SuDS in Schools

SuDS Planter Design Report

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Contents

Introduction

The SuDS in Sutton's Schools (SiSS) Project is a partnership project between the London Borough of Sutton and the South East Rivers Trust, funded by Thames Rivers Trust and the Environment Agency. The primary aim of the project is to alleviate flood risk within Sutton by retrofitting Sustainable Drainage Solutions (SuDS) on school grounds.

In a series of summative reports, the Trust aims to share the expertise and lessons learnt through the various contributions the organisation made to the project; supporting other SuDS in School initiatives in the future.

1. **SuDS Planter Design**
2. **SuDS Planter Installation**
3. **Rain Garden**
4. **Education & Engagement**
5. **Monitoring**

All reports can be found and downloaded from the South East Rivers Trust website:
www.southeastriverstrust.org/sudsinschools/

Information on the future of the SiSS Project can be found on Sutton Council's website here:
https://www.sutton.gov.uk/info/200670/environmental_sustainability/2028/suds_in_sutton_schools

Although rain gardens were investigated (see the **Rain Garden Report**), for this project, the South East Rivers Trust exclusively designed and installed SuDS planters. This report outlines the design process for these planters which ensured that their contribution to the overall flood risk benefits could be calculated and justified. Existing guidance, where available and relevant, was referenced throughout the design process to ensure all design decisions were well informed and supported by existing evidence and experience. In particular, the SuDS Manual and Guidance on the Construction of SuDS, both produced by CIRIA, were consulted to inform planter specifications.

Additional expertise has also been sought from SuDS designers, engineers and landscape architects.

Planter Materials and Locations

In the first phase of the project, some of the planters delivered by the Council contractors were constructed of wooden sleepers and some were constructed of brick. These materials have the advantage that they can be built in various shapes and sizes. However, wooden planters have to be treated carefully to ensure their longevity under wet conditions and the brick planters proved to be very expensive. Therefore, it was decided that other options would be trialled.

Recycled plastic was used for most of the planters delivered, chosen for these reasons:

- It can be used like timber to create different shapes and sizes
- It is hardwearing, maintenance-free and durable – even under wet conditions
- Sustainability – pupils liked it in particular because of its eco-credentials, diverting waste from landfill
- It is a material that has been tried and tested in schools - school management liked it because it matched other playground features on site such as picnic benches.

Galvanised steel troughs were also used and were chosen because:

- No assembly was required

- Large sizes were available
- It is hardwearing, maintenance-free and durable – designed to hold large volumes of water
- Low cost.

Originally it was planned to use the recycled lumber in more creative designs – for example by designing a series of cascading planters or hexagonal designs. Custom-made features increase costs and lead-in times significantly. For this reason, it was decided to use off-the-shelf options which were then adapted into school-friendly SuDS features.

Planter Fill Materials

Layers

Each planter consists primarily of a storage area, planting medium and top dressing. A transitional layer is present between the storage area and planting medium to prevent soil ingress into the storage area. Figure 1 provides an illustration of these layers.

The depth of fill was constrained by the height of the planter installed at each location. The aim was to find a happy medium between maximising the depth of planting layer to ensure healthy plant growth and the depth of the sub-base/storage layer, in order to maximise the volume of storage available within the planter.

For this reason, 750 mm (0.75 m) high planters were chosen for all recycled plastic planters, as opposed to a 600 mm (0.6 m) option. When making this choice in planter height, the average height of the children at each school was taken into account to ensure that the planters were as accessible as possible. The maximum height for the metal troughs was 610 mm. For these planters, the storage layer was reduced to maintain a sufficient planting medium depth.

Soil

The planting layer should have sufficient permeability to allow adequate drainage whilst also including enough organic content to support healthy plant growth. The SuDS Manual states that the permeability of soil filter material should be 100-300 mm/hr and should have an organic content of 3-5% weight for weight (w/w).

The SuDS Manual suggests use of an engineered soil, or if local soil is of suitable quality, a mix comprising 55% sand, 30% existing soil and 15% compost can be used. As getting the right mix of soil was so important, advice from SuDS specialists and a landscape architect was sought. As a result, a mix of 60-70% soil with 30-40% green waste compost was used.

