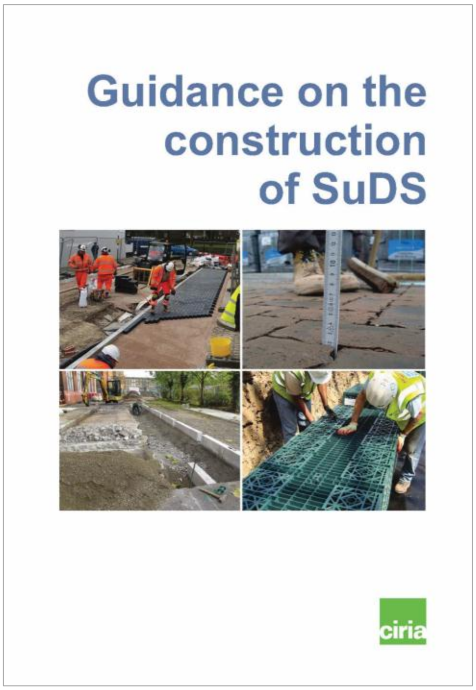

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Acknowledgements

ACO
CAPITA
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Why we did it

- SuDS knowledge has moved on
- Needed to be appropriate for its audience
- Companion document to the SuDS Manual
- Known inadequacies in SuDS construction

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Why we did it

- MAIN CHALLENGES
  - level changes
  - cut or fill
  - conflicts with services
- COMMON PROBLEMS
  - inadequacies in design drawings
  - recording of existing site information
  - additional hard surfaces
  - changes of materials
  - changes on site/poor construction
  - inexperienced contractor

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Industry Questionnaire

Why we did it

- Conflicts with areas of ecological importance
- Conflicts with tree root protection zones

■ AND GENERALLY WITH
- Visual quality
- Physical construction
- Functionality

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Industry Questionnaire

Considering particular difficult sites

■ SPECIFIC PROBLEMS DURING CONSTRUCTION

- groundwater (and groundwater source protection areas)
- unstable fill
- contaminated land
- steep slopes
- flat sites

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Industry Questionnaire

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G Case studies

H Appendices
Appendix A1

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1 November 2017

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simple English – few words – image rich

use of symbols – sharing knowledge – little jargon



Sue Illman, Illman Young Landscape Design and Steve Wilson, AECOM

Jargon busters

Jargon buster

- A **component** is a drainage feature that can take many different forms.
- **Exceedance flow** is the overflow of water from a drainage system that occurs when the rainfall is greater than the capacity of the system.
- **Infiltration** is where water is allowed to soak into the ground.
- **Interception** is preventing runoff from leaving a site for the majority of small rainfall events.
- A **management train** is a sequence of components that are connected together to drain surface water from a site.
- A **swale** is a SuDS component that is similar to a wide shallow ditch, but with a flat bottom.

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Sharing helpful information

Handy hint

Undertake a visual survey (including photographs or videos) of the site to ensure that what is shown on the topographic survey appears the same as seen on the ground, as there may have been site activity between the time of the survey and when work starts.

Watch point

Be aware that service plans from the utility companies are rarely accurate. Service locations will need to be confirmed on site before excavations (this should have been undertaken as part of the detailed design process).

Hold point

Starting work without all the necessary information creates risk for the project's successful delivery.

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Learning from other's experience

CASE STUDIES
- Mini-case studies within chapters
- Major case studies chapter


CASE STUDY 23.3 Misinterpretation of design drawings

During the construction of a retrofitted series of inter-connected SuDS, the design drawings specified the construction of a gabion basket filled with stone as an outlet detail. However, the design drawings were misinterpreted by the contractor and as a result the outlet was constructed as a solid section of mortar jointed granite setts, which inevitably blocked the flow of water into the lower basins.

As the SuDS was unable to function, it was necessary for the contractors to remove the outlet as constructed, and re-build it according to the original design drawings as a stone filled gabion basket.

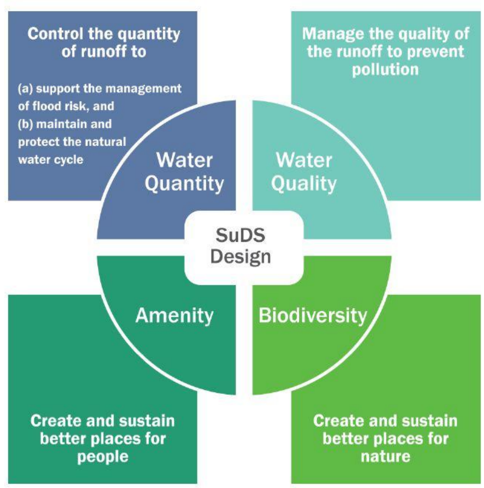
Lessons learnt

- It is vital that where the appointed contractors do not have good experience with SuDS construction, that the SuDS designer (or someone with the required understanding) is retained on the project. This will ensure that the contractor fully understands the design intent, so that components are constructed correctly and will fulfil their function.

Figure 23.12 'Outlet' blocking flow along the SuDS management train

Working with the SuDS principles

THE 4 PILLARS OF SUDS
- Maintenance of soil structure
- Maintenance of infiltration capacity
- Prevention of compaction, erosion, pollution, silt or sediments
- Difficulty of reinstating damaged soils
- Maintenance of existing vegetation/ecology



What's different about building SuDS?

HOW TO GET IT RIGHT

- Being properly prepared before starting – the site and the scheme
- Planning the works to get it right
- Planning to avoid potential site problems
- Managing the site and works during construction
- The typical challenges of specific SuDS components

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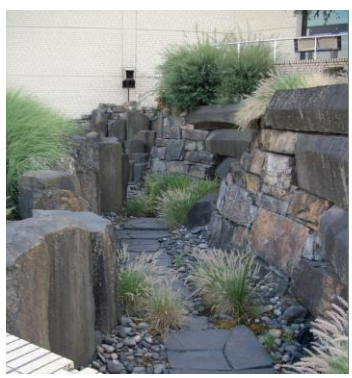
Traditional drainage and SuDS – the differences

A **Introduction**

Chapter 1 What are SuDS?
Chapter 2 What makes SuDS different?

