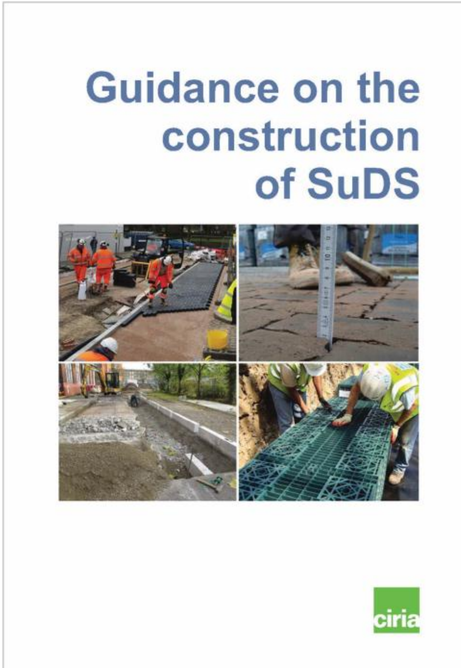

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C768 SuDS Construction Guidance

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The new SuDS Construction Guidance was launched on 1 November 2017 as document C768, which can be downloaded from the Susdrain website.

Acknowledgements

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This document has been supported by the collaborative funding of the companies shown above, without whose backing, it would not have happened.

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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Whilst the original handbook for SuDS Construction (C698) has been around for a long time, the understanding of SuDS design and construction has moved on, and is now much more comprehensive and robust, reflected in the new SuDS Construction Manual, published in 2015. This guidance is therefore intended to be a companion document to the SuDS Manual. It was also felt that to be effective, then the guidance needed to be appropriate for the audience who would get most benefit from it, and is therefore written explicitly for all those likely to be directly involved in their construction.

The need for this guidance has also been acknowledged widely in the industry, as it is understood that many instances of poor construction have occurred.

Why we did it

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- 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

www.ciria.org | www.susdrain.org *Industry Questionnaire*

To ensure that the new guidance fulfilled the knowledge gap in the construction industry, a detailed questionnaire was sent around all those known to be involved in SuDS construction, to understand the problems that were experienced on site, and both the nature of the challenges that had arisen, and the context within which they had happened. The responses showed a very high level of consistency throughout, and a great sense of frustration from those involved in the construction process.

The main challenges arose from 3 causes: level changes (from the design drawings), cut and fill issues not be resolved prior to construction, and conflicts with services once the works started on site. Problems frequently cited included inadequacies in the design drawings (full details of levels throughout the system, capacity, flow controls etc not provided), existing site information not comprehensively recorded, and the implications of that information included within the drawings, the need for additional hard surfaces being added during the contract, but their drainage requirements not addressed, changes of materials (which did not have the same functionality), changes on site or poor construction arising from a lack of knowledge of the implications of change, or merely, not understanding what 'good construction' meant. This final point highlighted that many projects are still undertaken by contractors who may never have built a SuDS previously, and therefore do not understand either what it is crucial to get right, or how to do it.

Interestingly challenges around building SuDS in areas of ecological importance or in proximity to existing trees did not arise frequently.

Overall, the consequence of these various issues resulted in either poor visual quality, physical construction or their functionality, or a combination of those factors.

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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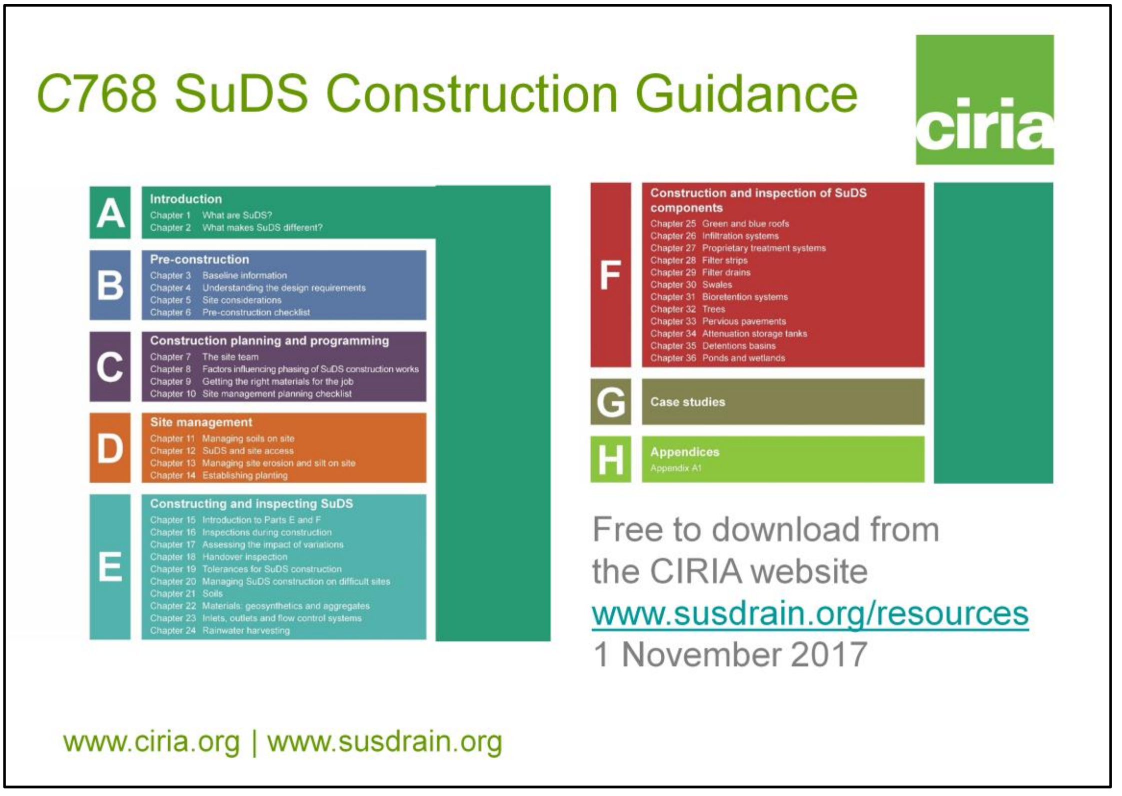
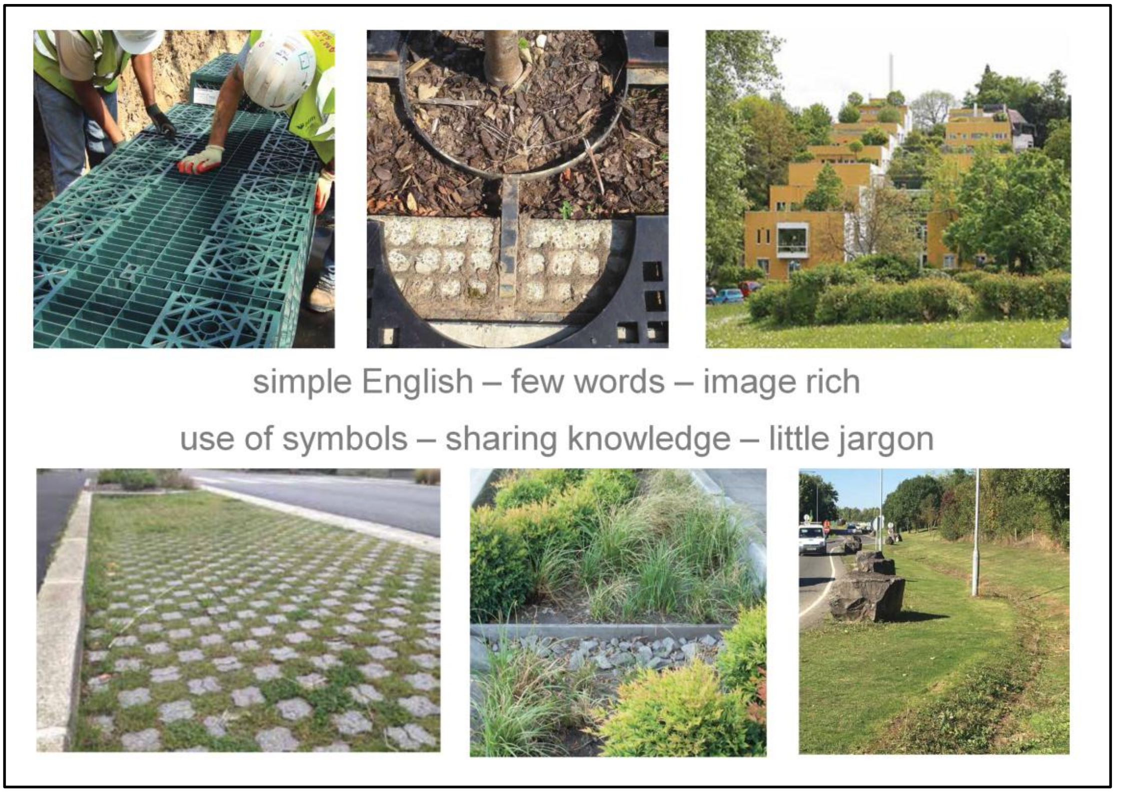
Industry Questionnaire

