

4.5 Special measures - relieving earth pressure for deeper installations

4.5.1 Special measures

The earth pressure at the design depth for the tank may exceed the lateral strength of Polystorm Lite and Polystorm cells (once it has been factored down). If this is the case there are a number of solutions:

1. Redesign the drainage system to make the invert of the tank shallower.
2. Place the cells in a stepped configurations where the tank gets wider from the base to the top (Figure 19).
3. Reinforce the lower part of the backfill with geogrids (Figure 20).
4. Use mass concrete backfill in the lower part of the backfill (Figure 21).

Reducing lateral pressure on a Polystorm Tank

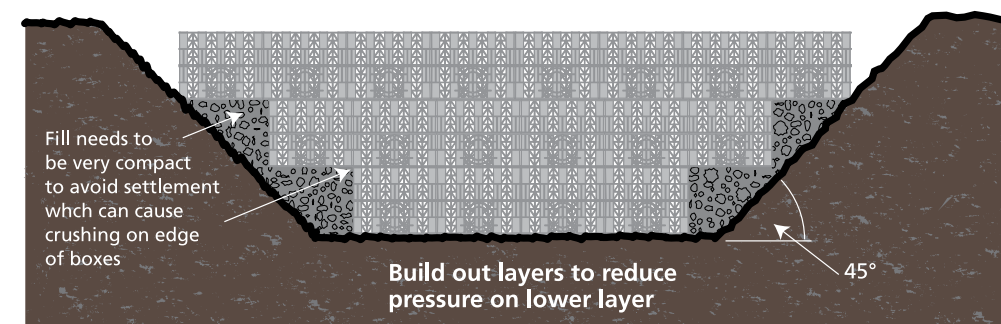


Figure 19

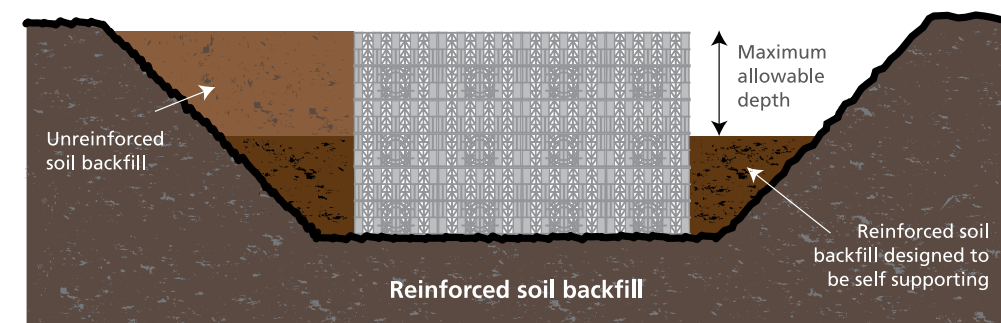


Figure 20

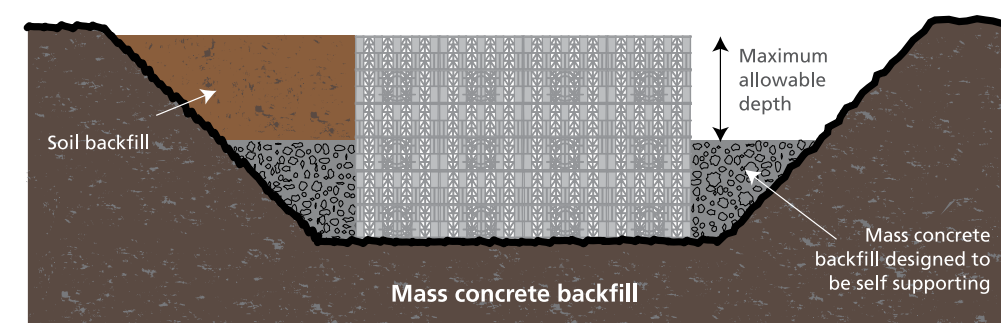


Figure 21

4.6 Hydraulic design

4.6.1 Hydraulic design

Hydraulic design calculations provide the storage volume required on any particular site that is required to reduce the speed, frequency and volume of rainfall run-off into rivers or sewers. The required volume depends on the site location, the size of the area being drained, the soil infiltration rate (for soakaways) or allowable discharge rate (for attenuations systems).

The design of SUDS should follow the requirements in the CIRIA Report C 697 The SUDS Manual.