- Hard and soft
- Multiple benefits
- Need for care in construction
- Why SuDS can affect construction planning



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The site and the scheme

B

Pre-construction

Chapter 3 Baseline information
Chapter 4 Understanding the design requirements
Chapter 5 Site considerations
Chapter 6 Pre-construction checklist

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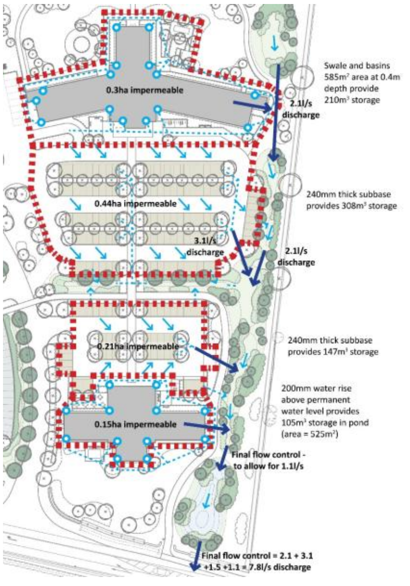
Pre-construction



BEING PROPERLY PREPARED

- Baseline information - the site
- Understand the scheme requirements
- Checking how the design works and the specification requirements
- On and off site considerations
- Pre-construction checklist

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The team approach

C — **Construction planning and programming**

Chapter 7 The site team
Chapter 8 Factors influencing phasing of SuDS construction works
Chapter 9 Getting the right materials for the job
Chapter 10 Site management planning checklist


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Construction planning and programming

PLANNING THE WORKS TO GET IT RIGHT

- The site team
- Understand the phasing requirements
- Getting the right materials for the job
- Site management planning checklist

TABLE 8.1 Construction phasing challenges for SuDS

Construction factors that affect phasing	Potential challenge for SuDS
Need for construction access	Can areas of pervious paving be used, if protected? Design should allow for the weight and amount of construction phase traffic. Are there limitations to the weight of construction plant allowed to run over attenuation tanks that have been installed?
Storage of topsoil and other materials	Open space areas are often used for compounds and material storage. SuDS areas may conflict with space needed for storage of soil or other materials. Stockpiles can influence movement of surface water across a site.
Major cut and fill undertaken early in the contract	If completed early, can the SuDS be maintained in good condition? Is there sufficient space on site to allow SuDS to be completed early?
Site drainage	Some SuDS may be used temporarily for site drainage, but will require full restoration before completion. Site drainage should not discharge into completed SuDS unless approved by the designer. Temporary outfalls may be required before full completion of the SuDS.
Procurement of planting	May need to pre-order plants to secure supply in-line with programme due to seasonal availability.
Procurement of materials and products	May need to pre-order materials or products that have lead-in times. The availability of aggregates, porous concrete or asphalt will depend on proximity to quarries and batching plants.
SuDS construction to be phased, but taking consideration of remediation works to deal with contamination	Excavation for SuDS should not take place after capping layer construction (or capping layer should be replaced as necessary below the SuDS).

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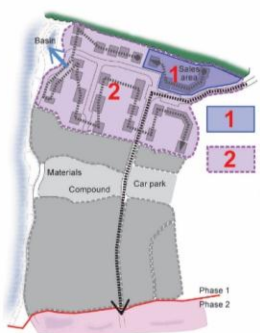
Project planning

TABLE 7.1 Roles within the SuDS construction team both pre-contract and during construction

From design through to construction		During construction							
Site designer		*Contract manager*		*Site manager*		*Foreman/site supervisor*		*Site operatives*	
Their input to traditional drainage construction	What will they do differently for construction of SuDS?	Their input to traditional drainage construction	What will they do differently for construction of SuDS?	Their input to traditional drainage construction	What will they do differently for construction of SuDS?	Their input to traditional drainage construction	What will they do differently for construction of SuDS?	Their input to traditional drainage construction	What will they do differently for construction of SuDS?
Employed after site layout is determined, but little input into it	Should be involved throughout the design development process to influence the site layout and enable SuDS to be incorporated effectively, and delivered as planned. SuDS should be designed for ease of construction.	Manage a single subcontract package for groundworks and road/sewer construction.	Manage several different packages that would normally fall outside drainage construction, from landscape to ground modelling.	Supervise a single subcontract package for groundworks and road/sewer construction.	Supervise and co-ordinate works for different subcontractors who may work only work on a single SuDS component or on different phases of construction.	Manages/supervises the day to day construction including trench excavation, pipe laying and backfilling, and manhole construction.	Day to day supervision of wide range of installations where levels, tolerances and details are the key to success, some of which may be unfamiliar.	Trench excavation, including pipe laying, backfilling, manhole construction etcetc	Requires a wide range of expertise from different operatives, from trench excavation and pipe laying, to paving construction, re-grading and planting
Drainage engineers model, design and specify the surface water system	Drainage design team will include a range of professionals, eg drainage engineers, architects, public health engineers, landscape professionals, ecologists, planners, sports pitch designers etc.	Surface water sewer construction is programmed as one of the first elements to be constructed.	Construction of the surface water management scheme (or parts of the scheme) is programmed to occur at various times throughout the construction process.	Manage construction of the surface water drainage as one of first items and use the system to drain the site during construction. Use sub-base as construction access/ platform.	Manage SuDS construction taking place throughout the development/ construction. Some SuDS may be located on roofs of buildings rather than at ground level. It may not be possible to use the road sub-base as a construction platform (if it is permeable).	Work to tolerances for drainage and designs – an area where they have a lot of experience.	Ensure that where tolerances are tighter for SuDS construction, that they are achieved.	Landscape contractor or subcontractor are not involved with drainage.	Landscape contractors working on a SuDS need to understand the requirements that may be different to traditional landscape practice (eg tighter tolerances may be necessary).
Scheme designed to adoption standards of sewerage undertaker, highways or local authority (LA)	Scheme designed to adoption standards of adopting body (which may be a wider range of organisations). Design to meet guidance in The SuDS Manual (CIRIA C753) is a common requirement.	Check construction drawings and design intent to ensure all material is in place to successfully construct the scheme.	Check construction drawings and design intent to ensure all material is in place to successfully construct the scheme. Required to check a wider/more complex range of materials.	Will need to consider the impact of construction activities on piped drainage system.	Consider impact of construction activities on SuDS or partially completed SuDS (eg muddy runoff running into swales, or cranes needing to access on top of plastic tanks). Programme temporary drainage measures where appropriate.	Required to work with a wider/more complex range of materials.	Ensure the site team are trained to build using unfamiliar materials or processes.	Limited input	Planting to soft SuDS, requires an understanding of the specialised soils needed for different components.
Limited input during construction as materials are well understood and changes have no impact on other aspects of development	Should be consulted when changes made to site levels, material specifications, etc are proposed, as some changes can have wider implications (eg on physical appearance or performance of landscape).			Ensure drainage runs do not conflict with tree planting – which can result in tree planting being changed on site.	Supervise and understand the requirements for soft SuDS planting to ensure it can be installed as per construction drawings/ specification.				