Many people had not encountered these specific problems, or only very occasionally, with the most common being contaminated land.



As this document is seen as a companion to the SuDS Manual, it has been laid out and styled in a similar manner, and the contents reflect the way that information has been provided in the Manual in terms of the list of SuDS components, how they are constructed, and what needs to be checked to ensure they are built to fulfil their design purpose. However, its approach is entirely different, as it does not deal with design and is not presented in a highly technical manner.



The guidance is written to make it as easy to understand as possible, by anyone regardless of their prior knowledge of SuDS. It deliberately uses simple English, text is kept to a minimum, with pictures used wherever possible to illustrate and explain the issues being discussed. Symbols are also used to show whether the images are illustrating good or bad practice. Knowledge that has been developed in the industry through building SuDS is also shared to help the readers, and technical jargon avoided.

Jargon busters

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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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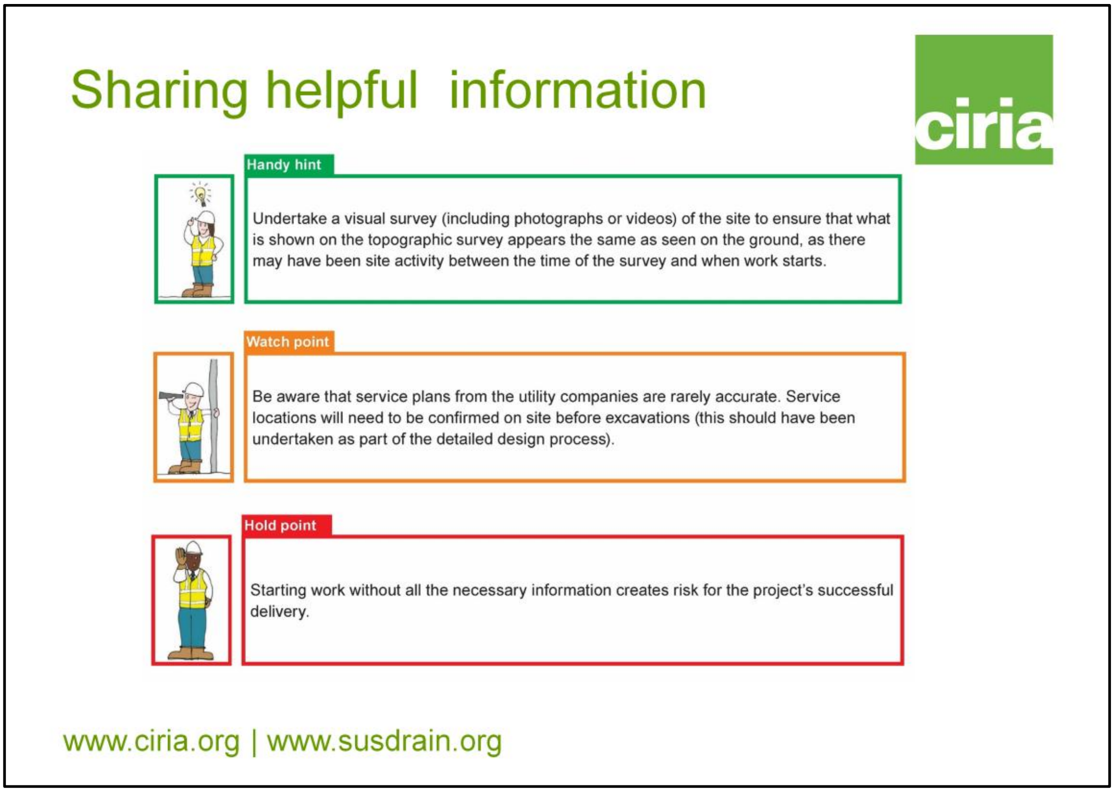
Where jargon has to be used, the words are explained in a 'jargon buster' at the end of each chapter. In the main this amounts to around 3 or 4 terms in any chapter. The word that occurs most frequently is 'component', and is repeated in almost every chapter. Dealing with jargon in this way ensures that readers can 'dip into' any chapter without needing to read introductory chapters first.



As part of the initial industry survey and through the Project Steering Group a wide range of 'good advice' was received. This is presented through a 'traffic light system' relevant to the chapter in which it is found. Handy Hints anticipate problems, so they can be avoided, or offer a simple solution to a common problem, which may be useful. Watch points identify potential problems to be particularly aware of, as they frequently occur on site. Hold points identify points in the construction process where the works must be inspected prior to continuing with their construction.