The landscape architect advised on a soil which leant more towards supporting healthy plant growth, rather than maximising infiltration rates through a high sand content. A soil with approximately 60% sand content was recommended. However, sourcing such a soil proved difficult and ultimately a soil with a sand content as close to this as possible was selected (77% sand).

For all planters the planting layer was at least 350 mm in depth.

Storage Layer

As outlined above, a minimum planting layer of 350 mm was recommended. With a freeboard from the surface of the planter to the overflow pipe of approximately 50 mm (0.05 m) and further 50 mm gap to the top of the planter, this would leave approximately 300 mm for a sub-base / storage layer.

The advantage of using geocellular crates in the planters was a good volume of storage could be achieved, whilst limiting the depth of the storage layer, allowing a thicker depth of planting medium to be used. Typically 250 mm depth of geocellular crates was used with approximately 400 mm of planting later, compared to 300 mm depth of gravel and 350 mm of planting layer (further detail is provided in Table 1 and Table 2). The former option was preferred as it was viewed as beneficial for the plants to provide a deeper planting layer.

Transition layer

A permeable geotextile membrane was chosen as a transition layer between the storage layer and planting medium. The SuDS Manual highlights that in some cases there is a potential for such membranes to clog, and therefore careful selection of the membrane type was necessary. A non-woven membrane with relatively large pore size was selected (140 µm Characteristic Pore Size +/- 42.00 µm).

Top Dressing

A final top layer of 20 mm gravel was spread over the surface of the planter to a depth of 30 mm-50 mm, to prevent erosion and suppress weed growth.

Figure 1. Completed planter, with illustration of internal planting layers. In this example, geocellular crates were used as a sub-base/drainage layer.

Planter Locations

Off-the-shelf recycled plastic planters and galvanised steel troughs come in a maximum size of approximately 3 m x 1.2 m (of varied depths). There are risks with planters larger than this, such as the potential to not withstand the load and the runoff would not be evenly distributed throughout. Therefore, locations were chosen where planters of these dimensions could provide the required capacity (justification outlined below).

Planter Specifications

Planter Sizes

The area and volume of each planter was determined based on a number of factors, including:

- Storage requirements set out in existing plans created by Metis Consultants as part of the wider SiSS project
- Likely runoff volumes entering the planter, a factor of roof area and likely rainfall depths
- On-site constraints
- Available planter sizes and ease of construction.

The SuDS Manual states that typically the surface area of a bioretention feature would be 2-4% of the overall site area being drained, to prevent rapid clogging of the bioretention surface. Based on this guidance, the area of any planter (when looking down on it from above) would not be less than 2-4% of the roof area it was draining.

A key project objective was to maximise the storage of roof runoff and slow it down as much as possible. Therefore, where possible, the size of the planter was maximised.

Runoff Volumes

Runoff volumes entering each planter were calculated by multiplying predicted rainfall depths by the area of roof draining into the planter.

The area of roof draining into each planter was calculated using existing site plans, where available, as well as a combination of site visits, Google Earth and GIS. An example of roof area calculation is shown below in Figure 2. A conservative approach was taken when sizing roofs, with a preference to over-estimate roof size rather than under-estimate to reduce any risks associated with clogging of the planters.

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Figure 2. Approximate roof areas and downpipe locations in playground at Carshalton High School for Girls.

Predicted rainfall depths were based on high level estimates of rainfall depths for different return period events, outlined in the Susdrain Factsheet: ‘Designing attenuation storage for redeveloped sites’.

The return period is the likelihood of a particular sized rainfall event occurring in any given year. For example, a rainfall event described as having a 1 in 2 year return period is predicted to occur on average once every two years. It is noted that the rainfall depths predicted by the Susdrain factsheet are not region-specific and do not take the potential impacts of climate change into account, however they provide a useful indication of likely water volumes and were deemed appropriate for the project.