1 — **Sales area and show home completed first**

2 — **First group of units – Areas 1 and 2**

Drained by piped system to basin with geocellular units below it to increase capacity within limited areas.

Basin installed during first operation on site with drainage and road infrastructure.

General considerations:

- basin needs to be used for construction runoff – needs silt management.

5, 6, 7 — **Areas 5 and 6**

- Drains to swales and basin in POS.
- Temporary connection not practical for this area.
- Cannot be completed until site facilities are relocated and SuDS in POS constructed.

- Remediation taking place in Phase 2 area not available for compound or materials storage during construction of phases.
- Not available for SUDS construction until after completion of units in Phase 4, 5 and 7 – temporary discharge required.

Figure 8.1 Site planning diagrams (contd)

3, 4 — **Areas 3 and 4**

- These will drain to basin and swales in public open space (POS) at completion.
- During construction and before SuDS construction, water will temporarily discharge to watercourse.

Considerations:

- suitable route for temporary discharge
- connecting drainage to a temporary, and then a final, discharge point
- pollution control during construction.

HA — **Units for housing**

- Housing associations normally require a completed street scape before they will take possession of any units. This includes any concrete block paving to ensure the safety of residents.
- Concrete block permeable paving may not be suitable in these areas if it has to be laid before the completion of other areas.
- The main construction route will have mud on it at times, which could get tracked into side roads and clog the permeable surface.
- Basins and swales will also have to be completed in the POS before occupation.

Key

Main construction access

Should be solid surfacing during construction. If a permeable finish is required, this is to be laid post-construction (see Part E, Chapter 24).

1→6 **Build sequence and direction of build in each area**

- To be based on the sales plan for the site, which determines the number and type of units to be built each year.

Swales and basins within POS

- Areas required for site offices, compound, materials storage and parking for site staff.
- Not available for SuDS construction until Phase 2 is released by the remediation contractor and site facilities can be relocated.

Temporary discharge until final SuDS is constructed

Direction of surface flow to SuDS features

Considerations:

- presentation of the public frontages for sales
- infrastructure in place to allow the planned number of units to be completed
- cranes used throughout the site for lifting roof trusses etc into place
- crane movement over geocellular tanks and permeable sub-base required – especially in areas not designed for HGV traffic in the final layout
- stability over geocellular tanks and permeable sub-base required during lifting operations (see Part D, Chapter 12)
- SuDS are required to fit around these issues.

Managing the site

D **Site management**

Chapter 11 Managing soils on site
Chapter 12 SuDS and site access
Chapter 13 Managing site erosion and silt on site
Chapter 14 Establishing planting

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Managing the site

AVOIDING WHAT CAN GO WRONG

- Managing soils
- SuDS and site access
- Managing soil erosion and site silt
- Establishing planting

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1

Getting it right

Area to be used for soil storage heap should be free draining and not prone to flooding, site or sediment flows, or be close to an area used for disposal of site-waste materials. Soil should not be sited within the protected root zone of retained trees.

What can go wrong

Soil structure and nutrient content can be damaged by flooding.

Site waste could contaminate soil and prevent plant growth or kill plants.

Soil heap could damage the root zone of retained trees.

Soil poorly and inappropriately stored within retained tree root zones

2

Getting it right

Area for soil heap should be cleared of weeds or other site materials before depositing soils.

What can go wrong

Contamination can occur by perennial weed roots – even very small fragments of root can infest stockpiles.

Area designated and prepared before soil is deposited

3

Getting it right

Ensure that soil stripping and stockpiling is not carried out in very wet conditions.

What can go wrong

Soil structure damaged and soil organisms killed.

Soil stripped and deposited in good weather conditions

4

Getting it right

Ensure topsoil is not contaminated by other excavated site materials.

What can go wrong

Quality of topsoil is reduced and will require remediation/screening before use

Topsoil contaminated by other materials and poorly stored

5

Getting it right

Soil is laid in layers not exceeding 600 mm, and lightly consolidated. Height no greater than two metres overall.

What can go wrong

Soil structure can be damaged and soil organisms killed.

Heavily compacted soil lacks oxygen and soil organisms (grey colour). Soil structure has been damaged

6

Getting it right

Shape soil heap to shed water at gradients (ideally) no greater than 1 in 2.

What can go wrong

Water ponding on top of heap can cause washouts.

Topsoil stockpiled at steep gradient to shed water

7

Getting it right

Where soil is to be stored for an entire growing season (March to September), soil heap is sown with a clover or low maintenance grass seed mix to prevent weeds growing and seeding on it.

What can go wrong

Soil becomes contaminated with weeds (root fragments or seeds), causing weed problems when reused on site.

11.3 CHECKLIST FOR MANAGING SITE SOILS

The following list should be used as the basis for on-site checks, but should be amended to suit the site requirements and its specification.

