Sustainable Urban Drainage Systems

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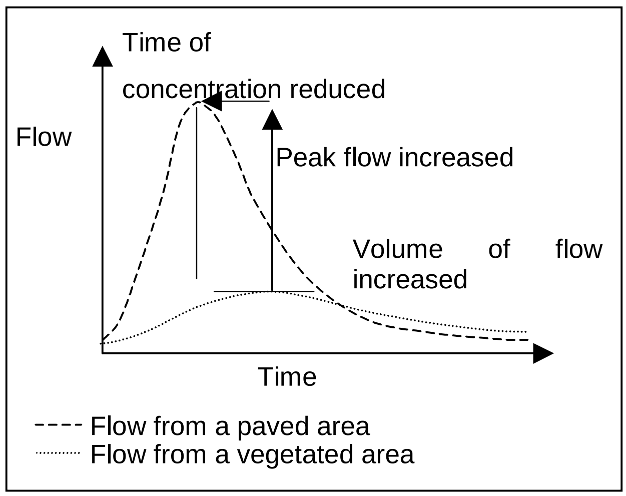
CIRIA is currently managing a research project on the best practice in Sustainable Urban Drainage Systems (SUDS). This is producing technical guidance for Scotland and Northern Ireland (C521) and England and Wales (C522), as well as a best practice report (C523) that discusses the main issues in this subject area. One of the outputs of the project is a set of training material that can be used by the partners in the project to explain SUDS and promote the concepts. The draft material was prepared by Cedo Macsimovik et al of Imperial College and was presented at the WaPUG conference by Brian Reed of CIRIA.

This paper outlines some of the problems associated with conventional urban drainage techniques and introduces some of the alternative methods of draining surface water in a more sustainable manner.

Conventional drainage systems

The impacts of development on the water cycle are well known. Roofs and paved areas do not allow rainwater to soak into the ground as effectively as green-field sites. This increases the amount of runoff from developed areas. The use of pipes and concrete channels allows the water to drain rapidly and reach areas downstream much faster than water from an undeveloped site. This increase in the volume of runoff coupled with faster flow rates will lead to increased flooding downstream. This can result in damage to property, erosion and the need for engineering works downstream to cope with the changed flow regime.



Hydrograph showing the impact of development on the flow regime.

This urban runoff also has an impact on water quality. The runoff from roads washes silt, organic matter and debris into the drains. This can contain pollutants such as oils, heavy metals and chemicals from vehicle exhausts and industrial emissions, some of which could be toxic. As the roofs and paved areas are only washed intermittently by heavy rain, the pollutant loading varies during a storm, with contaminants being concentrated in some portion of the runoff. This has an impact on the receiving watercourse leading to a reduction in water quality.

Water quality is also affected by the increase in water quantity. Where the drains are connected to a combined sewerage system, the increase in flow can be too great for the sewer to cope with and the water overflows. This can either result in flooding of an area or a discharge to a watercourse. As the sewer carries both runoff and foul water, the floodwater will contain faecal material and other gross pollutants hazardous to health.

In the past the response has been to try to build solutions to these problems. Developments in the upper reaches of a catchment have resulted in the need to increase the size of sewers downstream. The contaminated nature of the runoff has resulted in the need to treat excessive amounts of water. The fluctuations in the load reaching treatment works leads to inefficient operation. Building separate surface and foul sewers are one attempt to reduce the problem, but the washing off of contaminants from impermeable areas and continued flooding problems still occur.

More sustainable approaches

Several techniques are available to control the problem as near to the source as possible. These all attempt to mimic the natural processes involved. The aim is to restore the ground and surface water flow patterns that existed before the development took place. This includes:

- storage
- treatment
- infiltration.

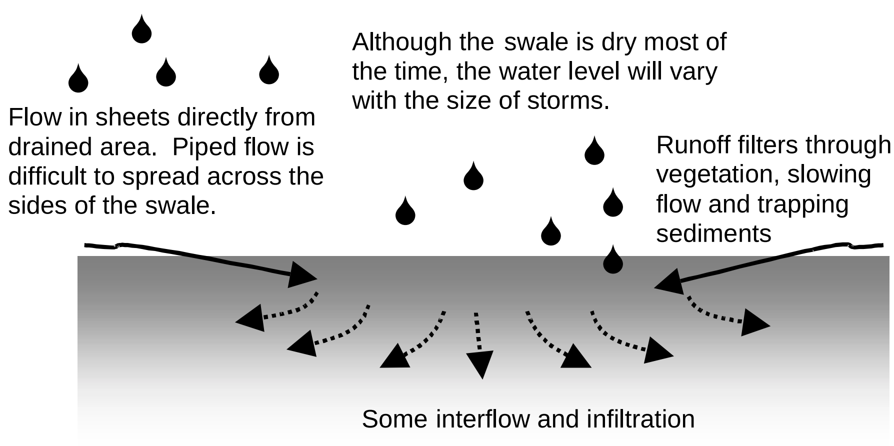
These processes can be achieved in a variety of ways. Storage can be provided:

- within a permeable paved surface
- in conveyance systems such as very gently sloping channels or oversized pipes
- in permanent ponds or basins that only fill up during storms and then drain away slowly.