Learning from other's experience

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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

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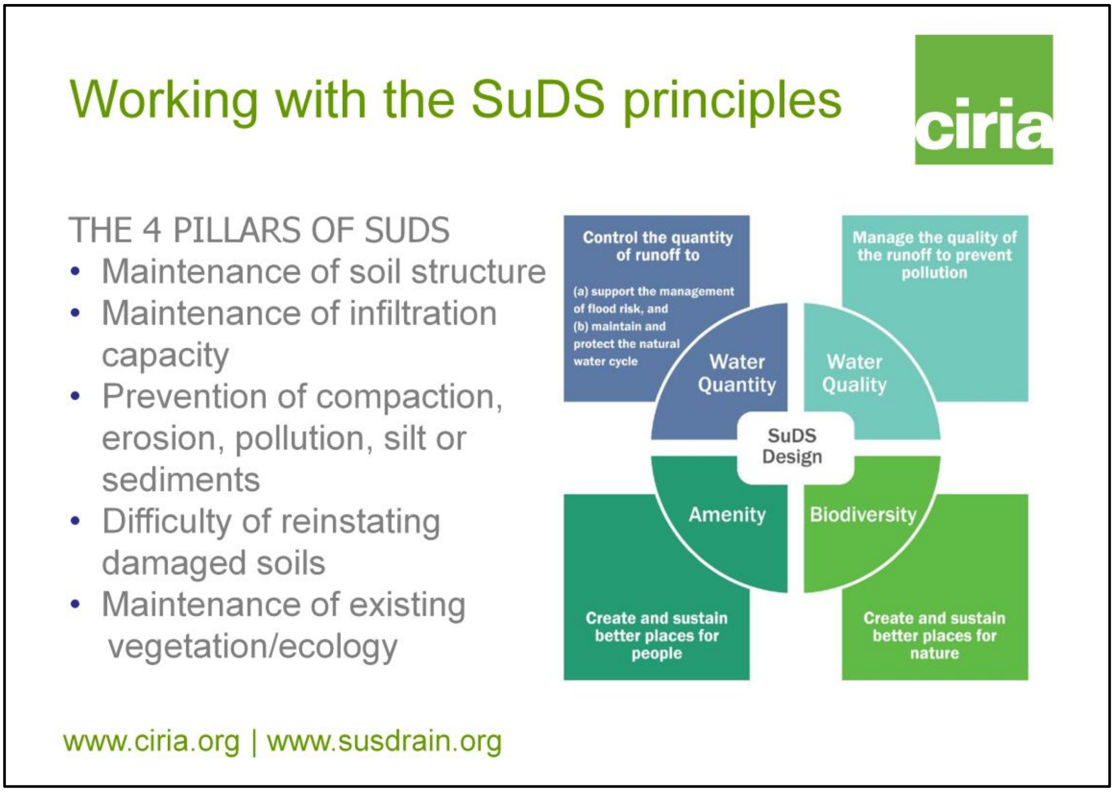
Industry experience is also shared through a wide range of case studies. Most chapters have 'mini-case studies' at the end, which explore a specific issue that has occurred on site. Towards the end of the Guidance there are five major case studies that explore an entire project. In both types of case study, the range of problems that have arisen on site are reviewed to identify what lessons can be learnt from them, and how these challenges can be avoided in the future.



Whilst the 4 pillars of SuDS should underpin every SuDS project, unless the practical requirements of successfully constructing SuDS are understood these principles can easily be undermined. The key lies in understanding the ways in which SuDS construction requires a different approach to ensure that the soils are maintained in good condition, so their structure will still sustain plant life, will drain effectively, and does not become polluted with silts or sediments, as trying to reinstate damaged soils can be very difficult to do. Similarly, protecting and maintaining the existing trees and vegetation resource and/or specific habitats must be understood and planned, as they are very difficult to replace.

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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The guidance has therefore sought to address these constructional challenges by working through the typical construction contract from the early planning stages through to completion and handover, but reconsidering it to understand what need to be done differently to enable the SuDS to be constructed successfully.

Traditional drainage and SuDS – the differences

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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 initial chapters briefly explain what SuDS are, and what makes them different to traditional drainage. The fact that soft SuDS can use vegetation to deliver surface water drainage can be a challenge to those only familiar with laying pipes and manhole chambers. The need for care in their construction is explained alongside the way that they may affect the construction planning process, especially when the weather conditions and seasons affect their completion.

The site and the scheme

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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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The second chapter considers the information that needs to be gathered and the issues that need to be understood prior to construction.

Pre-construction

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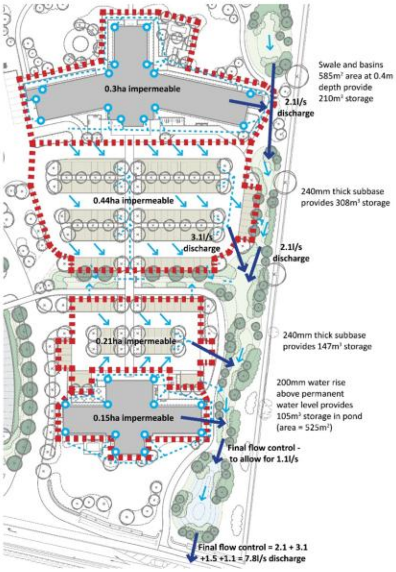

BEING PROPERLY PREPARED

- 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 site and the scheme

Being properly prepared means assembling and understanding all the relevant information about the site that may affect the construction of the SuDS. Then understanding how the scheme design works as a whole and how each part of the system relates to each other. This is particularly relevant to levels and regarding. The scheme design should then be cross-referenced to the specification to ensure that the materials used will deliver the volumes, storage and control flows as designed. Consideration should also be given to the land, vegetation, habitats or other factors on the surrounding land, as these could affect the construction work either directly (through flooding/overland flows or services) or through constraints such as the timing of the works due to protected species.

Chapter C considers the ‘who does what and when’ of SuDS construction planning, and why getting the right materials is so important.

Team work between various professionals is important and also between the designer and contractor.

Construction planning and programming

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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

This considers the ‘who does what, why and when’ of SuDS construction planning, and why getting the right materials is so important.

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.				

The typical roles of both the design team and site construction team are analysed to explain their roles in a traditional contract and SuDS contract to explain how they differ.