TABLE 11.1 Pre-construction checklist

Pre-construction checklist	✓
Location of soil heap is appropriate, and not subject to surface water flows, site sediments or silts	
Area for soil stockpile has been cleared of weeds and/or other site materials before depositing soil	
Weather conditions before stripping and stockpiling operations, and cease activities during and immediately after heavy rainfall	
Overall height of soil heap is no greater than two metres, profile to shed water, angle of bank slope (ideally) not greater than 1 in 2, and that it is adequately consolidated, but not compacted	
Soil heap has been sown with a ground cover, and that cover is adequate to prevent weed infestation	
Outcome of soil test before reuse and that appropriate fertilisers are used to improve the soil to the specified standard	

SuDS and site access

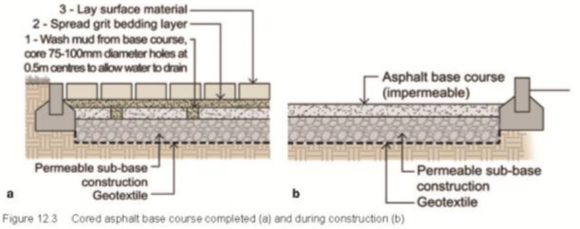

Figure 12.3 Cored asphalt base course completed (a) and during construction (b)

This process prevents mud/site material blocking the permeable base. It is then filled with granular material to allow drainage, before final permeable finish

Figure 12.1 Cleaning the asphalt layer before coring

Figure 12.2 Sacrificial sub-base layer allows use of permeable sub-base for parking during construction

Managing soil erosion and silt


Figure 13.1 Mud being spread by vehicles or from soft surfaces onto permeable paving

Figure 13.2 Muddy runoff washing into SuDS

13.2 CHALLENGES RELATED TO MANAGING EROSION OF SUDS

These challenges primarily occur on slopes, or where the velocity of water is strong enough to cause erosion. Where erosion of the soil surface occurs, silt is washed down the system and surfaces are damaged.

1 Getting it right

Make sure all areas of the SuDS are ready to receive water before allowing it to flow into them. Use turf on areas of soil intended to take water if they need to be used before they become fully established and pin it down.

What can go wrong

Erosion of banks and bed could occur if planting is not established or erosion protection not supplied.

Grass to base of swale failing due to lack of time to establish

2 Getting it right

Use erosion control mats or fencing over higher/steeper side slopes to allow grass or other vegetation to establish. (Note this also applies to soil slopes near to SuDS, especially pervious surfaces, to prevent soil washing onto the surface).

What can go wrong

Soil erosion through washouts down slopes, which can also damage planted areas on the slope. Gullies form, and plants or paving become buried in silt at the foot of the slope.

Washout from banks causing silt build up on paths


Handy hint

Use turf and pin it down to prevent slippage if areas need to take water before the grass has fully established.

13.3 CHALLENGES RELATED TO MANAGING SILT

Silt can arise from erosion in the SuDS or from nearby areas of soft landscape and from general muddy water on site.

1 Getting it right

Keep areas of exposed soil near to the SuDS or draining towards it to a minimum.

What can go wrong

If soils are not protected or established with vegetation, erosion will occur causing silt to be washed out.

Soil washed down slope, creating flow channels

2 Getting it right

Where earthworks leave exposed soil, form slopes to collect water in temporary areas where silt can be managed. Alternatively use silt fences.

What can go wrong

Erosion will occur causing silt to be washed out.

Using SuDS basin to collect silt

Establishing planting

- Why you should plant early
- How plants/grass contributes
- Why plants die
- The 5 stages to planting

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E

Constructing and inspecting SuDS

Chapter 15 Introduction to Parts E and F
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Key factors

Chapter 17

Assessing the impact of variations

This chapter provides information on how to assess the potential impacts of contract variations on SuDS.

17.1 INTRODUCTION

Variations are a normal part of a construction contract, but some have the potential to seriously affect the performance, visual quality, maintenance regime or safety of SuDS. Variations should be reviewed both for their direct effect and their potential knock-on effect on entire systems, to ensure that either this does not happen or that risks are minimised.

17.2 QUESTIONS TO ASK

The following potential variations will need to be checked and confirmed by the original SuDS designer as appropriate, or novated/contractor or employed designer, who has a full understanding of the SuDS, how each part operates, and its overall expected design performance.

TABLE 17.1 Things to consider when addressing contract variations

Variation proposed	Check
Increase in hard surfaced area	Are the new areas pervious or impervious? Does the adjacent and downstream part of the component have sufficient capacity for an increased impermeable area? If the outflow is controlled to a specific discharge, then find out whether the control device needs checking/changing.
Changes in levels	Will the new SuDS gradients still work? Are the bank gradients stable and safe? Has the capacity and ability to manage runoff rates and volumes of the component reduced? If the area is permeable, will the change in gradient still conform to the maximum allowed for percolation through the surface? Changes in water levels will affect the performance of flow controls.
Additional cut material to be disposed of on site	Will it change levels or bank gradients to the SuDS? Will the drainage gradients still work? Will they still be safe and stable? Has the capacity of the component reduced? Is the additional material suitable/similar to other site soils?

TABLE 17.1 Things to consider when addressing contract variations (contd)

Variation proposed	What needs checking
Substitution of proprietary products or materials	Will these perform to the same standards as those originally specified? Are they as long lasting? Are there knock-on effects to other materials or the construction process that will increase costs? Are there more difficult or different maintenance requirements?
Substitution of plants or seed mixes	Will the substituted plant or grass species grow in the conditions likely to be found in the SuDS? Does the change of planting affect its visual quality throughout the year? Will the changes affect the agreed maintenance plan?
Changes in works programming/ sequencing of operations	Can the planting still be completed at the appropriate time of year? Will the necessary plants be available? Will they be able to establish sufficiently before the SuDS are used? Will seeding need to be substituted for turf in the base of SuDS if works are to be completed in winter?
Value engineering or inadvertent change	Will they affect the capacity/quality of the SuDS? Will its performance or safety be undermined? Will the changes affect the agreed maintenance plan or the service life?