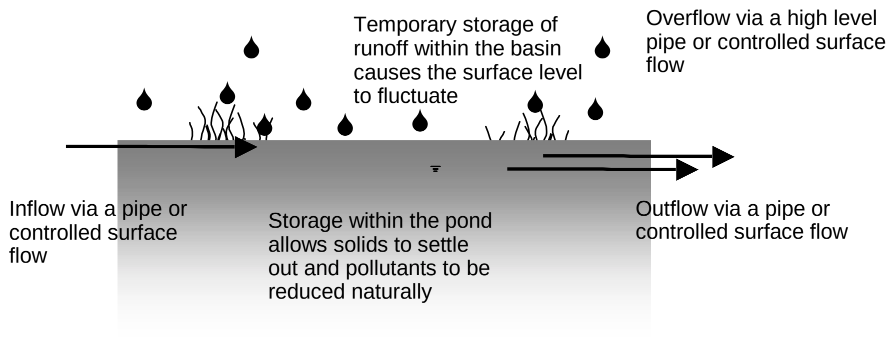
Treatment takes a variety of forms, but mainly falls into processes such as settlement, filtration and biological action. The processes occur in a variety of places such as:

- permeable surfaces and filter drains
- grassed channels (swales) and filter strips
- infiltration devices
- basins and ponds.

Infiltration not only takes place in purpose built areas such as soakaways and infiltration trenches, but also through the sides of ponds and channels. It can be seen therefore that many of the features constructed as part of a sustainable urban drainage system fulfil several roles. A swale with a gentle gradient not only drains the site, but also slows down the flow, storing the rainfall within the channel. The low velocity of the flow allows settlement of solids whilst the grassed banks provide a medium for bio-filtration. The water will also percolate into the soil, being subject to physical and biochemical filtration as it naturally infiltrates. This combined action reduces the area of land required compared with a system that treats and attenuates flows separately.



Cross section across a swale. The water will flow slowly along the swale to disposal or further treatment, evening out the flow rate and improving water quality through settlement and filtration.



Cross section through a pond. Wetlands are similar but have more vegetation. In a basin the area will be dry most of the time.

The fact that various techniques perform several functions is not limited to technical matters. The water features can form an integral part of the landscaping for a development. Thus visual and conservation considerations also impact on the design of a sustainable drainage system.

The amenity value of a properly designed sustainable drainage system should be balanced with the other two goals – to control water quality and quantity of runoff. By integrating sustainable urban drainage systems into the overall plan of a development, public areas can fulfil dual roles. Landscaping of the development will be enhanced, not just through the inclusion of water features, but also the improved soil moisture levels that result from infiltration will reduce the need for irrigation. Developing any open water or wetland feature into a conservation area has a high level of public interest.

Where basins or channels are dry for most of the time, the areas can serve a dual purpose. Paths, car parking or sports fields can all be allowed to flood and provide cost-effective temporary water storage. Through correct design these can rapidly recover from an inundation and serve their more obvious purpose for most of the year. This idea can be taken further with the use of permeable pavements, where rainwater is retained within the paving sub-base and then drains away at a natural flow rate. These advantages only accrue however if all parties involved in the drainage system are involved at an early stage of the design process, to allow ideas and opportunities to be discussed and the wider project objectives shared. The design and operation should involve a wide range of professionals, including landscape architects, ecologists, engineers, hydrologists and water quality scientists. The public should also be involved, as the drainage methods selected have to meet their demands in terms of amenity, operation and perceived safety.

Barriers to wider use of SUDS

Although the theory of sustainable urban drainage is accepted and used overseas, it has not gained wide acceptance in the UK. A barrier is the availability of information, both in general terms of the options available and in specific areas such as technical design and maintenance. The initial problem is a lack of awareness of the problems and the solutions now available.