This identifies three types of storage that are required:

- **Interception storage** - this is not actually storage - the aim is to reduce the frequency of run-off and prevent run-off from sites for rainfall events up to 5mm in order to simulate the behaviour of greenfield catchments more closely. This is achieved using infiltration or source control methods where evapotranspiration can reduce the volume of run-off.
- **Attenuation storage** - used to reduce the peak discharge rate from a site (i.e. how fast water flows off the site) and is used to store excess water where the rate of discharge is limited to greenfield run-off rates (or other agreed rate). It is designed to operate for a range of annual probabilities (typically 1 in 30 years and 1 in 100 years).
- **Long term storage** - used to reduce the additional volume of run-off caused by developments. Stores excess water that is the difference in total volume of run-off between the developed and greenfield site for a 1 in 100 year 6 hour rainfall event. Outflow from the long term storage should be to either infiltration or to a water course or sewer at 2 l/s/ha or less.

Polystorm can be used to provide attenuation, long term storage and can be designed into systems that provide interception storage (e.g. soakaways or below swales or infiltration basins). The SUDS manual also requires treatment of pollution in run-off and Polystorm can help these treatment systems work more effectively by controlling the flow of water through them (for example by providing attenuation storage upstream of a wetland). The exact design requirements for any site should be agreed with the Environment Agency.

4.6.2 Design of attenuation storage

The volume of Polystorm required for attenuation storage is typically calculated using drainage design software based on the Wallingford Procedure. The volume of temporary run-off storage required is shown in Figure 22 and is simply the difference between the volume of run-off that enters the tank during a design storm and the volume of water that is allowed to flow out in the same period (which is governed by the discharge rate allowed by the regulators). In this way Polystorm can be used to limit the peak rate of run-off from a site (usually to the greenfield run-off rate). The calculations are completed for a range of return periods and durations.

Attenuation storage volume

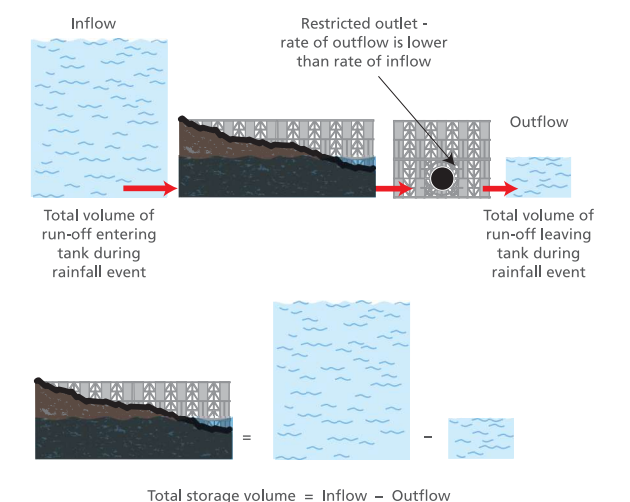


Figure 22

4.7 Hydrological rainfall

4.7.1 Hydrological rainfall zones for the UK

(HR Wallingford, Use of SUDS in high density developments, defining hydraulic performance criteria, Report SR 640, December 2003).

The table below can be used to size a Polystorm tank. The tables are based on the hydrological rainfall regions shown on the map.

The tables are based on the following assumptions:

- Storage is provided for development design events of 1 in 30 years, 1 in 100 years and 1 in 100 years plus 20% increase for climate change but the greenfield run-off rate is always considered to be 5 l/s/ha
- Time of entry and time of concentration within the drainage system is not considered
- 100% run-off is assumed