Other unanticipated changes, such as the discovery of unmapped services, below-ground structures or contamination may also necessitate variations. Where such changes require a fundamental design change then the entire system should be re-evaluated by the designer to ensure it can still deliver the original design criteria for quality, quantity, amenity and biodiversity. These changes may also affect both the project programme and the nature of the works to be undertaken, so there may need to be a more comprehensive project review including the Construction Method Statement.

Watch point

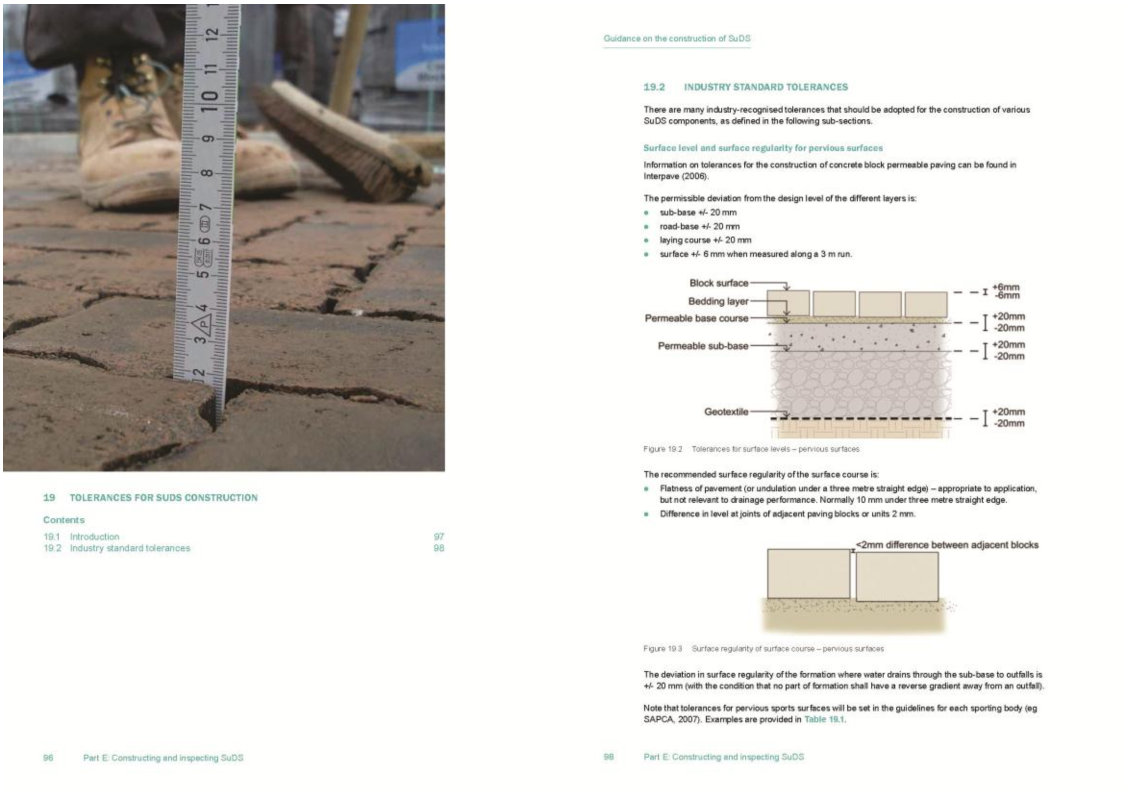
Check whether contract variations will negatively affect the SuDS.

Value engineering or inadvertent change should not affect the storage capacity or quality of the system, its performance or safety. Value engineering should not be a cost-reduction exercise. The process should consider alternative solutions and identify and eliminate unwanted costs, while improving function and quality.

Watch point

Generally a component or proprietary system that conforms to a British, European or International Standard, or one that has been independently certified through a recognised national or international verification scheme, should be used in preference to an independent assessment of the supplier or manufacturers' claims. Where no independently-assessed components are available, it is important that the supplier or manufacturer's claims are assessed by the SuDS designer and/or approving or adopting body. Even where a system is certified by a national or international verification scheme (eg BBA certificates) the restrictions and requirements for use stated in the certificate should be assessed against the specific design. For example many BBA certificates for geocellular tanks have restrictions on the loads that can be applied to the tank and the depth of installation.

Sue Illman, Illman Young Landscape Design and Steve Wilson, AECOM


19 TOLERANCES FOR SUDS CONSTRUCTION

Contents

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19.2 Industry standard tolerances 98

19.2 INDUSTRY STANDARD TOLERANCES

There are many industry-recognised tolerances that should be adopted for the construction of various SuDS components, as defined in the following sub-sections.

Surface level and surface regularity for pervious surfaces

Information on tolerances for the construction of concrete block permeable paving can be found in Interpave (2006).

The permissible deviation from the design level of the different layers is:

- sub-base +/- 20 mm
- road-base +/- 20 mm
- laying course +/- 20 mm
- surface +/- 6 mm when measured along a 3 m run.

Figure 19.2 Tolerances for surface levels – pervious surfaces

The recommended surface regularity of the surface course is:

- Flatness of pavement (or undulation under a three metre straight edge) – appropriate to application, but not relevant to drainage performance. Normally 10 mm under three metre straight edge.
- Difference in level at joints of adjacent paving blocks or units 2 mm.

Figure 19.3 Surface regularity of surface course – pervious surfaces

The deviation in surface regularity of the formation where water drains through the sub-base to outfalls is +/- 20 mm (with the condition that no part of formation shall have a reverse gradient away from an outfall).

Note that tolerances for pervious sports surfaces will be set in the guidelines for each sporting body (eg SAPCA, 2007). Examples are provided in Table 19.1.