In the Susdrain factsheet, rainfall depths over a storm event are detailed as:

- 1 in 1-year event = approx. 12 mm
- 1 in 10-year event = approx. 26 mm
- 1 in 30-year event = approx. 38 mm
- 1 in 100-year event = approx. 56 mm

The predicted volume of water flowing into each planter was therefore calculated as:

Water entering planter = Rainfall Depth x Roof Area

If downpipe Number 2 from Figure 2 is used as an example, the following volumes of water coming off the roof can be predicted:

- 1 in 1-year event:

0.012 m (rainfall depth) x 24 m (roof area) = **0.29 m^3 (total volume of water)**

- 1 in 10-year event:

0.026 m (rainfall depth) x 24 m (roof area) = **0.62 m^3 (total volume of water)**

- 1 in 30-year event:

0.038 m (rainfall depth) x 24 m (roof area) = **0.91 m^3 (total volume of water)**

- 1 in 100-year event:

0.056 m (rainfall depth) x 24 m (roof area) = **1.34 m^3 (total volume of water)**

In reality a standard downpipe may not be able to cope with the amount of rainfall during larger, less frequent rainfall events, and therefore less water may enter each planter.

Calculating Planter Capacity

As shown in Figure 1, the majority of the planter volume is taken up by the drainage layer, planting mix and top dressing. Above the top dressing there is an area where water can pool – once the planter is full up – before spilling into the overflow pipe. The overflow pipe was set approximately 50 mm (0.05 m) above the surface of the top dressing (see Figure 1).

If the volume of each layer, as well as the amount of open space in each layer, is known then the total water storage capacity of the planter can be calculated.

The transition layer can consist of a thin layer of sand or geotextile and does not store much water. Similarly, the top dressing is thin and so is discounted in order to simplify the calculations.

The most commonly used planter was 3 m in length, 1 m wide and 0.75 m high. Two different types of sub-base/drainage later were used; geocellular crates and gravel.

Gravel

Where gravel was used as a sub-base or storage area, this was spread at a depth of approximately 300 mm (0.3 m). On top of that, the planter mix was spread at a depth of approximately 350 mm (0.35 m). This leaves approximately 50 mm (0.05 m) to the overflow pipe and a further 50 mm (0.05 m) to the top of the planter. Table 1 shows how the storage volume is then calculated.

Table 1. Dimensions and storage volume – Gravel Sub-Base Planter.

Features	Length (m)	Width (m)	Depth (m)	Void Space (%)	Storage Volume (m^3)
Gravel sub-base	3	1	0.3	30 approx.	0.27
Planting Medium (soil)	3	1	0.35	20 approx.	0.21
Planter Surface to Overflow Pipe Level	3	1	0.05	100	0.15
Total available storage					**0.63**

Geocellular Crates

Where geocellular crates were used as a sub-base or storage area, this was spread at a depth of approximately 250 mm (0.25 m). On top of that, the planter mix was spread at a depth of approximately 400 mm (0.4 m). This leaves approximately 50 mm (0.05 m) to the overflow pipe and a further 50 mm (0.05 m) to the top of the planter. Table 2 shows how the storage volume is then calculated.

Table 2. Dimensions and storage volume – Geocellular Sub-Base Planter.

Features	Length (m)	Width (m)	Depth (m)	Void Space (%)	Storage Volume (m^3)
Geocellular sub-base	3	1	0.25	95	0.71
Planting Medium (soil)	3	1	0.4	20 (high level estimate)	0.24
Planter Surface to Overflow Pipe Level	3	1	0.05	100	0.15
Total Available Storage					**1.10**

Tables 1 and 2 indicate that use of geocellular crates increase the potential storage capacity of the planters by approximately 0.5 m^3.

Pipework and Connections

The amount of water in the planters is based on the volume and rate of water delivered via the downpipe, the rate of infiltration through the planter, the storage volumes within the planter and the rate of water leaving the planter via the outflow. There will also be some input via rainfall directly onto the planter, and some uptake by plant roots, however this is expected to be relatively small compared to drainage in and out. It would also be very difficult to estimate these factors and so they were discounted.