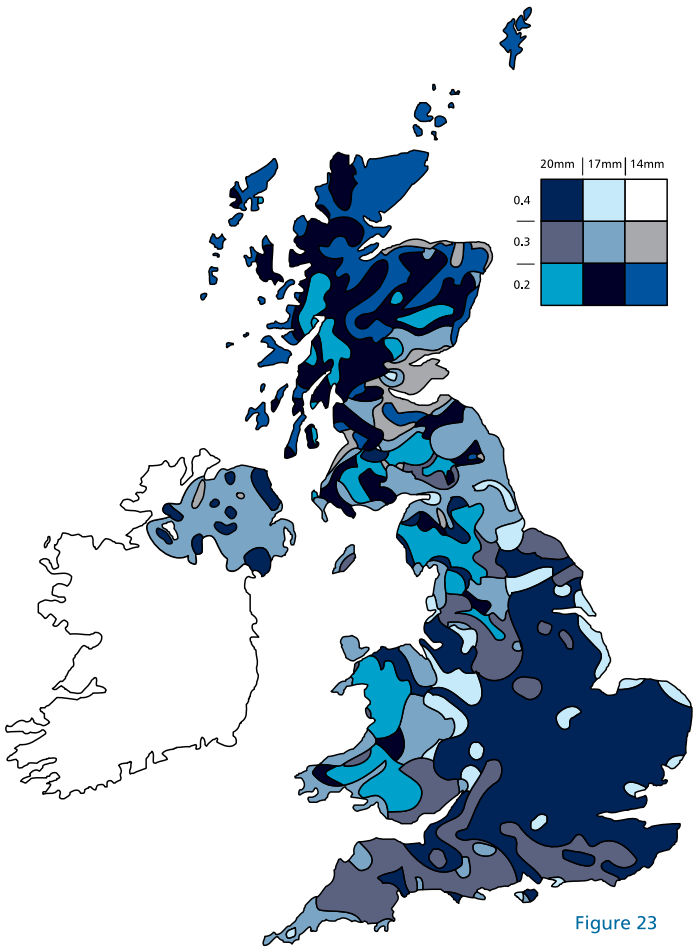


Figure 23

Required attenuation storage (m³ of storage per Ha of impermeable area)				
	r	1 in 30 year design event	1 in 100 year event	1 in 100 year event plus 20% climate change
Ms-60 = 20mm	0.4	357	510	643
	0.3	413	583	749
	0.2	556	770	968
Ms-60 = 17mm	0.4	293	419	545
	0.3	335	483	631
	0.2	444	637	822
Ms-60 = 40mm	0.3	258	383	511
	0.2	335	500	665

Table 11

Note: Volumes include allowance for 95% void ratio of Polystorm.

Polystorm has a void ratio of 95% (i.e. for every 1m³ there is 0.95m³ of space available for water storage).

The volume of Polystorm required is therefore calculated by dividing the required storage volume by 0.95.

This factor is allowed for in the design table.

Example of Polystorm sizing for attenuation storage

Site in London has an impermeable area as follows:

1200m² roof area

1475m² car park and other areas

Therefore the total impermeable area = 2675m².

Assume the required return period for the drainage design is 1 in 100 years as agreed with the Environment Agency.

From Table 11 London is in the region where

Ms-60=20mm and r=0.4.

Therefore from the table the volume of the Polystorm tank required is 510m³/ha.

Required attenuation storage on this site

= 510 x 2675/10000 = 136.4m³.

Design of long term storage

Long term storage can be designed using the volumes in CIRIA C697 The SUDS manual and these are summarised in the table below.

Long term storage volumes (CIRIA C697)	
Soil type (from maps in Wallingford Procedure for Europe of Flood Studies Report)	Storage volume (m³/ha)
1	320
2	180
3	130
4	60
5	20

Table 12

The discharge rate for the long term storage is 2 l/s/ha or to infiltration (soakaway).

The long term storage is part of the attenuation storage but it is normally located in a separate tank that is restricted to an outflow of 2 l/s/ha. Alternatively one large tank can be fitted with an outlet control that achieves the different discharge criteria for the different storage volumes.

Example of Polystorm sizing for long term storage

As for the previous example consider a site in London which has an impermeable area as follows:

1200m² roof area

1475m² car park and other areas

Therefore the total impermeable area = 2675m²

The attenuation storage is provided by Polystorm that has a volume of 86m³ and the flow out of this is restricted to 7 l/s/ha.

Assume the site is over Soil type 3.

From Table 12 the long term storage required is 130m³/ha

So required long term storage on this site

= 130 x 2675/10000 = 34.7m³

Redistribution of storage requirements gives:

Attenuation storage tank = 136.4 – 34.7

= 101.7m³ with an outflow of 1.2 l/s

Long term storage tank = 34.7m³ with an outflow of 0.4 l/s

4.7.2 Siltation

The drainage system upstream of Polystorm tanks should be designed so that silt and other debris is removed from the run-off and is prevented from entering the tank. This can be achieved using silt traps, permeable pavement or other methods. Polystorm can be used below basins and swales to provide underdrainage. This has the advantage of preventing silt entering the tank but also makes the swale more effective at removing pollution and makes it more aesthetically pleasing by keeping the base dry. If silt does enter the Polystorm tanks it may be difficult to remove. However after a site is completed the level of silt entering the tank is relatively small on most sites. It is simple to make an allowance for loss of storage due to siltation and the tank can be over designed by the amount (typically a 10% increase in tank size will deal with any siltation over a 50 year period). Off line tanks are less prone to siltation because the low flows (which contain most of the silt) bypass the tank. Soakaways are very prone to siltation if upstream treatment is not provided to remove silt. It is critical that silt from the construction site is not allowed to enter the Polystorm tank.

