INTRODUCTION TO SUDS

BASIC PHILOSOPHY OF SUDS

SUDS, or Sustainable Drainage Systems, is an approach to drainage which has the objective of minimising the impact that the surface water runoff from any development exerts on its environment by replicating, as closely as possible, the natural drainage from the development site before the development is carried out. This applies to both the quality and quantity of the surface water runoff.

The introduction to the philosophy of SUDS, set out in the SUDS Manual, published by CIRIA (2007), is reproduced below

Appropriately designed, constructed and maintained SUDS are more sustainable than conventional drainage methods because they can mitigate many of the adverse effects on the environment of stormwater runoff. They achieve this through:

- *reducing runoff rates, thus reducing the risk of downstream flooding*
- *reducing the additional runoff volumes and runoff frequencies that tend to be increased as a result of urbanisation, and which can exacerbate flood risk and damage receiving water quality*
- *encouraging natural groundwater recharge (where appropriate) to minimise the impacts on aquifers and river baseflows in the receiving catchment*
- *reducing pollutant concentrations in stormwater, thus protecting the quality of the receiving water body*
- *acting as a buffer for accidental spills by preventing a direct discharge of high concentrations of contaminants to the receiving water body*
- *reducing the volume of surface water runoff discharging to combined sewer systems, thus reducing discharges of polluted water to watercourses via CSO spills*
- *contributing to the enhanced amenity and aesthetic value of developed areas*
- *providing habitats for wildlife in urban areas and opportunities for biodiversity enhancement.*

TRADITIONAL DRAINAGE PROCEDURES AND THEIR IMPACTS

Undeveloped "greenfield" sites dispose of the water from rainfall by several methods. These are normally:

(1) Evapotranspiration (evaporation from surfaces and transpiration from the leaves of vegetation): these methods return water directly to the atmosphere and consequently do not form part of the runoff to watercourses. During the spring and summer months these methods can dispose of a significant proportion of the total water falling on an area.

(2) Infiltration: this method allows water to percolate into the underlying topsoil and subsoil, from where it makes its way slowly to receiving watercourses, or the groundwater. In the cooler, low-growth months, the most of the water from short-term or isolated rainfall events is disposed of in this way.




(3) Surface flow: If the underlying soils become saturated, the water falling on an area will discharge to the receiving watercourse by flowing across the surface of the ground. The frequency with which this will happen depends on the permeability of the underlying soil, but, typically, it tends to occur during persistent rainfall in winter months, or during intense rainfall events during the summer.

When a previously greenfield area is developed, by the construction of housing or commercial developments, or by the provision of a new roadway, the surface of the ground in the area, which was generally largely permeable, becomes largely impermeable and the area supporting grasses or other plant life is significantly reduced. As the amount of precipitation on the site is not changed, the total quantity of water to be disposed of is unchanged, but the modifications to the character of the site due to development results in changes to the proportions of the rainfall disposed of by the methods described above.

(1) Evapotranspiration: The amount of evaporation from surfaces is reduced because, although the area of impermeable surface on the ground is increased, there is a considerable reduction in the leaf surface area, which is normally much the greater of the two. The amount of transpiration is also significantly reduced due to the reduction in leaf area. The reduction in removal of water by these methods ensures that a larger proportion of rainfall reaches the underlying ground and adjoining watercourses

(2) Infiltration: Infiltration is considerably reduced due to the overall reduction in permeability of the area.

(3) Surface flow: The proportion of water disposed of by surface flow increases considerably due to the large increase in impermeable ground surface. In developed areas this is the predominant method of water disposal.

Historically, the drainage of urban road and street developments has been by means of underground pipe networks. These accept the runoff from the impermeable areas of the development and convey it away from the site efficiently, thereby ensuring that the risk of flooding on the site itself is minimised.

However, as water flowing over impermeable surfaces and through pipes reaches the watercourses more quickly than the other methods, the changes in the characteristics of a site due to development result in an overall increase in the total runoff and a significant reduction in the time taken to affect flow in watercourses. This results in an increase in flow in the watercourse, leading to an increased risk of flooding of areas downstream of the site.