Calculating Potential Flow Rates

To best inform the choice of pipework and connections, particularly in relation to sizing, estimation of the potential flow rates in and out of the planter was carried out.

Without extensive physical testing of flow rates through pipes of different sizes, estimation of potential flow rates was based on the Colebrook-White equation for pipe full flow[1] [2]. Pipe diameter, slope and material (roughness) are the inputs, with the flow rate at capacity estimated. The equation inevitably makes a number of assumptions, and returns values that are based on specific slopes.

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[1] https://tools.pipelife.com/Colebrook

[2] https://ingeniir.com/stormwater/colebrookwhitepipe

However, the equation is very useful to achieve a level of quantification for the pipe sizing and an understanding of how the planter may behave.

A slope of 1 in 200 was assumed for the inflow pipe and outflow pipe. The pipe material was set as plastic smooth bore.

Inflows

The inflow to the planter is primarily via the downpipe, with water distributed along the planter. Using a 68 mm plastic smooth bore downpipe as an example, a maximum flow rate of approximately 1.9 l/s (0.0019 m^3/s) is estimated. This is the greatest volume of water per second that could be transported into the planter via a downpipe of 68 mm diameter. Whether the downpipes ever become full will depend on the amount of rainfall and roof size. This value varies for different downpipe sizes.

Table 3. Estimated maximum flow rate for a 68 mm downpipe, with water distributed into planter via a pipe set at approximately 1 in 200 slope.

Diameter of inflow (mm)	Estimated maximum flow rate (litres per second)	Estimated maximum flow rate (cubic metres per second)	Estimated maximum flow rate (litres per hour)	Estimated maximum flow rate (cubic metres per hour)
68	1.9	0.0019	6840	6.84

Outflows

The planters are drained via a perforated drainage pipe running along the bottom of the planter. There is no definitive diameter to use for the internal pipework. The choice will influence the rate at which the planter drains, and is a balance between wanting to slow the flow from the planter into the surface water sewer network, and preventing the planter from reaching capacity too quickly and for too small rainfall events.

Other factors influencing how quickly the planter drains are the soil mix and therefore infiltration rate, impact of plants and soil conditions prior to any particular rainfall event will be important.

Again, the Colebrook-White equation was used to get a feel for the potential flow out of the planter.

Table 4. Estimated maximum flow rate for a 68 mm downpipe, with water distributed into planter via a pipe set at approximately 1 in 200 slope.

Diameter of outflow (mm)	Estimated maximum flow rate (litres per second)	Estimated maximum flow rate (cubic metres per second)	Estimated maximum flow rate (litres per hour)	Estimated maximum flow rate (cubic metres per hour)
30	0.21	<0.001	752	0.75
40	0.46	<0.001	1648	1.65
50	0.84	<0.001	3020	3

For the trial planter, a 50 mm diameter outflow pipe was chosen. However, on review and based on Table 3, it was decided that a 50 mm outflow pipe might drain the planters too quickly, meaning we do not slow the flow into the drain enough. A 32 mm diameter was ultimately chosen, as a 30 mm diameter pipe is not available. It was felt that it was important to limit the flow out of the planter to a reasonable level to maximise the potential for flood storage, especially where extra storage was provided by the geocellular storage. One hour after a rainfall event begins, up to 0.75 m^3 of water can drain from the bottom of the planter. Depending on the choice of storage layer, an additional 0.62-1.1 m^3 of water can be stored in the planter before it overflows. This means that over an hour following the beginning of a rainfall event, between 1.37 m^3 and 1.85 m^3 can enter the planter before water drains via the overflow pipe.

In reality the infiltration rate of the soil will have a notable impact of the volume and rate of water which can drain out of the bottom of the planter.

The overflow pipe diameter of 50 mm was chosen, allowing water to drain out of the planter more quickly, reducing the risk of water overtopping the planter edges.