Typical silt trap

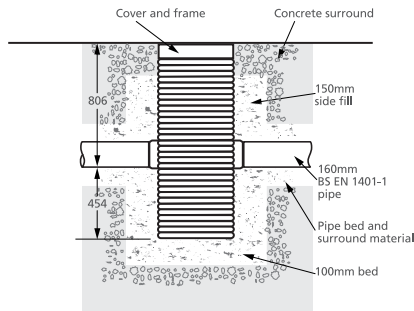


Figure 24

4.8 Soakaway design

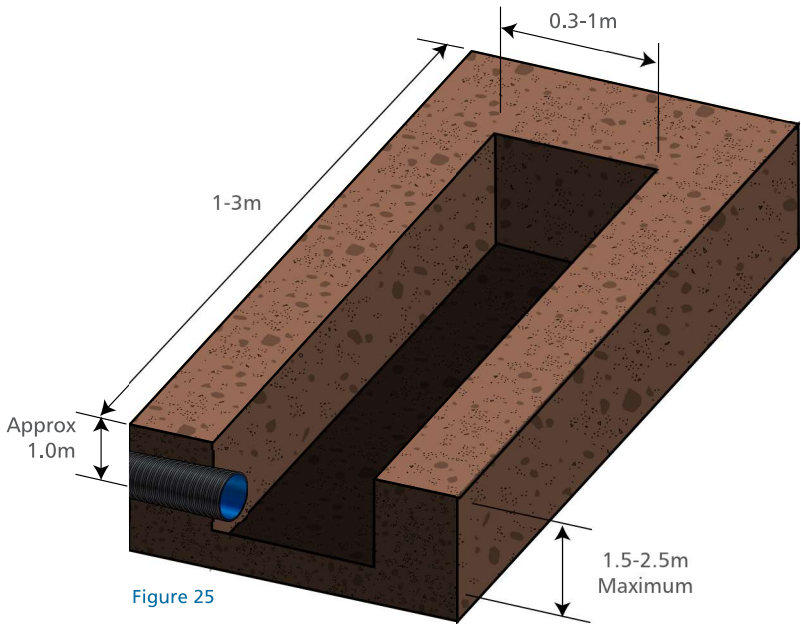
4.8.1 Percolation test for designing a soakaway system

This percolation test follows the procedures laid out by the BRE Digest 365

Step 1 - Dig a trial hole

- The base of the trial hole should be approximately the same depth as anticipated in the full size soakaway
- Overall excavation depth is typically: 1.5m-2.5m for areas <100m²
- The test hole should be typically 0.3m-1m wide and 1m-3m long (make a record of the test hole dimensions)

Step 2 - Fill the hole with water



- Fill trial hole with water - this needs to be done rapidly to mimic a real storm event
- Record the time taken for the water level to fall within the trial hole from 75% to 25% full
- Repeat 3 times, allowing the trial hole to drain between tests
- Best practice for soakaways longer than 25m is to perform a second percolation test at a different location to that of the 1st test site