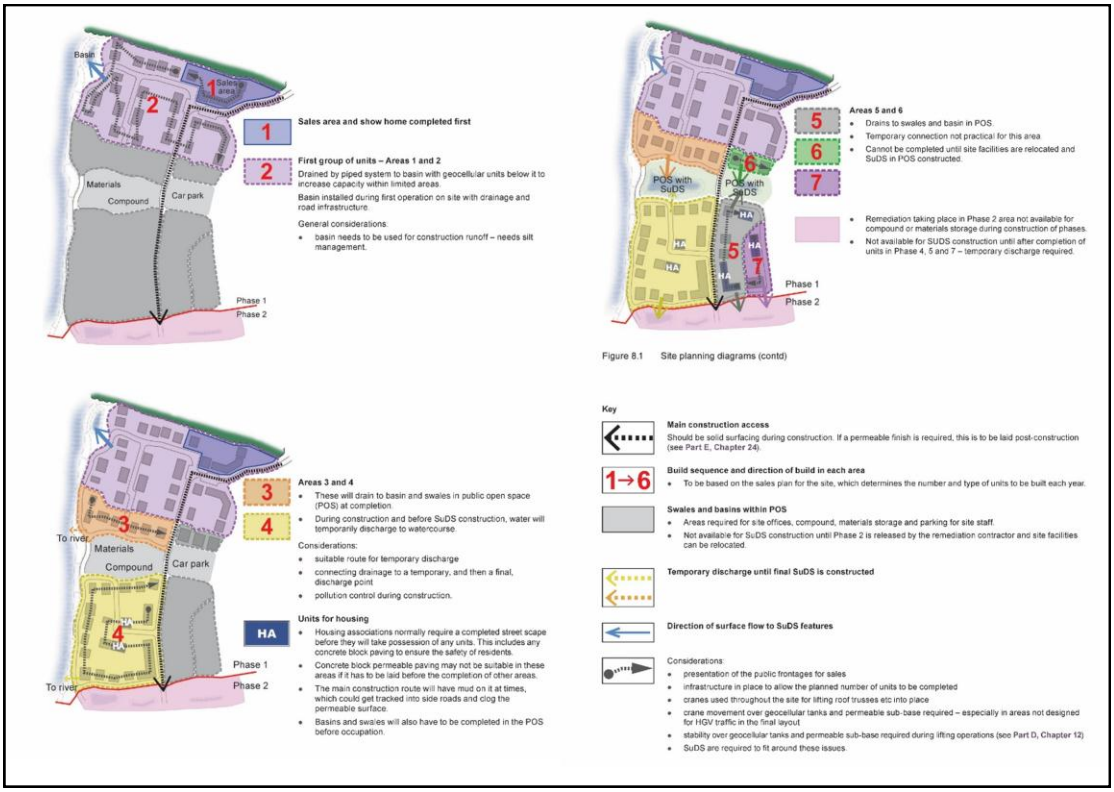

Figure 8.1 Site planning diagrams (contd)

Phasing of works is one of the most important factors in site planning, and is influenced by a wide range of factors. A housing site in particular is used to demonstrate the issues involved, many of which are not SuDS related (such as the desire to have the show homes at the front entrance), but the way in which they influence the delivery of the SuDS is important. The example shows (for example) how the final SuDS retention ponds are used for materials storage and parking during all phases of the works, and are only able to be constructed, and therefore used, in the final phase, requiring temporary surface water measures to be put in place in the meantime.

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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Chapter 4 considers how a number of key site issues need to be managed to enable the SuDS to be delivered successfully.

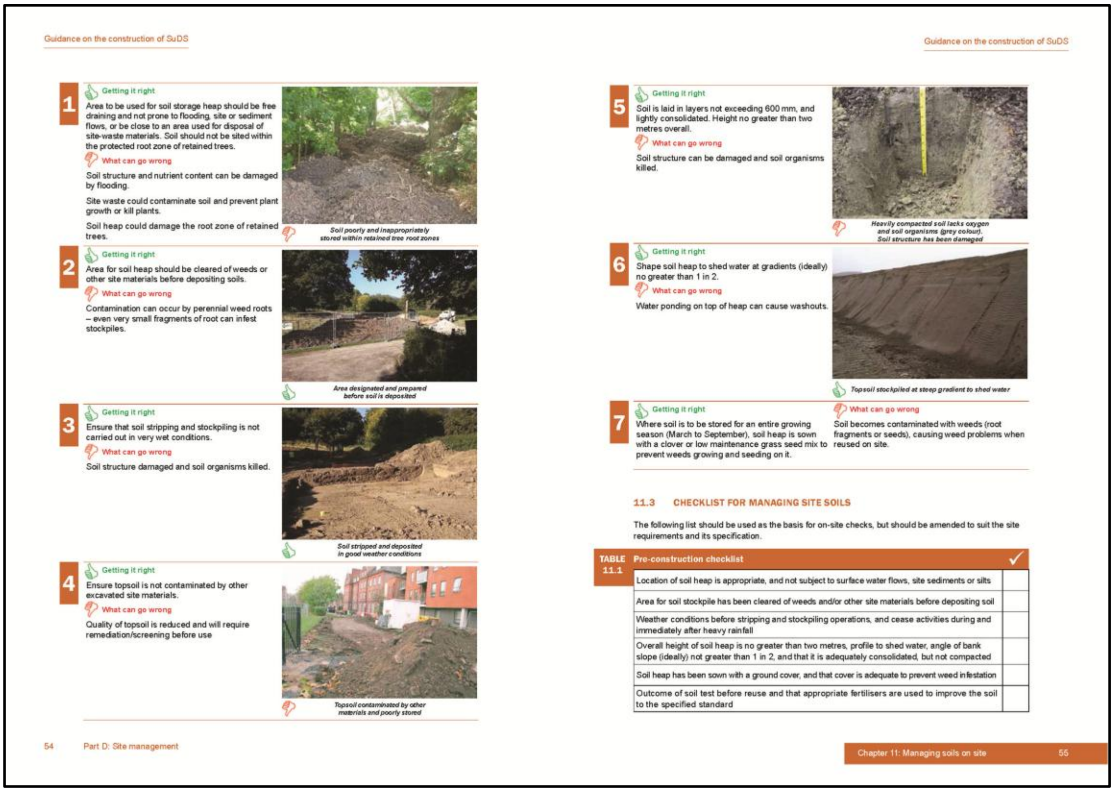
Managing the site

AVOIDING WHAT CAN GO WRONG

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

www.ciria.org | www.susdrain.org *Getting the site management right*

These are the four key problems that arise on site and can ultimately affect the ability of the site to deliver the designed scheme.


Guidance on the construction of SuDS

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

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Guidance on the construction of SuDS

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

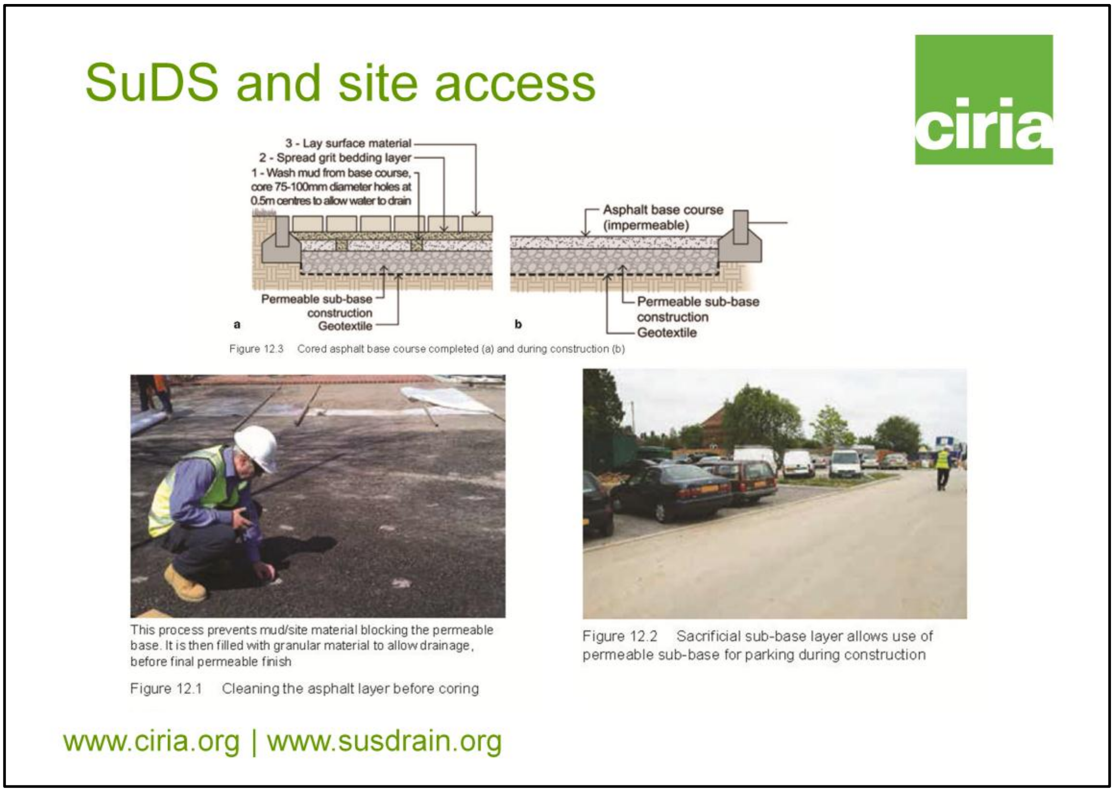
The following list should be used as the basis for on-site checks, but should be amended to suit the site requirements and its specification.