Tolerances

- The appropriate specification and tolerances
- Paving falls/levels
- Materials – aggregates/ geomembranes etc
- Porosity/infiltration

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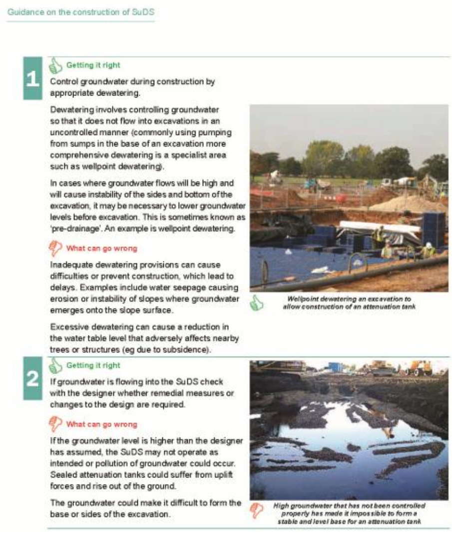
The key to inspections

Difficult sites – high groundwater

- Need for forward planning
- Appropriate scheme
- Managing water flows into the excavations


Guidance on the construction of SuDS

1 Getting it right

Control groundwater during construction by appropriate dewatering.

Dewatering involves controlling groundwater so that it does not flow into excavations in an uncontrolled manner (commonly using pumping from sumps in the base of an excavation more comprehensive dewatering is a specialist area such as wellpoint dewatering).

In cases where groundwater flows will be high and will cause instability of the sides and bottom of the excavation, it may be necessary to lower groundwater levels before excavation. This is sometimes known as 'pre-drainage'. An example is wellpoint dewatering.

What can go wrong

Inadequate dewatering provisions can cause difficulties or prevent construction, which lead to delays. Examples include water seepage causing erosion or instability of slopes where groundwater emerges onto the slope surface.

Excessive dewatering can cause a reduction in the water table level that adversely affects nearby trees or structures (eg due to subsidence).

Wellpoint dewatering an excavation to allow construction of an attenuation tank

2 Getting it right

If groundwater is flowing into the SuDS check with the designer whether remedial measures or changes to the design are required.

What can go wrong

If the groundwater level is higher than the designer has assumed, the SuDS may not operate as intended or pollution of groundwater could occur. Sealed attenuation tanks could suffer from uplift forces and rise out of the ground.

The groundwater could make it difficult to form the base or sides of the excavation.

High groundwater that has not been controlled properly has made it impossible to form a stable and level base for an attenuation tank

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Difficult sites – contaminated land


1 Getting it right

Arrange safe excavation and disposal of contaminated soils in accordance with waste management legislation.

What can go wrong

Incorrect disposal to the wrong landfill site can result in prosecution, fines and/or imprisonment in the worst cases.

Placing contaminated soils in clean areas spreads the toxic materials and results in clean-up costs.

Excavation of SuDS basin in contaminated soils with geotextile separator and clean subsoil being placed

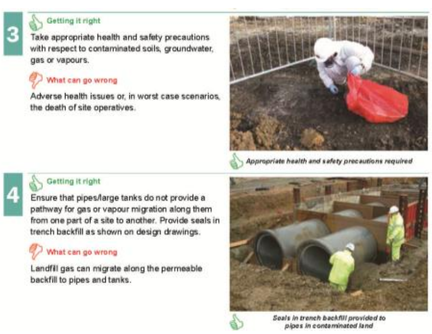
2 Getting it right

Make sure that excavation for SuDS is not digging through any capping layer provided to stop people coming into contact with contaminated soils.

What can go wrong

Capping layer is damaged by SuDS excavation and requires repair.

Excavating through a capping layer into contaminated waste


3 Getting it right

Take appropriate health and safety precautions with respect to contaminated soils, groundwater, gas or vapours.

What can go wrong

Adverse health issues or, in worst case scenarios, the death of site operatives.

Appropriate health and safety precautions required

4 Getting it right

Ensure that pipes/large tanks do not provide a pathway for gas or vapour migration along them from one part of a site to another. Provide seals in trench backfill as shown on design drawings.

What can go wrong

Landfill gas can migrate along the permeable backfill to pipes and tanks.

Seals in trench backfill provided to pipes in contaminated land

- Appropriate scheme
- Management of contamination if excavated
- Record keeping

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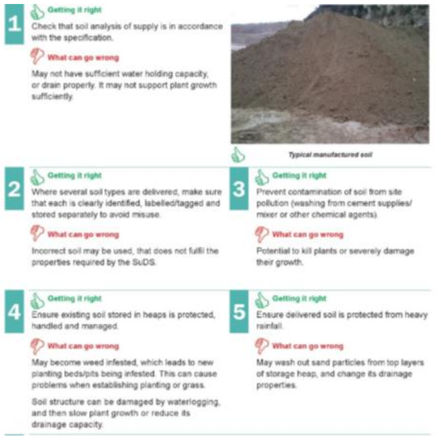
Soils

UNDERSTANDING THE DIFFERENT TYPES

- Natural
- Specialist
- Manufactured
- Bioretention or filter media
- Structural
- Engineered

…and why and where to use them!



1 Getting it right
Check that soil analysis of supply is in accordance with the specification.
What can go wrong
May not have sufficient water holding capacity, or drain properly. It may not support plant growth sufficiently.

Typical manufactured soil

2 Getting it right
Where several soil types are delivered, make sure that each is clearly identified, labelled/tagged and stored separately to avoid misuse.
What can go wrong
Incorrect soil may be used, that does not fulfil the properties required by the SuDS.

3 Getting it right
Prevent contamination of soil from site pollution (washing from cement supplies/ mixer or other chemical agents).
What can go wrong
Potential to kill plants or severely damage their growth.

4 Getting it right
Ensure existing soil stored in heaps is protected, handled and managed.
What can go wrong
May become weed infested, which leads to new planting beds/pits being infested. This can cause problems when establishing planting or grass.
Soil structure can be damaged by waterlogging, and then slow plant growth or reduce its drainage capacity.

5 Getting it right
Ensure delivered soil is protected from heavy rainfall.
What can go wrong
May wash out sand particles from top layers of storage heap, and change its drainage properties.