Step 3 - The results - Soil infiltration rate

$$f = \frac{V_{(p75-25)}}{a_{(p50)} \times t_{(p75-25)}}$$

$V_{(p75-25)}$ = Volume of the hole from 25% to 75% depth

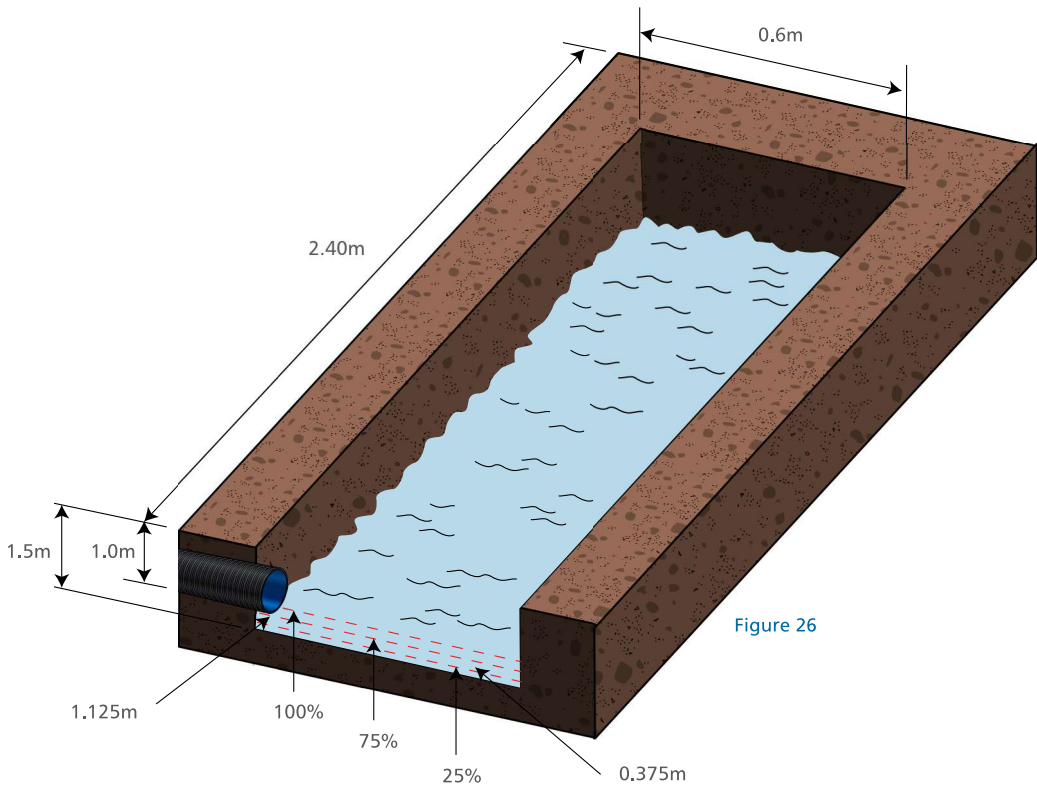
$a_{(p50)}$ = Internal surface area of the hole up to 50% of the depth and including the base area

$t_{(p75-25)}$ = The time for the hole to drain from 75% to 25% full in seconds

- Contact the Polypipe WMS technical support team and advise them of the dimensions of the test hole and lowest timed result (in minutes)
- Polypipe WMS will take this data and estimate the soakaway size required

Worked example

Invert of the discharge drain - 1.0m below the surface. When cleaned and trimmed the test hole was 2.51m deep, 2.40m long and 0.60m wide. An effective storage depth of 1.5m therefore adopted.



Test hole volume between 75% and 25% effective depth:

$$V_{(p75-25)} = 2.40 \times 0.60 \times (1.125 - 0.375) = 1.08\text{m}^3$$

Test hole depth at 75% and 25%

The mean surface area through which outflow occurs, taken to be the hole sides at 50% effective depth, including the base of the pit:

$$a_{(p50)} = 0.75[2(2.40 + 0.6)] + (2.4 \times 0.6) = 0.75(6) + 1.44 = 5.94\text{m}^2$$

The time taken for water to drain from 75% to 25% full:

$$t_{(p75-25)} = 102 - 11 = 91 \text{ minutes}$$

Number of minutes to drain from 75% to 25% depth

Soil Infiltration rate $\frac{1.08}{5.94 \times (91 \times 60)} = 3.33 \times 10^{-5} \text{ m/sec}$

4.8 Soakaway design

4.8.2 Infiltration

Calculation principles

There are two approaches, either of which may be adopted: the Construction Industry Research and Information Association (CIRIA) Report 156 Infiltration Drainage - Manual of Good Practice or BRE Digest 365 Soakaway Design.

A simplified approximate approach can be used on a very small site (i.e. a single house development) where detailed site infiltration rate information may not be required nor available (see table below). Approved document H3 (refer to 1.1, page 10) allows a storage volume equal to the area to be drained multiplied by 10mm for areas up to 25m². Beyond this size, design should be carried out in accordance with BS EN 752-4 : 1998 or BRE Digest 365. BS EN 752-4 : 1998 suggests a storage volume equal to 20mm multiplied by the area to be drained.