TABLE 11.1

Pre-construction checklist	✓
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	

Chapter 11: Managing soils on site 55

This style of presentation about soils is typical of the way the document is arranged, and uses the universal ‘thumbs up’ (in green) and ‘thumbs down’ (in red) to explain what ‘getting it right’ means, and if not ‘what can go wrong’. Ideally, each of the identified problems are illustrated by either an example of things being done incorrectly, or if not, an example of good practice.



Site access is known to be a major problem on site, and is seen as a factor as to why pervious paving can't be used due to the mud and silt that will be deposited on site roads. This section therefore explains how this can be done effectively.

Managing soil erosion and silt is also seen as fundamental to the successful delivery of SuDS due to their potential to block or damage systems if not properly managed, resulting in both delays and additional costs to reinstate the works properly.

Establishing planting

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

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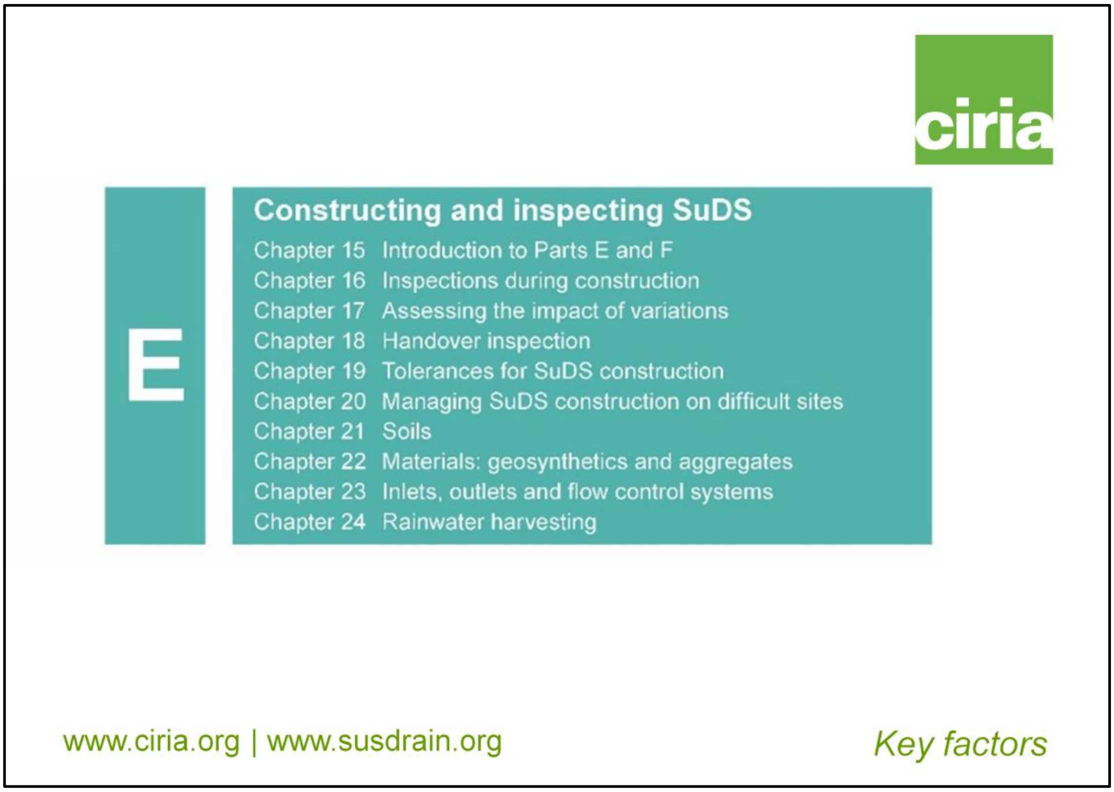
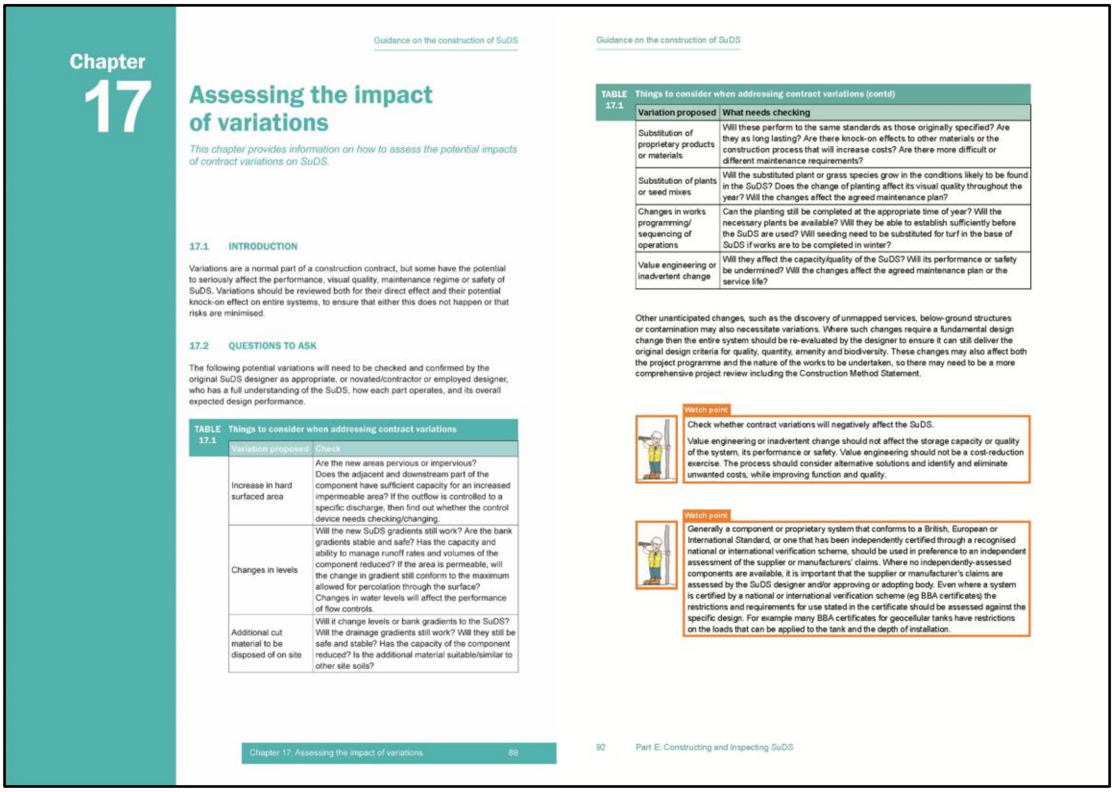
Establishing planting within soft SuDS was also seen as a challenge by many, mainly due to a lack of understanding of their needs in terms of soil condition. Knowing that the right plants are being delivered and used in the right place (for their functionality and their appearance) and that they are supplied to the right specification also presented challenges.



