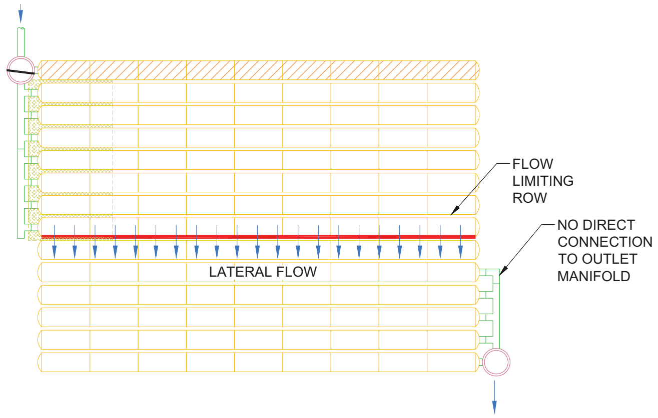

Figure 4: Limiting row of chamber potentially causing backwater

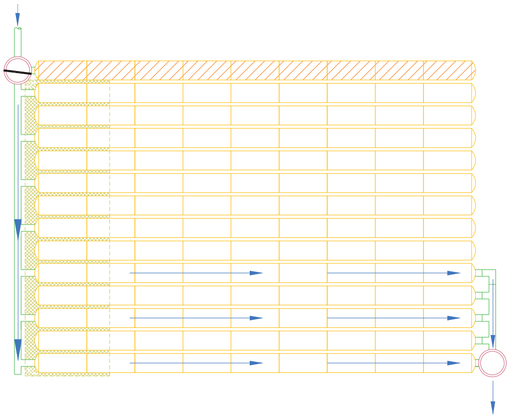

Figure 5: Typical inlet/outlet manifold system

In figure 5 the manifold is spread out to inlet every other row. With this configuration there are now 63 chambers connected to the inlet manifold, laterally feeding 54 chambers that do not have inlet stubs. Also there are three chamber rows connected on both the inlet and outlet ends (creating three direct flow paths from the inlet to the outlet).

The aggregate used for StormTech’s chambers have permeability’s (Darcy *k* values) that range from 0.1 ft/s (0.03 m/s) to 1.6 ft/s (0.5 m/s) (No. 57 and No. 3 respectively) [5]. StormTech has estimated of flow through the stone beneath the chambers (one direction) as:

Stone Gradation	Darcy “k” ft/s (m/s)	SC-310		SC-740	
		Velocity ft/s (m/s)	Q* cfs (L/s)	Velocity ft/s (m/s)	Q* cfs (L/s)
#3	1.6 (0.5)	0.91 (0.28)	3.04 (86.1)	1.2 (0.37)	4.2 (118.9)
#357, 4, 467, 5	0.6 (0.2)	0.34 (0.10)	1.14 (32.3)	0.4 (0.12)	1.6 (45.3)
#56, 57	0.1 (0.03)	0.06 (0.02)	0.19 (5.4)	0.07 (0.02)	0.26 (7.36)

** Flows listed are one direction only and are based on Darcy’ equation of Q = kiA. Assumptions include a hydraulic gradient equal to the height of chamber, 6” of foundation stone, no water ponded in the adjacent chamber row, and a flow path length of 41 inches for the SC-740 and 30 inches for the SC-310.*

The StormTech Technical Services Department can assist the design professional in specifying StormTech stormwater systems. As part of this assistance StormTech has developed a proprietary sizing tool for the inlet manifolds based on the common equations and assumptions listed in this Tech Sheet. Please contact the StormTech Technical Services Department for assistance with sizing inlet manifolds.

Disclaimer: The hydraulic performance of manifolds for detention systems is dependent upon many variables including but not limited to; headwater and tail water conditions, the inflow hydrograph and headloss through the piping system. StormTech has used assumptions to simplify the manifold design process. The design engineer for the project must verify that the assumptions and calculations are appropriate for the specific application.

[1] Brater, E.F. and King, H. W., Handbook of Hydraulics for the Solution of Hydraulic Engineering Problems, 6th ed., McGraw-Hill, New York, 1976
[2] Cassidy, J.J, Chaudhry, M.H., and Roberson, J. A., Hydraulic Engineering, 1 st ed., Houghton Mifflin, Boston, 1988
[3] Gerhart, P.M., Gross, R.J., and Hochstien, J.I. Fundamentals of Fluid Mechanics, 2 nd ed., Addison-Wesley, New York, 1992
[4] Munson, B.R., Okiishi, T.H., and Young, D.F., Fundamentals of Fluid Mechanics, 5 th ed., John Wiley & Sons, Danvers, 2006
[5] Cedergren, H.R., Seepage, Drainage, and Flow Nets, 3rd ed., John Wiley & Sons, New York, 1989

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