Guidance on soakaway for single house development ⁽¹⁾		
Number of units	Storage volume (m ³)	Max area to be drained (m ²)
1	0.19	19.0 ⁽²⁾
2	0.38	25.0 ⁽²⁾
3	0.57	28.5 ⁽³⁾
4	0.76	38.0 ⁽³⁾
5	0.95	47.5 ⁽³⁾
6	1.14	57.0 ⁽³⁾

Table 13

- (1) When doubt exists over suitability of ground for infiltration permeability figures should be derived by test (see BRE Digest 365).
- (2) In accordance with Approved Document H3 (refer to 1.1 page 10).
- (3) In accordance with BS EN 752-4 : 1998, Clause NG 2.4.

When the BRE or CIRIA approach is used, the design volumes and areas for trench or cuboid type installations can be found from Tables 14 and 15.

Volumetric data per linear metre for one cell (0.5m) wide trench configuration			
Number of cells high	Storage volume (m ³)	Side areas (m ²)	Base area (m ²)
1	0.19	0.8	0.5
2	0.38	1.6	0.5
3	0.57	2.4	0.5

Table 14

Volumetric data for 3D usage - two cells high									
Cells long (1m side)	2 wide (0.5m side)			4 wide (0.5m side)			8 wide (0.5m side)		
	Vol m³	Side m²	Base m²	Vol m³	Side m²	Base m²	Vol m³	Side m²	Base m²
1	0.76	3.2	1.0	1.52	4.8	2.0	3.04	8.0	4.0
2	1.52	4.8	2.0	3.04	6.4	4.0	6.08	9.6	8.0
4	3.04	8.0	4.0	60.8	9.6	8.0	12.16	12.8	16.0
8	6.08	14.4	8.0	12.16	16.0	16.0	24.32	19.2	32.0
10	7.60	17.6	10.0	15.20	19.2	20.0	30.40	22.4	40.0
100	76.00	161.6	100.0	152.00	163.2	200.0	304.00	166.4	400.0

Table 15

Concrete ring converter

Table 16 enables the conversion of a specified nominal diameter pre-cast concrete ring soakaway volume into the equivalent number of Polystorm Lite and Polystorm cells.

Concrete Ring conversion						
Depth of soakaway	900	1050	1200	1300	1500	1800
0.25	1	2	2	2	3	4
0.50	2	3	4	4	5	7
0.75	3	4	5	6	8	11
1.00	4	5	7	8	10	14
1.25	5	6	8	10	12	17
1.50	6	8	10	12	15	21
1.75	7	9	11	14	17	24
2.00	7	10	13	16	20	27
2.25	8	10	13	16	20	29
2.50	8	11	14	18	22	31
2.75	9	12	16	20	24	34
3.00	11	14	18	21	28	41

