This handbook provides guidance on the construction of Sustainable Drainage Systems (SUDS) to facilitate their effective implementation within developments. The handbook is aimed at site engineers and SUDS practitioners.

This site handbook can also be used in conjunction with CIRIA publication C697, *The SUDS Manual* which provides comprehensive guidance on the planning, design, construction and operation of SUDS.

This book constitutes Environment Agency R&D Report SC020114/2

This handbook was produced as a result of CIRIA Research Project RP697, SUDS updated guidance on technical design and construction. The work was carried out by HR Wallingford (Bridget Woods-Ballard and Richard Kellagher), Black and Veatch (Peter Martin), University of Abertay (Chris Jefferies), Robert Bray Associates (Bob Bray) and CIRIA (Paul Shaffer).

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Site handbook for the construction of SUDS

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Sustainable Drainage Systems (SUDS) are drainage systems designed to contribute to the achievement of sustainable development. Rather than traditional pipe and sewer arrangements, the philosophy of SUDS is to replicate as closely as possible the natural drainage from a site before development.

They aim to mimic natural drainage from an undeveloped situation, where rainfall soaks into the ground and saturates soil and vegetation before significant runoff occurs. The systems are designed both to manage the environmental risks resulting from urban runoff and to contribute wherever possible to environment enhancement.

SUDS elements are generally small scale and relatively shallow. They usually require the use of only fairly simple civil engineering construction and landscaping operations, such as excavation, filling, grading, topsoiling, seeding and planting. These operations are specified in various standard construction documents, such as the Civil Engineering Specification for the Water Industry (CESWI, WRc, 1998).

The performance and operation of SUDS depend upon careful planning and implementation during the construction phase, because there are some specific considerations that require changes to conventional construction practices. The use of inappropriate plant, failure to protect the system from construction runoff and detritus, and a lack of integration of landscaping with construction, can all be the cause of poor performance SUDS.

This handbook provides readily accessible guidance for easy reference and use on site. The CIRIA publication, The SUDS Manual (C697), provides more detailed guidance for owners, developers, planners, designers, contractors, managers and operators.
Appropriately designed, constructed and maintained SUDS are more sustainable than conventional drainage methods because they can mitigate many of the adverse effects of urban stormwater runoff on the environment. They achieve this through:

- controlling run-off rates and volumes, thereby lessening the risk of downstream flooding
- reducing pollutant concentrations, thereby protecting downstream water bodies
- encouraging natural groundwater recharge (where appropriate)
- contributing to the enhanced amenity and aesthetic value of developed areas
- providing habitats for wildlife in urban areas and opportunities for biodiversity enhancements.

As they are intended to mimic nature, the construction and landscaping techniques required are generally simple. However, it is important to realise that the SUDS principles described above need to apply to the construction phase as much as the finished product.

Therefore, from a construction viewpoint, SUDS require that specific attention is given to:

1. The planning and phasing of construction to ensure that the performance of the facilities is not compromised by over compaction or clogging with construction debris for example. Please refer to the section on general construction issues associated with SUDS in this handbook.
2. Construction planning taking account of programming and erosion, sediment and pollution control measures, together with the need for method statements and inspections by the designer. Please refer to the sections on construction planning, inspections and method statements.
3. Erosion which will reduce the effectiveness of SUDS facilities, and add to the silt load that any other drainage feature downstream will have to deal with. Please refer to the section on erosion, which addresses both erosion control procedures and erosion protection techniques.
4. Sediment entrapment facilities which are necessary to reduce sediment discharges to downstream properties and receiving waters. Please refer to the section on sediment control.

5. Surface water runoff and pumped water from construction sites which must not pollute receiving waters. Please refer to the section on pollution control.
3 General construction issues associated with SUDS

- The planning of temporary drainage during the construction phase is critical both to the success of SUDS and to the avoidance of pollution downstream. Silt-laden waters from construction sites are one of the most common forms of waterborne pollution.

- Runoff from the construction site must not be allowed to enter SUDS drainage systems unless it has been allowed for in the design and specification. Construction runoff is heavily laden with silt, which can clog infiltration systems, build up in storage systems and pollute receiving waters.