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Right soil right place

Inlets and outlets

MANAGING THE SYSTEM

- Pipe sizes
- Headwalls, weirs and flow controls

VISUAL AND MANAGEMENT ISSUES

- Visible and maintainable
- Aesthetically pleasing

1 Getting it right
Pipes and flow controls must be set at the correct levels.
What can go wrong
Storage may not operate correctly if outlet levels are set incorrectly.

Traditional headwall for pipes carrying high flows and SuDS headwall with smaller pipe carrying low flows

2 Getting it right
Construction of detailed finishes must be robust, eg flush concrete, stone or other surrounds to pipes. The cut ends of plastic pipe should be not be left exposed.
What can go wrong
System performance may be affected.
Finishes may be unsightly, which can lead to complaints.

Poor detailing makes this visually unacceptable

3 Getting it right
Ensure that design drawings are double checked for details and dimensions before construction.
What can go wrong
System unlikely to work as anticipated if the dimensions are not correct and may fail and cause flooding of development or excess flow from the site.

This notch in the brickwork weir should have had a steel plate built into it to control flow

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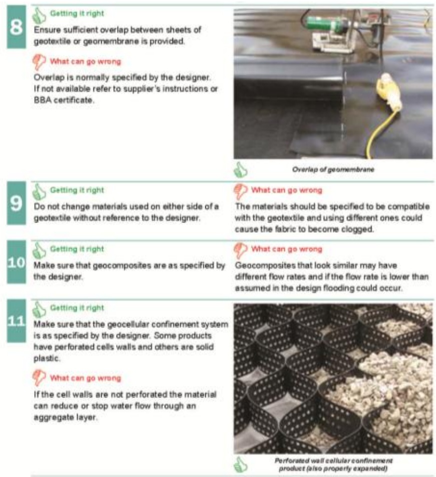
Managing flows and storage

Materials: geosynthetics and geomembranes

UNDERSTANDING THEIR USE
- Right product right place
- Specification and substitution

PERFORMANCE ISSUES
- Sequencing during construction
- Potential for damage
- Protection



8

Getting it right

Ensure sufficient overlap between sheets of geotextile or geomembrane is provided.

What can go wrong

Overlap is normally specified by the designer. If not available refer to supplier's instructions or BBA certificate.

Overlap of geomembrane

9

Getting it right

Do not change materials used on either side of a geotextile without reference to the designer.

What can go wrong

The materials should be specified to be compatible with the geotextile and using different ones could cause the fabric to become clogged.

10

Getting it right

Make sure that geocomposites are as specified by the designer.

What can go wrong

Geocomposites that look similar may have different flow rates and if the flow rate is lower than assumed in the design flooding could occur.

11

Getting it right

Make sure that the geocellular confinement system is as specified by the designer. Some products have perforated cells walls and others are solid plastic.

What can go wrong

If the cell walls are not perforated the material can reduce or stop water flow through an aggregate layer.

Perforated wall cellular confinement product (also properly expanded)

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Their role and usage

F

Construction and inspection of SuDS components

Chapter 25 Green and blue roofs
Chapter 26 Infiltration systems
Chapter 27 Proprietary treatment systems
Chapter 28 Filter strips
Chapter 29 Filter drains
Chapter 30 Swales
Chapter 31 Bioretention systems
Chapter 32 Trees
Chapter 33 Pervious pavements
Chapter 34 Attenuation storage tanks
Chapter 35 Detentions basins
Chapter 36 Ponds and wetlands

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SuDS components

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31.2 Challenges when constructing bioretention systems 187
31.3 Good practice checklist 191

Chapter **31**

Bioretention systems

This chapter considers the challenges that may arise when constructing bioretention systems (including rain gardens) and how to avoid them.

- *Information on the soils to be used in bioretention systems is provided in Part E Chapter 21.*
- *A construction checklist for bioretention systems is provided in Section 31.3.*
- *A complete set of construction checklists for all aspects of construction are provided in Appendix A1.*
- *Detailed guidance on the design and construction of bioretention systems can be found in The SuDS Manual (CIRIA C753) Chapter 18.*
- *General information on construction checklists can be found in The SuDS Manual (CIRIA C753) Appendix B6.*

31.1 INTRODUCTION

Bioretention systems are planted SuDS components that collect runoff from roofs or hard surfaces, allowing it to pond on the surface and slowly infiltrate into the ground, or connect into a drainage system. Bioretention systems also include components that have historically been known as rain gardens and stormwater planters, reflecting their use at both a domestic scale and within streetscapes. Bioretention swales are similar to under-drained swales but they are longer than pure bioretention systems and have the same surface profile as a swale (see **Part F Chapter 30**).

All systems (except the smallest domestic scale rain gardens) use an engineered soil as both a growing medium for the plants, and to allow water to filter easily through to the drainage system or infiltration surface beneath. They can be widely variable in their scale, appearance and design, although their construction complies with the same drainage principles. Where designed appropriately, these systems can provide significant water storage capacity and sufficient rooting areas for large trees in urban areas. Planting for bioretention systems should be tolerant of dry soil conditions as they are both free-draining, and likely to be dry much of the time. Also, filtering water through planted systems improves water quality.

Figures 31.1 to 31.8 illustrate the range of bioretention systems, and how they work.

Where water does not infiltrate, it is important that it is connected into a sub-surface drainage system to ensure that the rooting area of the vegetation drains effectively (over a 24 to 48 hour period). Plant roots that sit in water over an extended time are likely to die. An overflow may also be required to deal with storm events beyond the design capacity of the system.