Section E considers the factors around constructing SuDS and the issues that need to be managed to ensure their successful delivery.



Guidance on the construction of SuDS

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?

Chapter 17: Assessing the impact of variations 89

Guidance on the construction of SuDS

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.

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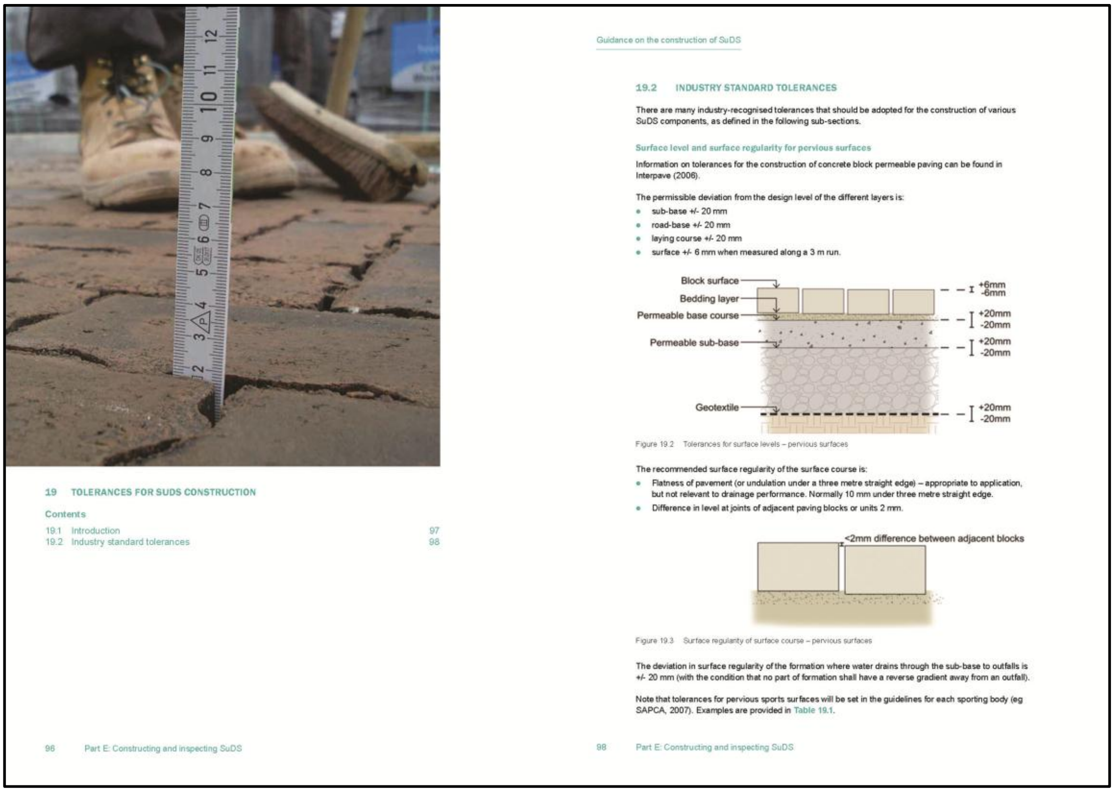
Variations that are not considered for potential impact on the SuDS, can make a significant change to the ability of the scheme to deliver its intended design function (whether quantity, quality, amenity or biodiversity). Additional areas of hard surfaces, changes to cut and fill volumes or specification changes to materials were frequent examples of where problems arose.



19 TOLERANCES FOR SUDS CONSTRUCTION

Contents

96 Part E: Constructing and inspecting SuDS

Guidance on the construction of SuDS

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.

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Industry standard tolerances particularly relevant to SuDS are identified.

Tolerances

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

"I imagine that bank gradients were mentioned in the tolerances section I didn't read"

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The key to inspections

The standards generally relate to paving falls and levels, materials, such as aggregate sizes, and the geomembranes, or the porosity values/infiltration rates for geotextiles or soils.

Difficult sites – high groundwater

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

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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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Various factors that could make construction of SuDS difficult are discussed. One example is high groundwater. This requires adequate forward planning to manage water inflows to excavations.

Difficult sites – contaminated land

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

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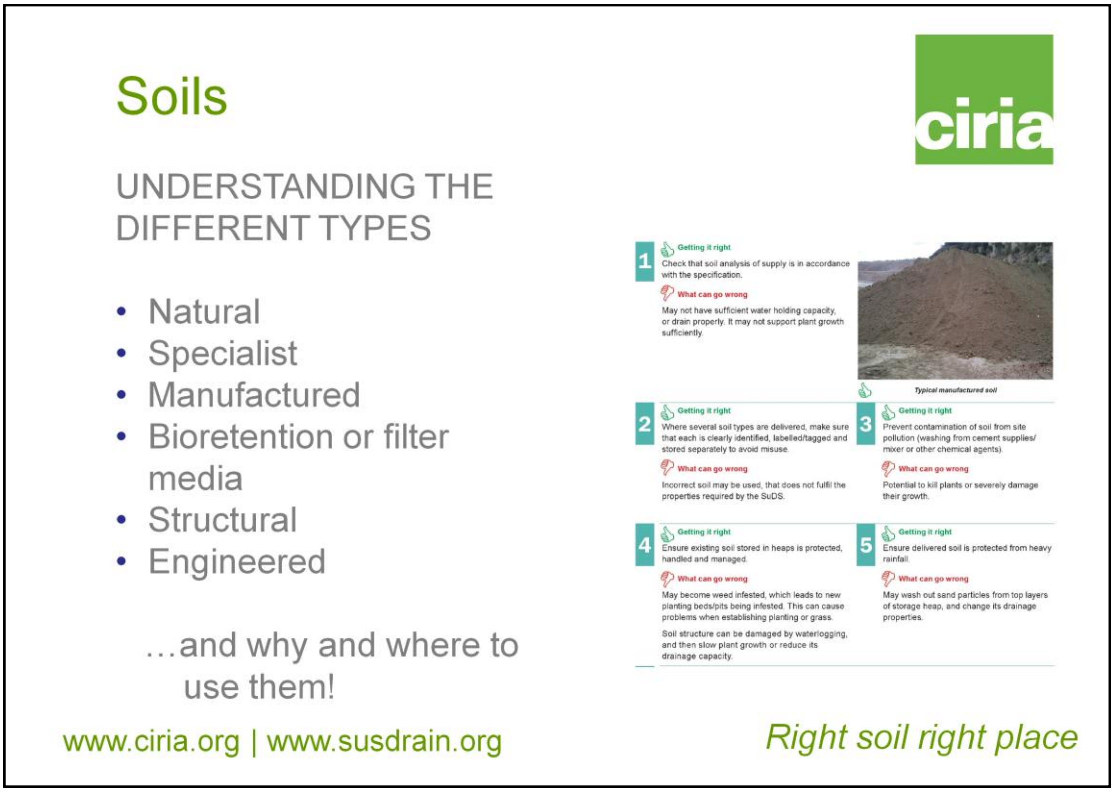
The presence of contamination will also require forward planning to avoid adverse impacts on remediation schemes and management of excavated soils that are contaminated.