Table 16

4.9 General layouts - typical arrangement of Polystorm structures and manifolds

Typical arrangement

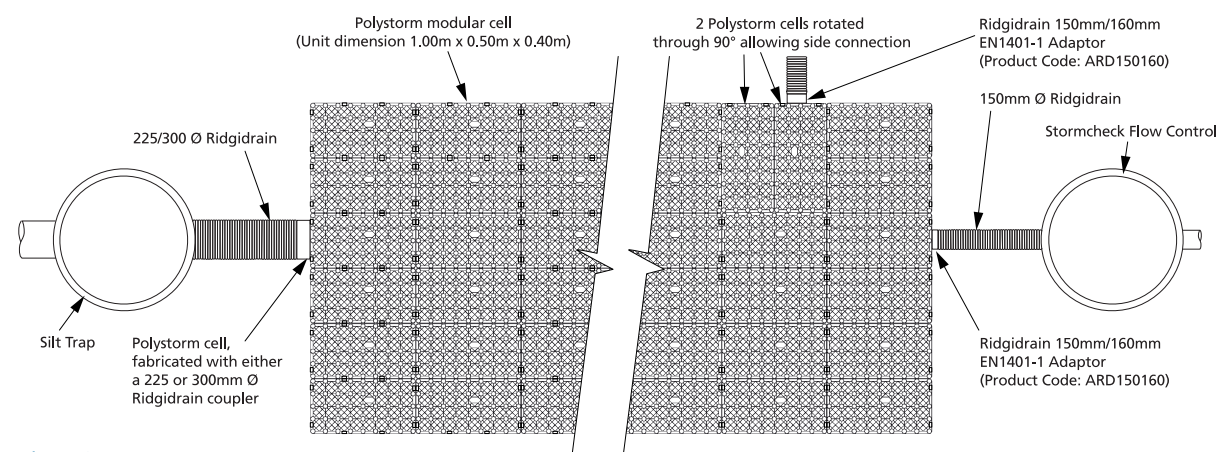


Figure 27

Cross section view of typical arrangement

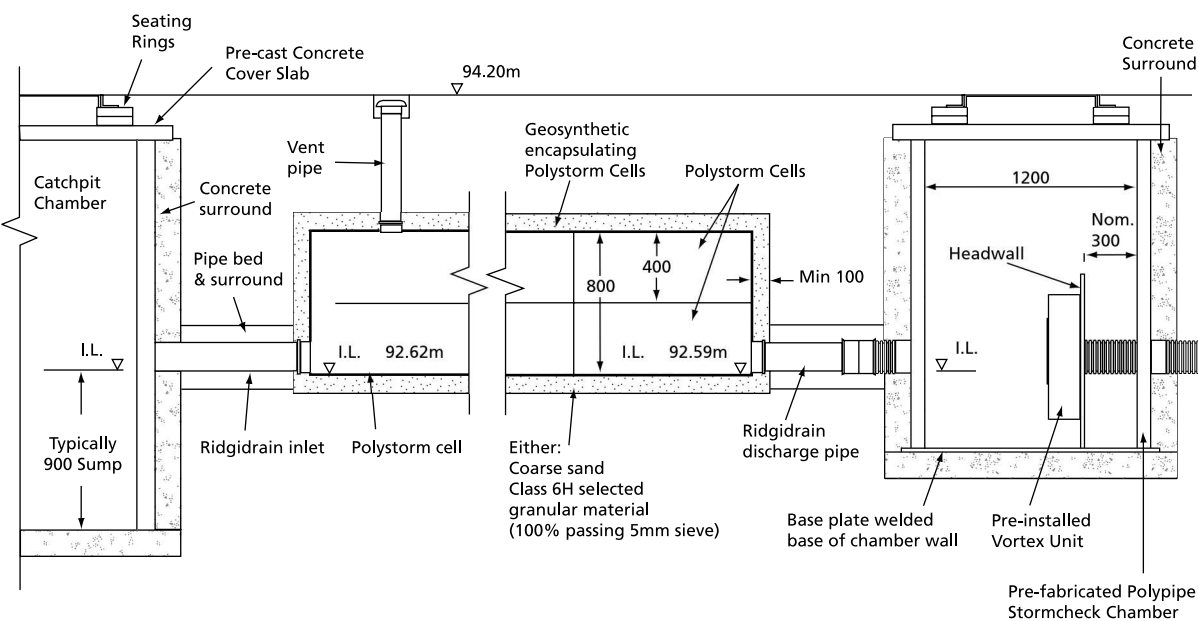


Figure 28

Example of offline solution

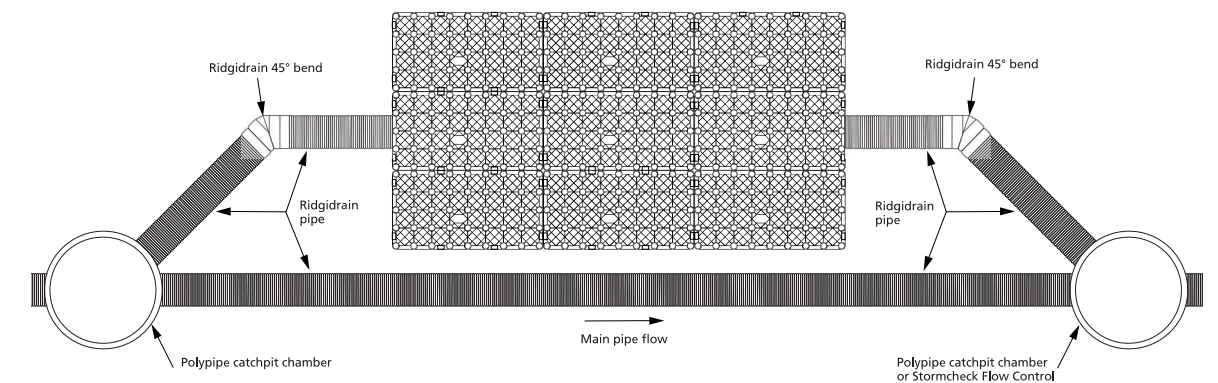