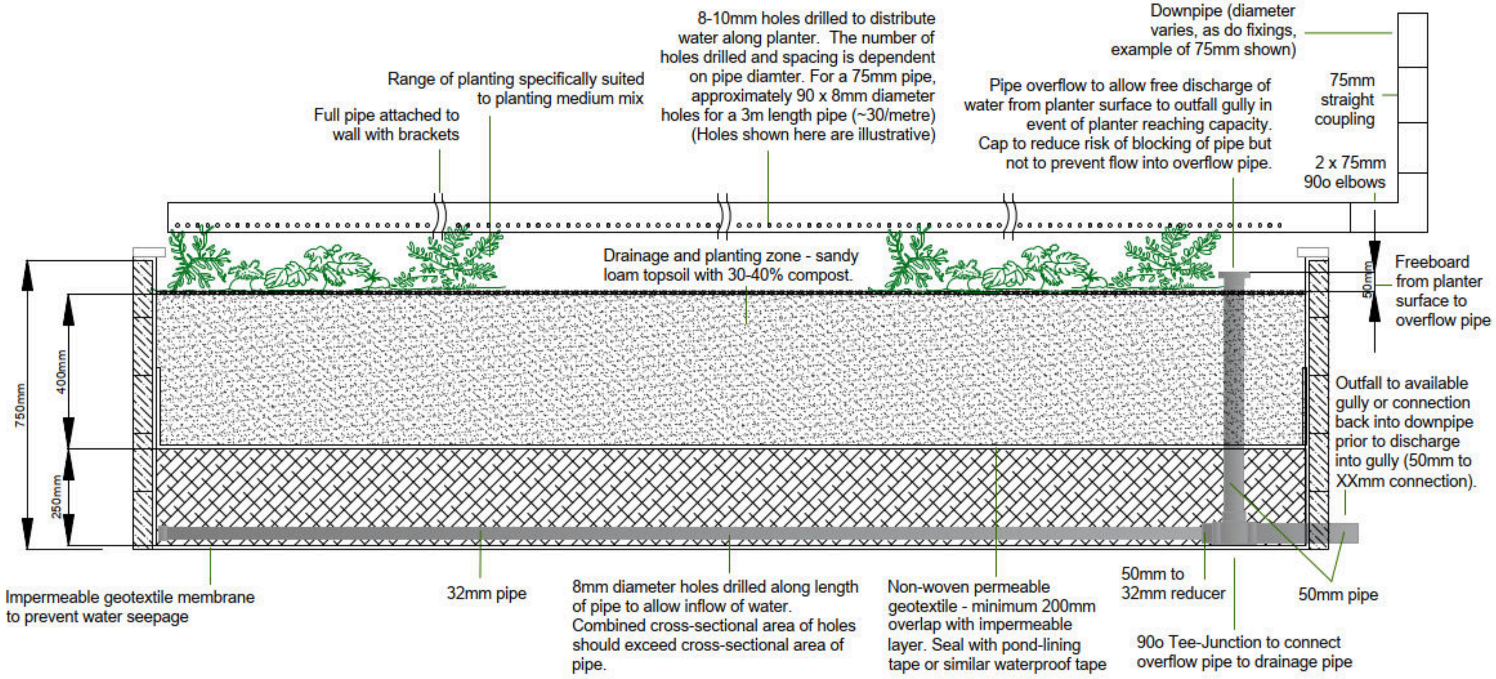
Internal Pipework

The internal pipework of the planters consists of the following features:

- A drainage pipe at the bottom of the planter to slowly drain the planter
- An overflow pipe to drain the planter from the surface in the event of particularly extreme rainfall resulting in the planter reaching capacity, or water not infiltrating quickly enough (this reduces the likelihood of the planter overtopping)
- An outfall pipe running out to the existing surface water gully.

Figure 3 shows the typical internal and external pipework for the planters. Water enters the drainage pipe at the bottom of the planter via several holes drilled along its length. Typically, 8 mm diameter holes were drilled into the pipe. The total cross-sectional area of the holes along the length of the planter should exceed the cross-sectional area of the pipe itself. This allows water to enter the pipe without being the limiting factor, and then the size of the pipe itself limits drainage from the planter. The size and number of holes was designed to provide a total cross-sectional area greater than the diameter of the drainage pipe itself.