RUNOFF WATER QUALITY

In addition to the increase in quantity and rate of runoff, development usually results in an adverse impact on the quality of the runoff water. A considerable number of contaminants can be taken up by the water but the most significant in urban centres are; sediments, oils, salts and litter. These are more or less continuous low concentration contaminations. Accidental spills from container vehicles or tankers can result in infrequent but high volume and concentration contaminants.

SUSTAINABLE DRAINAGE METHODS

In general, SUDS can be divided into two categories

(a) Controlling and managing runoff quantity

(b) Controlling and managing runoff quality




(a) Controlling and Managing Runoff Quantity in Urban Centres

The main processes used to control runoff quantity are:

(1) Piped systems and other conduits

As described above, this is the traditional method of managing surface water flows from development sites. It is most commonly effected by means of piped sewers but other methods, such as open channels have been used. Traditionally, the piped drainage network collected together at an outfall location, where it discharged, unattenuated and untreated, into the local watercourse. This uncontrolled discharge is not acceptable as sustainable drainage. Pipe networks are, however, still an essential component in the management of surface water on site.

(2) Infiltration

Infiltration involves allowing surface water runoff to soak into the ground, as would have happened in the pre-development greenfield site conditions. This is the most desirable approach because it most closely replicates the natural hydrological process and recharges the groundwater, provided that the runoff quality is satisfactory. In addition it considerably slows down the rate of runoff to watercourses. It is not suitable where the existing aquifer is sensitive or vulnerable and is of limited use where the local soils are of poor permeability.

(3) Attenuation and storage

This process consists of providing a storage device or devices on the surface water system together with a controlled outlet from the storage. The control device is used to restrict the runoff rate from the storage to previously determined "greenfield runoff rates". During a rainfall event the flow rate in the piped drainage system increases considerably but the outlet flow from the storage remains at the pre-determined rate. Consequently the storage system fills up, partly or fully. At the end of the rainfall event the flow from the outlet continues at the set rate until the storage is empty. The storage can be provided by planters, dry ponds, wet ponds with suitable freeboard, underground structures, proprietary systems or oversized pipes. Although this process can significantly reduce the maximum rate of runoff to watercourses, the runoff can continue for some time and there is not necessarily the reduction in flow that can be achieved by infiltration.

(4) Water Harvesting

This involves the capture and use of runoff water on site. The captured water can be used as "grey water", where fully treated water is not a requirement. Flushing toilets and irrigation are acceptable uses. The system has to be designed so that sufficient storage for normal runoff control is provided. Water harvesting is does not normally feature in “road drainage”.

(b) Controlling and Managing Runoff Quality

There are many processes that can be utilised to control water quality in a sustainable drainage system. The mechanisms listed in the CIRIA SUDS Manual are:

- Sedimentation
- Filtration and biofiltration
- Adsorption
- Biodegredation




- Volatilisation
- Precipitation
- Uptake by plants
- Nitrification
- Photolysis

In urban streets, the contaminants to be removed are usually:

- Sediments: removable by sedimentation and filtration
- Hydrocarbons: removable by biodegredation, photolysis, filtration and adsorption
- Metals: removable by sedimentation, filtration, adsorption, precipitation and plant uptake
- Litter: normally controlled by trapping and removal during routine maintenance

There are numerous techniques employed for achieving satisfactory drainage systems. A non-exhaustive list is set out below:

- Filter drains
- Swales
- Ponds
- Subsurface tanks or proprietary devices
- Wetlands
- Silt traps
- Oversized pipes
- Filter strips
- Bioretention areas
- Detention basins
- Soakaways
- Infiltration trenches
- Infiltration basins
- Pervious pavements
- Sand filters

Of the above techniques, some of the most commonly used in roads and streets are described below:

Filter Drains

A filter drain is usually a linear trench filled with permeable material. It is commonly surrounded with an engineering membrane and a perforated pipe is laid near the bottom of trench. It provides conveyance, detention, sedimentation, filtration, adsorption and biodegredation.




Swales

A swale is a shallow, wide channel with grass or other vegetation growing in the channel. It is normally unlined, but, if necessary it can be lined with an impermaable membrane. It provides conveyance, detention, sedimentation, filtration, adsorption and biodegredation.

Ponds

A pond is a depression containing a permanent pool of water, with aquatic vegetation growing at the edges. It provides detention, sedimentation, filtration, adsorption and biodegredation.