Figure 29

Example of offline solution

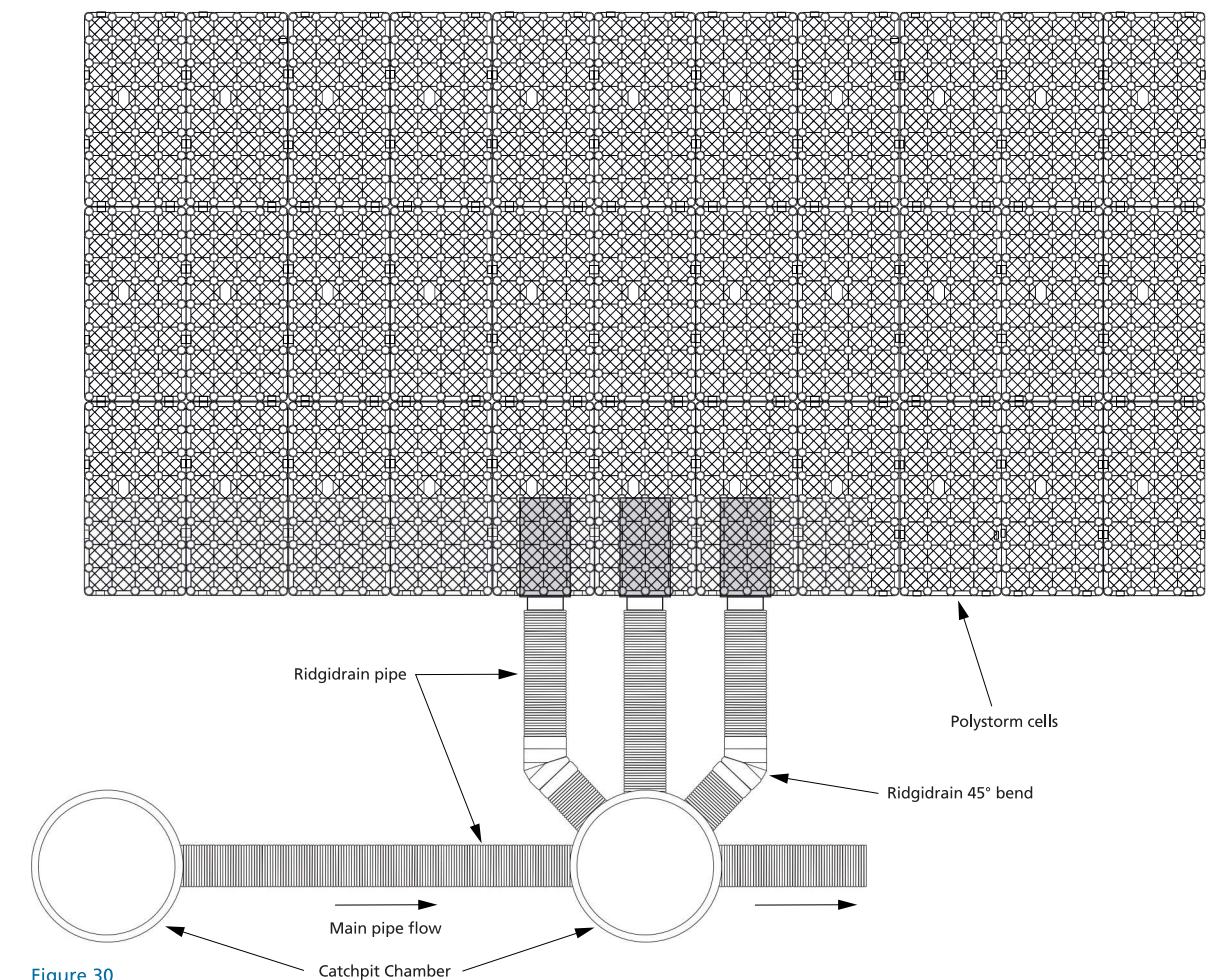


Figure 30

5.0 Installation - for attenuation and soakaway systems



The following section outlines site best practice for the installation of Polystorm Lite and Polystorm

Installation

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