Figure 31.1 Small domestic rain garden

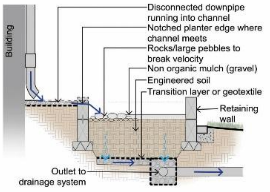

Figure 31.2 Cross section through rain garden

Figure 31.3 Bioretention planter

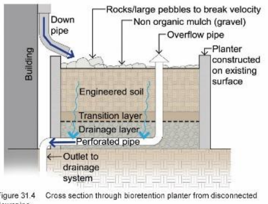

Figure 31.4 Cross section through bioretention planter from disconnected downpipe

Figure 31.5 Bioretention planter in street

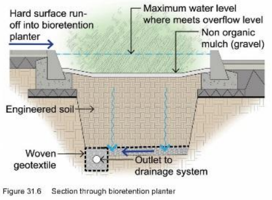

Figure 31.6 Section through bioretention planter

Figure 31.7 Bioretention swale

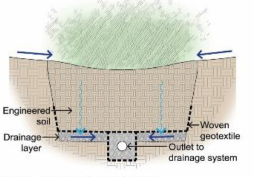

Figure 31.8 Section through bioretention swale

31.2 CHALLENGES WHEN CONSTRUCTING BIORETENTION SYSTEMS

Issues arising from constructing bioretention systems include the materials used, and their compliance to the specification and use within the system.

1

Getting it right

Ensure engineered soil mix, whether proprietary or mixed on site, complies with the particle size and proportions as specified.

What can go wrong

Too open a mix will drain too quickly, while insufficient organic content will not allow plants to establish properly.

Incorrect soil mix, does not drain sufficiently

2

Getting it right

Ensure depth of engineered soil mix is correct.

What can go wrong

System will not provide its designed storage capacity, or the soil volumes may not be sufficient for the specified plants or trees.

Bioretention system filled with specified engineered soil mix

3 Getting it right

Confirm geotextiles are as ordered/received (if used) and comply with specification for porosity.

What can go wrong

If too fine, geotextile may clog reducing water flow through geotextile causing water to be held back within planter. May cause flooding or kill the plants.

4 Getting it right

Transition zone material (if used) should be correct particle size and depth as specified – depth at least 100 mm.

What can go wrong

Insufficient depth or incorrect particle size will cause clogging and prevent effective drainage or it will be washed out and cause the system to stop working.

5 Getting it right

Ensure geotextiles are adequately lapped, and not damaged or torn.

What can go wrong

Silt may wash into drainage layer and clog aggregate reducing its discharge rate/cause it to back up.

Inspecting installation of gravel drain with geotextile wrapping

6 Getting it right

Check dams should be set at correct level and interval to allow designed volume of water to be stored.

What can go wrong

On sloping sites insufficient water will be stored.

Accumulating fall between check dams set at moderate intervals

7 Getting it right

Where an overflow system is provided, it should be set at the correct level (this may not be required for domestic-scale rain gardens).

What can go wrong

Extreme rainfall beyond capacity of system may flood local areas.

Overflow pipe connects to base drainage, with second overflow over the edge for extreme events

8 Getting it right

Only use plants as specified in correct numbers and sizes. Seek confirmation that plant changes are suitable species that meet the design requirements.

What can go wrong

Plants are likely to die if not suited to a system that is mainly dry and only wet when it rains.

Plant species and setting out inspected on site before planting

9 Getting it right

Ensure that mulches are not specified as organic loose materials – ideally gravel.

What can go wrong

Loose mulches can block overflows and will be washed down the system by water on the surface.

Surface mulched with gravel not bark

CASE STUDY 31.1 Poor levels in a rain garden

Figure 31.19 Level of soil above the level of inlets from road

The design for a rain garden showed a basin that had its base below the level of the nearby road with 1:3 side slopes. The design was not understood by the contractor who filled parts of the basin with topsoil to a level above that of the inlets from the highways. This prevented water from entering the rain gardens and removed much of the storage volume. Water could not reach areas where the basin had been constructed correctly. A scheduled inspection at the end of excavation was not completed and the biorientation was planted. The problem with the levels was discovered after the planting had been completed. The plants had to be removed and then replanted once re-contouring to the design profile was completed.

Lessons learnt

- The importance of site visits and hold points during construction, as well as ensuring shared understanding of the scheme between designer and contractor.

Jargon buster

- A **component** is a drainage feature that can take many different forms.
- A **forebay** is a small basin up-hill of a drainage component, designed to trap silt.
- **Infiltration** is the ability of the soil to absorb water.
- A **swale** is a SuDS component that is similar to a wide shallow ditch, but flat bottomed.
- **Engineered soils** are designed and manufactured to provide specific drainage and horticultural properties.

Constructing/installing bioretention attenuation storage systems or infiltration systems

Issues relate to lack of drainage, whether due to loss of infiltration in the soil or through inadequately installed piped systems.

Infiltration systems

1 Getting it right

Check base of the system before construction, and ensure the base is free draining to design capacity before filling with engineered soil mix. Remediate if necessary.

What can go wrong

Water will not drain or drains slowly, causing flooding, lack of storage and/or killing plants.

Attenuation storage systems

2 Getting it right

Ensure drainage pipe is provided in the base and connected to the downstream system.

What can go wrong

If incorrectly installed, water will not drain or only drain slowly, potentially causing flooding through, lack of storage and may kill the plants.

31.3 GOOD PRACTICE CHECKLIST

The following list should be used as the basis for on-site checks, but should be amended to suit the specific requirements of the site and SuDS component specification.

TABLE 31.1 Bioretention systems checklist

Bioretention systems checklist	✓
Where infiltration is required by the design ensure that permeability of natural soils is effective and delivers the design infiltration capacity	
Particle size of delivered engineered soils or individual soil elements for site mix comply with specification	
Depth of engineered soil is as designed/specified and undertake onsite permeability test to check soils drainage capacity	
Audit trail of changes to ensure revisions to scheme still fulfil requirements in-line with original scheme	
Graded filter or geotextile used, and compliance to specified materials/depth	
Piped drains are installed in base of system and connected to main drainage system correctly (not infiltration systems)	
Overflow system is in place, and functioning correctly	
Inspection tube installed correctly	
Plant sizes and species are supplied and located to the correct specification and design	
Organic soil mulches have not been used	
Specified components are in the correct place to break inlet velocity	
Where forebays are used, finished levels allow even flow of water into system	

Summary

- Informs design
- Improves communications
- Requires team working
- Helps overcome problems
- Achieves better outcomes
- Delivers good water management
- Helps prevent flooding

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