Subsurface Tanks or Proprietary Devices

Originally, these were commonly concrete underground tanks with a flow restricting device at the outlet. Proprietary 'crate' type systems, surrounded with a permeable or impermeable membrane are now more common. They provide detention, sedimentation, sometimes filtration and biodegredation.

Wetlands

Sometimes called a constructed wetland, it consists of an artificially constructed vegetated marshy area, which collects and treats water before discharging to a watercourse. It is similar to a pond but shallower. It provides detention, sedimentation, filtration, adsorption and biodegredation.

Silt Traps

This is usually a manhole, or a proprietary device which removes silt from the water before discharging to a watercourse. It provides sedimentation.

Oversize Pipes.

These are ordinary drainage pipes which are several sizes larger than is required for flow capacity. The additional capacity is used to temporarily store runoff. A flow restriction device is fitted at the outlet from the system. It provides conveyance, detention, possibly sedimentation and filtration.




Glossary

Sedimentation

Sedimentation is one of the primary removal mechanisms in SUDS. Most pollution in runoff is attached to sediment particles and therefore removal of sediment results in a significant reduction in pollutant loads. Sedimentation is achieved by reducing flow velocities to a level at which the sediment particles fall out of suspension. Care has to be taken in design to minimise the risk of re-suspension when extreme rainfall events occur.

Filtration and biofiltration

Pollutants that are conveyed in association with sediment may be filtered from percolating waters. This may occur through trapping within the soil or aggregate matrix, on plants or on geotextile layers within the construction. The location of any filtration will depend upon the internal structure of the particular SUDS technique, for example whether a geotextile layer is near the surface or at the subgrade in a previous surface.

Adsorption

Adsorption occurs when pollutants attach or bind to the surface of soil or aggregate particles. The actual process is complex but tends to be a combination of surface reactions grouped as sorption processes:

Adsorption	Pollutants bind to surface of soil / aggregate
Cation exchange	Attraction between cations and clay minerals
Chemisorption	Solute is incorporated in the structure of a soil / aggregate
Absorption	The solute diffuses into the soil / aggregate / organic matter.

Change in acidity of runoff can either increase or decrease the adsorption of pollutants by construction materials or soils. Eventually the materials onto which pollutants adsorb will become will become saturated and thus this method of treatment will stop.

Biodegradation

In addition to the physical and chemical processes, which may occur on and within a SUDS technique, biological treatment may also occur. Microbial communities may be established within the ground, using the oxygen within the free-draining materials and the nutrients supplied with the inflows, to degrade organic pollutants such as oils and grease. The level of activity of such bioremediation will be affected by the environmental conditions such as temperature and the supply of oxygen and nutrients. It also depends on the physical conditions within the ground such as the suitability of the materials for colonisation.

Volatilisation

Volatilisation comprises the transfer of a compound from solution in water to the soil atmosphere and then to the general atmosphere. The conversion to a gas or vapour occurs due to heat, reducing pressure, chemical reaction or a combination of these processes. The rate of volatilisation of a compound is controlled by a number of its properties and those of the surrounding soil. In SUDS schemes volatilisation is primarily concerned with organic compounds in petroleum products and pesticides.

Precipitation

This process is the most common mechanism for removing soluble metals. Precipitation involves chemical reactions between pollutants and the soil or aggregate that transform




dissolved constituents to form a suspension of particles of insoluble precipitates. Metals are precipitated as hydroxides, sulphides, and carbonates depending on which precipitants are present and the pH level. Precipitation can remove most metals (arsenic, cadmium, chromium III, copper, iron, lead, mercury, nickel, zinc) and many anionic species (phosphates, sulphates, fluorides).

Uptake by plants

In ponds and wetlands, uptake by plants is an important removal mechanism for nutrients (phosphorous and nitrogen). Metals can also be removed in this manner (although intermittent maintenance is required to remove the plants otherwise metals will be returned to the water when the plants die). Plants also create suitable conditions for deposition of metals, for example as sulphides in the root zone.

Nitrification

Ammonia and ammonium ions can be oxidised by bacteria in the ground to form nitrate, which is a highly soluble form of nitrogen. Nitrate is readily used as a nutrient by plants.

Photolysis

The breakdown of organic pollutants by exposure to ultra-violet light.