There are a wide range of different soils that can be used in SuDS, and the choice of soil relates to their function within the system. Using the wrong type of soil or soil mix will affect its ability to either drain freely or retain moisture, affecting the ability of plants to thrive within the system and their ability to improve water quality.

Inlets and outlets

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MANAGING THE SYSTEM
- Pipe sizes
- Headwalls, weirs and flow controls

VISUAL AND MANAGEMENT ISSUES
- Visible and maintainable
- Aesthetically pleasing

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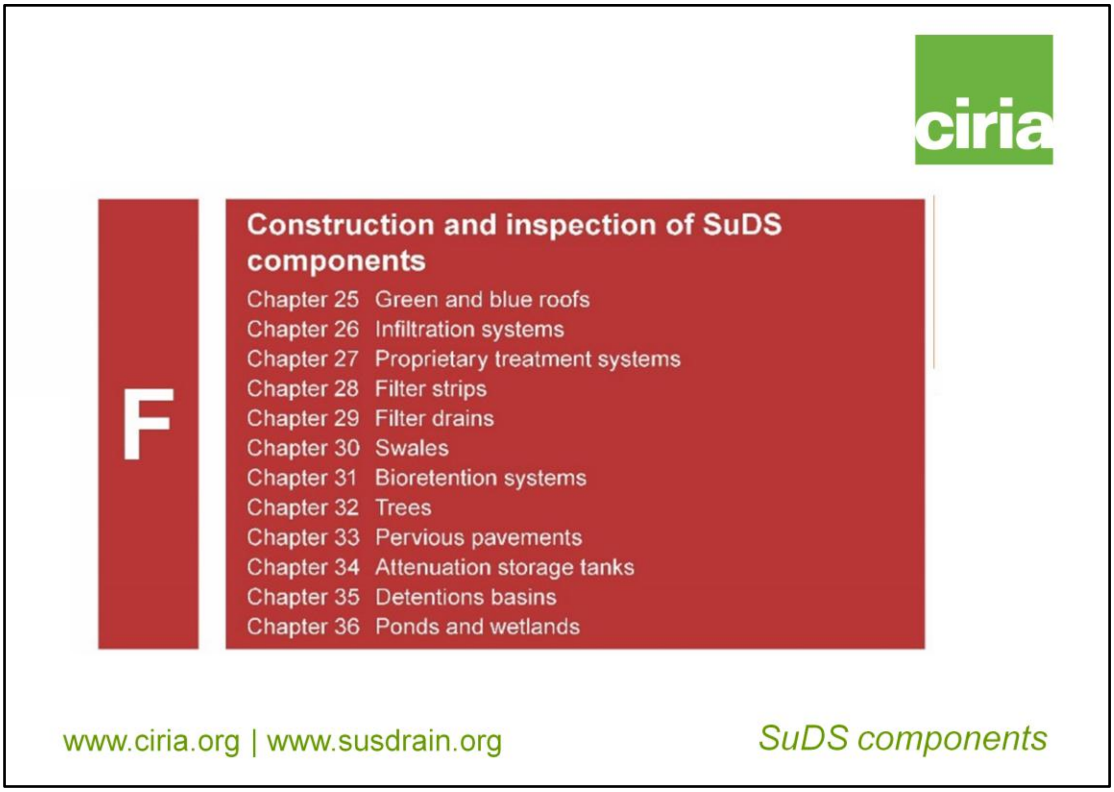
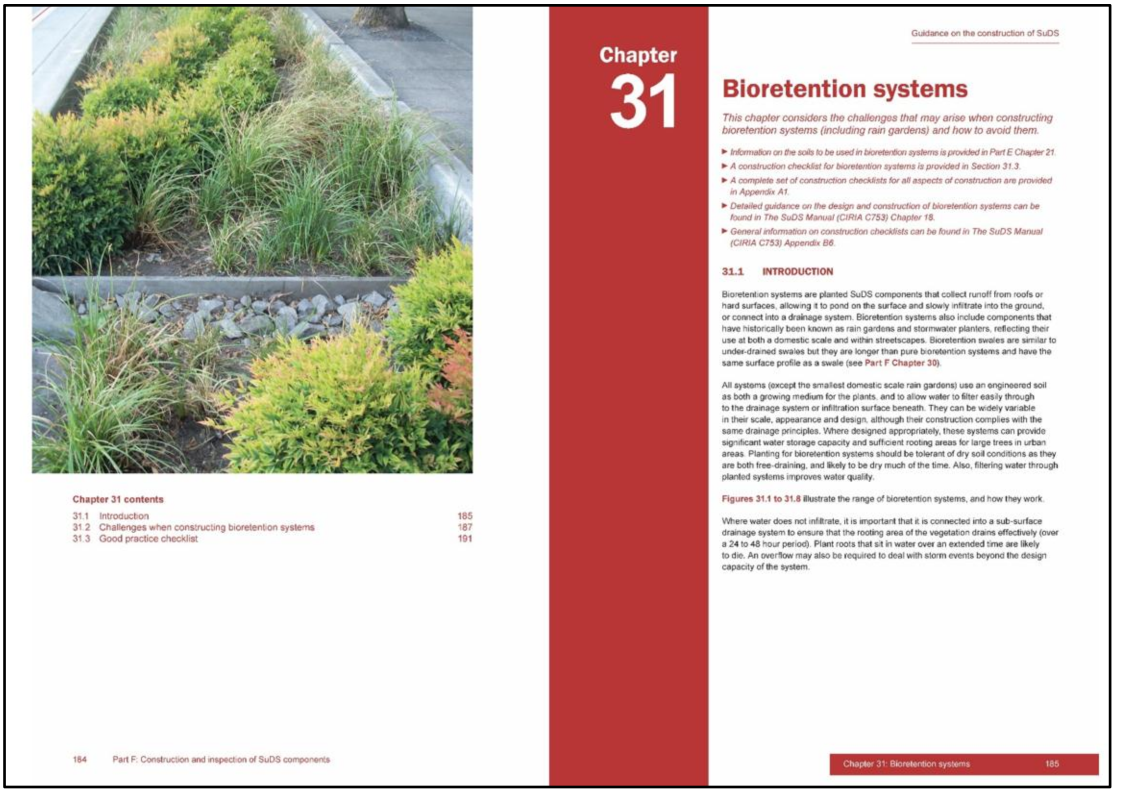
Managing flows and storage

Inlets and outlets should be constructed exactly as shown on the design drawings. The specified size of flow control should be provided. They should be finished in an aesthetically pleasing manner.

Geosynthetics are complex materials. Many appear to be similar on visual inspection but could have widely varying performance. Substitution of products should only be done with the agreement of the designer. Some geosynthetics are prone to damage during construction if not protected (eg geomembrane liners).



Chapter F then deals with the specific challenges for each individual SuDS component. The component list is the same as the SuDS Manual.



Chapter
31

Chapter 31 contents

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.

Biorentention systems have been used to illustrate the way that the construction of each component is dealt with in the individual chapters. The introduction explains what the component is, how it functions, and the different ways that the component can be designed.