The overflow pipe was designed with a 50 mm diameter to allow water to drain from the surface of the planter at a higher rate, to reduce the risk of the planter overtopping. As shown in Figure 3, the diameter of the pipe leaving each planter was set at 50 mm to allow the overflow pipe to discharge freely. The drainage pipe and overflow pipe meet at a junction before leaving the planter via this 50 mm pipe. This configuration allows slower bottom drainage and quicker surface drainage of the planter.



Drawing Title: SuDS in Sutton Schools - Rain Garden Planter Long Section	Date Drawn: 25/05/2021	Drawn By: EB
Drawing Reference: N/A	Scale: 1:10 at A3	Checked By: TH

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Figure 3. Illustrative Planter Long Section showing external and internal pipework

Connecting the Planter

For more detail on how downpipes were connected to the planters, the accompanying **SuDS Planter Installation Report** should be referred to. A summary of the overriding design principles is provided below.

The downpipe diameter, material and condition varied from site to site and this impacted the connections used. Typically, push-fit PVC piping was used, with the existing downpipe diverted by use of a 90^{o} connector, in turn connected to a section of full pipe running the length of the planter and fixed to the wall.

Holes were drilled into the full pipe to allow water to 'rain' onto the planter (Figure 4). As well as being visually appealing, this method means that water is distributed more evenly across the planter to the benefit of the plants, and with less force, meaning that erosion is less of an issue.

At one location a large amount of leaves and moss were being transported from the roof and deposited in the full pipe, blocking the distribution holes. In response, the pipe was turned approximately 5-10^{o} so that the holes were not at the bottom of the pipe, but at the side. This means that any debris settles at the bottom of the pipe and doesn't easily block the holes. A small number of drainage holes were drilled into the bottom of the pipe to drain any water sitting in the pipe below the level of the drainage holes.

At sites where significant amounts of material are expected to come off the roof, a 'leaf catcher' was installed on the downpipe upstream of the off-take to the planter to make maintenance easier. Otherwise the full pipe along the length of the planter can be periodically rodded to clear debris.

Figure 4. Planter with water 'raining' onto surface

Figure 5. Example of connection back into existing drainage

Monitoring the Planters

Existing guidance and specialist input has been consulted in the design of the planters. However, monitoring of the planters over time will provide the best evidence of the performance of the planters and their effectiveness in storing and slowing the flow of rainfall. The data will also help inform and improve future planter design.

A separate **Monitoring Report** provides details of the monitoring carried out as part of this project.

Landscaping

The planting schemes were developed with the assistance of an experienced SuDS landscape architect, Wendy Allen. Child-safe plant lists for these five different scenarios were provided:

- A mini-beast planter in part or full shade
- A bee/butterfly friendly planter
- A planter to provide year-round interest in full sun
- A planter to provide year-round interest in part shade
- A sensory garden planter with plants that look, sound, smell and feel nice.

Guidance on the size of plants to order, planting density, the inclusion of native species, adding features for wildlife and general advice for putting these together successfully into planting schemes was also provided. Using this guidance, landscaping plans were developed for each planter. These were created in response to both staff and pupil input.

Examples of this can be seen in the images below.

Figure 6. Mini beast features added at the request of the school’s Eco Council

Figure 6. Insect refuge for when pooling occurs on the surface of the planter

Figure 7. Bird bath, perch and feeders to give office staff the opportunity to spot birds while they work

Figure 10. A sensory garden including: flowering plants, soft seed heads, rustling grasses and dwarf hedges for topiary

Figure 11. Planters with benches to provide extra seating in an area used to eat lunches and planting schemes that provide year-round interest to enhance the space

Summary

The planter designs have been based on expert guidance and best practice where applicable. At the same time a number of innovations and adaptations have been required to successfully deliver the planters.

Monitoring will be carried out on two example planters to learn how the planters perform in different rainfall events, quantifying the performance of the planters in slowing the flow. Importantly, continued monitoring will allow important lessons to be learned in relation to design and performance, allowing improved design and delivery of planters in the future.

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