- Normally, drainage is an early activity in construction. For SUDS, although the form of the drainage will be constructed during the earthworks phase, the final construction should not take place until the end of site development work, unless adequate provision is made to remove any silt that is deposited during construction operations.

- All inlets and outlets should be carefully constructed, taking account of all design details. Inlet systems should spread the flow and must avoid scouring of soil or other material from surfaces. Outlets will tend to be smaller than inlets forcing water to be stored within the drainage system.

- Careful levelling and grading is crucial to the performance of many SUDS features to ensure that water flows through the system without ponding – which can damage vegetation and cause unattractive muddy zones to develop. In particular, grass filter strips and swales must be lower than the impermeable surfaces that they drain.

- Before runoff is allowed to flow through SUDS techniques with surface-formed features such as swales, they must be fully stabilised by planting or temporary erosion protection. This will prevent erosion of the sides and base, and the clogging of other parts of the system by the silt that is entrained.

- Car parking and other paved areas are usually constructed (or partially constructed) during the initial stages of the development, and then used as access roads and storage areas. If pervious surfaces are specified in the SUDS, pavement construction should be carried out at the end of the development programme, unless adequate protection is provided to preventing clogging or blinding once it has been constructed. The storage of soil or subsoil on the surfaces of permeable systems (including filter drains) will destroy their function.
Construction planning, therefore, needs to take account of the programming and erosion, sediment and pollution control measures, together with the need for inspections by the designer to confirm acceptability.

Provision should have been made in the construction contract to review the performance of the SUDS when it is completed, and to allow for minor adjustments and refinements to be made to optimise the physical arrangements, based on observed performance. Such adjustments are likely to have to be made late in the construction phase, or in the maintenance period.

Figure 3.1 Earthworks on a SUDS site
Construction planning needs to take account of the programming and erosion, sediment and pollution control measures, together with the need for inspections.

The features requiring particular attention during the construction phase are: site access, storage of materials, site drainage during construction, and protection of surfaces from erosion, sedimentation or overcompaction.

Construction programming considerations are summarised below. The generalised construction activities shown in the table do not usually occur in a specified linear sequence, and programmes will vary due to season, weather and other unpredictable factors.

<table>
<thead>
<tr>
<th>Construction activity</th>
<th>Programme consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify and sign protection areas (eg buffer zones, filter strips, trees).</td>
<td>Site delineation should be completed before any construction activity begins.</td>
</tr>
<tr>
<td>Construction access, construction entrance, construction routes, equipment parking areas and cutting of vegetation (with any necessary boundary controls).</td>
<td>The first land-disturbing activity. Establish protected areas. Stabilise bare areas and provide temporary protection as construction takes place.</td>
</tr>
<tr>
<td>Sediment traps and barriers. Basin traps, sediment fences, and outlet protection (with any necessary boundary controls).</td>
<td>Install principal basins after construction site is accessed. Install additional traps and barriers as needed during grading.</td>
</tr>
<tr>
<td>Runoff control. Diversion, silt fence, perimeter ditches and outlet protection.</td>
<td>Install key measures after principal sediment traps have been installed and before grading begins. Install any additional runoff control measures during grading.</td>
</tr>
<tr>
<td>Runoff conveyance system. Stabilise stream banks, storm drains, channels, inlet and outlet protection, and slope drains.</td>
<td>Where necessary, stabilise stream banks as early as possible. Install principal runoff conveyance system with runoff control measures. Install remainder of system after grading.</td>
</tr>
<tr>
<td>Clearing and grading. Site preparation: traps, barriers, diversions, drains, surface treatment.</td>
<td>Begin major clearing and grading after principal sediment and key runoff control measures are installed. Clear borrow and disposal areas only as needed. Install additional control measures as grading progresses.</td>
</tr>
<tr>
<td>Surface stabilisation: temporary and permanent seeding, mulching, topsoiling and installing riprap.</td>
<td>Apply temporary or permanent stabilisation measures immediately on all disturbed areas where work is either delayed or complete.</td>
</tr>
<tr>
<td>Building construction: buildings, utilities and paving.</td>
<td>Install necessary erosion and sedimentation control practices as work takes place.</td>
</tr>
<tr>
<td>Landscaping and final stabilisation: topsoiling, planting trees and shrubs, permanent seeding, mulching, installing riprap.</td>
<td>The last construction phase. Stabilise all open areas, including borrow and spoil areas. Remove and stabilise all temporary control measures.</td>
</tr>
<tr>
<td>Commissioning and pre-handover maintenance</td>
<td>Maintenance inspections should be performed weekly, and maintenance repairs should be made immediately after periods of rainfall.</td>
</tr>
</tbody>
</table>
Points to consider:

- Construction access: care should be taken not to damage valuable trees or disturb designated buffer zones. Trees should be protected around the drip line of the branches. Activities that could compact the root zone should be avoided.

- Sediment basins and traps should be installed before any major site grading takes place. Additional sediment traps and silt fences should be installed as grading takes place to keep sediment contained on site at appropriate locations.

- Key runoff control measures should be located in conjunction with sediment traps to divert water from planned undisturbed areas away from the traps and sediment-laden water into the traps. Diversions should be installed above areas to be disturbed before any grading operations. Any perimeter drains should be installed with stable outlets before opening major areas for development. Any additional facilities needed for runoff control should be installed as grading takes place.

- The main runoff conveyance system with inlet and outlet protection measures should be installed early, and used to convey stormwater runoff through the development site without creating gullies or channels. Install inlet protection for storm drains (as soon as the drain is functional) to trap sediment on site in shallow pools and to allow flood flows to enter the storm drainage system safely. Install outlet protection at the same time as the conveyance system to prevent damage to the receiving stream.

- Normally, install stream stabilisation, including necessary stream crossings, independently and ahead of other construction activities. It is usually best to programme this work as soon as weather conditions permit. Site clearing and project construction increases storm runoff, often making stream-bank-stabilisation work more difficult and costly.

- Begin clearing and grading as soon as key erosion and sediment control measures are in place. Once a development area is cleared, grading should follow immediately so that protective ground cover can be re-established quickly. Do not leave any area bare and exposed for extended periods. Leave adjoining areas planned for development, or those that are to be used for borrow and disposal, undisturbed as long as possible to serve as natural buffer zones.

- Runoff control is essential during the grading operation. Temporary diversions, slope drains, and inlet and outlet protection installed in a timely manner can be very effective in controlling erosion during this critical period of development.
After the land is cleared and graded, apply surface stabilisation on graded areas, channels, ditches and other disturbed areas. Stabilise any disturbed area where active construction will not take place for 60 working days, by temporary seeding and/or mulching or by other suitable means. Install permanent stabilisation measures as soon as possible after final grading. Temporary seeding and/or mulching may be necessary during extreme weather conditions with permanent vegetation measures delayed until a more suitable installation time.

Coordinate building construction with other development activities so that all work can take place in an orderly manner and on programme. Experience shows that careful project programming improves efficiency, reduces cost and lowers the potential for erosion and sedimentation problems.

Landscaping and final stabilisation is the last major construction phase, but topsoil stockpiling, tree preservation, undisturbed buffer areas, and well-planned road locations established earlier in the project may determine the ease or difficulty of this activity. All disturbed areas should have permanent stabilisation measures applied. Unstable sediment should be removed from sediment basins and traps and if possible incorporated into the topsoil, not just spread on the surface. All temporary structures should be removed after the area above has been properly stabilised. Borrow and disposal areas should be permanently vegetated or otherwise stabilised.

In planning construction work, it may be helpful to outline all land-disturbing activities necessary to complete the proposed project. Then list all practices needed to control erosion and sedimentation on the site. These two lists can then be combined in a logical order to provide a practical and effective construction programme.

Figure 4.1 Completed swale
When construction is finished, there is likely to be a commissioning period in which the permanent SUDS are made “live”, this is likely to include diversion of drainage flows into the new facilities. If permanent facilities have been used wholly or in part to drain the site, or as other forms of temporary works such as roads or storage areas, then there may be rehabilitation works required to reconstitute or restore them to their design condition. Once the permanent facilities have been demonstrated to work as envisaged, temporary drainage and sediment and erosion control measures can be carefully dismantled so as not to generate sediment loading on downstream systems.