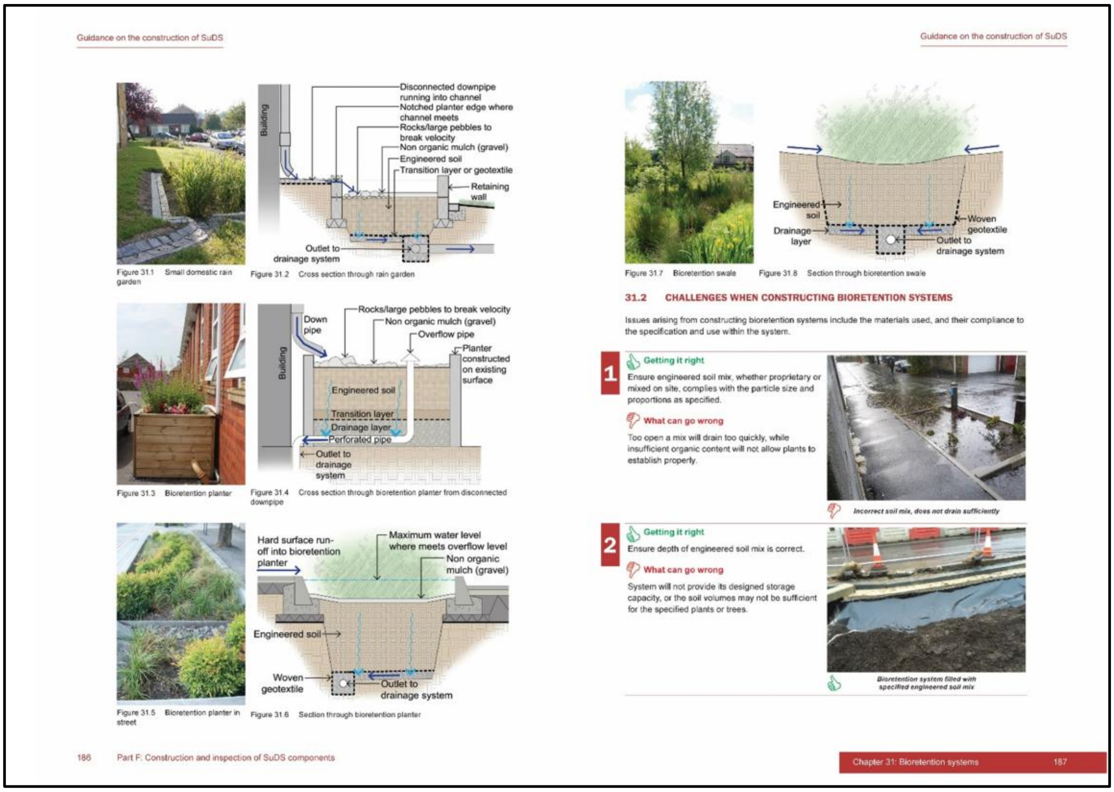

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Figure 31.1 Small domestic rain garden

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

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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

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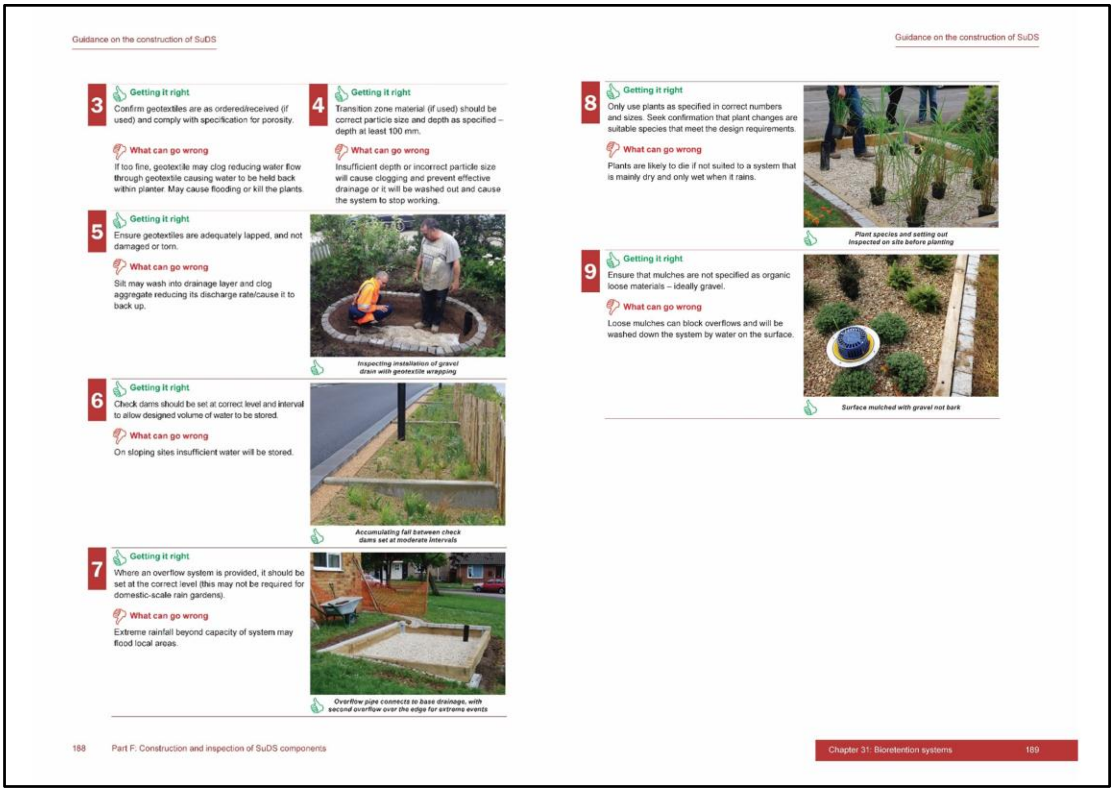
Here the different types of bioretention system are illustrated to show the wide variety of application, with disconnected downpipes draining to in-ground systems or raised planters, road drainage systems adjacent to the highway or more simple trenched components within an overall green system. The diagrams explain the key parts of each system and how it connects back into the drainage network.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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

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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

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The next section then identifies the challenges that typically arise in constructing bioretention planters with the images of either good practice or what can go wrong.

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		Attenuation storage 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.	2	**Getting it right** Ensure drainage pipe is provided in the base and connected to the downstream system.
	What can go wrong Water will not drain or drains slowly, causing flooding, lack of storage and/or killing plants.		**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	✓
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	

The end section contains a 'mini-case study' related that each particular component and the lessons learned from the challenges that arose in building it. The chapter ends with a checklist for its construction. The checklists are not intended to be exhaustive, but to identify the key issues. It is expected that people will use these as the basis for compiling their own checklists that are related to their own particular project. All the checklists provided within the guidance are collected as individually downloadable Word files at the end of the document.

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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In summary, the guidance seeks to help deliver better quality construction for SuDS. Understanding how to build SuDS correctly, can then help inform the design of SuDS generally. The team working necessary to build SuDS successfully will help improve communications both within the design and construction team, and encourage them to work together to overcome the problems that will inevitably arise. Ultimately this should ensure that better outcomes are achieved, and that the full design intent is realised on the ground, thereby delivering better water management and helping to reduce surface water flooding.