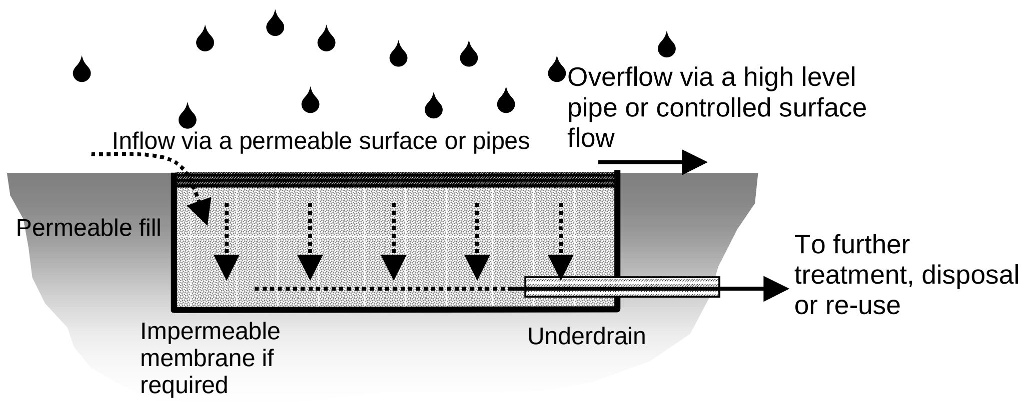
The proposed methods require an integrated approach to design so they need to be addressed early in the design process. Developers need to be aware of the opportunities that can be used to their advantage. Because of the lack of existing examples of such schemes, both developers and planners may hesitate in selecting or approving these innovative techniques. Even if the idea is accepted, engineers and architects have only limited experience in the design of the features and the technical literature is not readily accessible, being both scattered through various sources or based on overseas experience. This in turn does not promote integrated design or the selection of the most suitable techniques. There are no specific problems in building most of the proposed features, although permeable pavement construction is only a recent development and experience in a wide range of applications is limited. Contractors will have to develop experience in this area in order to refine the designs and gain confidence in the techniques.

The operation and maintenance of drainage schemes also present issues that have to be resolved. The developers of a project normally hand over the responsibility of the drainage to either a local authority or the owners of the land. The very features that make sustainable drainage attractive have to be considered in the division of management responsibilities. There are very few single function features. As ponds serve a role as a visual feature, a conservation area and a drainage resource, the question of who is best suited to maintain the area has to be addressed early in the design and selection process.

Previously pipes could be identified as providing urban drainage and the responsibility assigned to the relevant body. A swale, basin or flood plain that is fully integrated into the landscaping should be maintained as such. Attention, however, has to be paid however to some specific points. These include the disposal of settled solids from the runoff, the maintenance of infiltration features to ensure their continued effectiveness and the monitoring of the design to check that is it functioning correctly.

Outputs of the project

Various interested parties have joined together in a CIRIA (Construction Industry Research and Information Association) managed project to address some of the issues identified so far. This independent, co-ordinated approach aims at providing information on the best practice in planning, designing, constructing and managing urban drainage schemes sustainably. The project consists of several linked outputs, namely:



Cross section along a filter drain. Permeable surfaces can perform a similar function over a wider area

- a best practice manual, examining a series of demonstration sites and discussing the barriers encountered during each scheme, with examples of how they were overcome (C523)
- two design manuals (one for Scotland and Northern Ireland, one for England and Wales), introducing the factors that should be considered in the selection and design of SUDS (C521 and C522)
- a leaflet to bring about greater awareness of the opportunities available
- a web-site to disseminate information through the internet
- a training pack to aid in the education of developers, planners, designers and authorities

By basing this project on actual examples, the information should be directly relevant to the issues and barriers encountered by practitioners seeking an alternative, long term solution to the management of urban runoff.

Consensus

The publications however are not the most significant output from the project. The various organisations involved in the project are producing standards and guidance on the best practice in the design and management of SUDS. Areas of agreement include:

Benefits

Wider use of SUDS can lead to:

- reduction of flood risk
- reduction of pollution of receiving water bodies
- improvement of urban amenities
- better use of resources.

Barriers

Potential barriers to the wider adoption of SUDS include:

- lack of design guidance
- uncertainty over the costs involved
- operation and management uncertainty
- adoption and ownership disputes.

Runoff quantity

The baseline standard for flow rates from developed sites should be similar to the flowrates from the site before development. This should be checked for a wide range of flood frequencies, including:

- baseflows (to ensure aquatic habitats are not disrupted)
- annual flows (for water quality management)
- flows at various frequencies (e.g. 0.1, 0.03, 0.02, 0.01 and 0.005) to see the impact of flooding on roads, properties and risk to life.

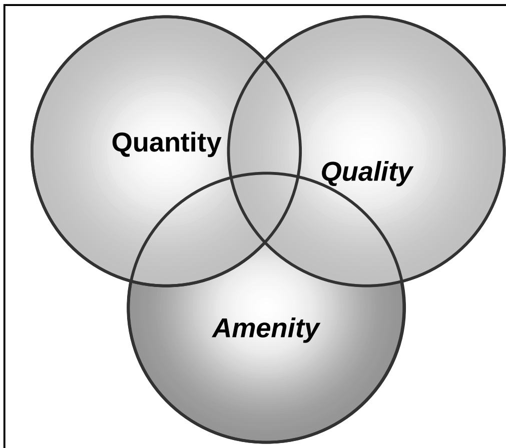
These standards may be adjusted in light of local factors.

Runoff quality

Runoff can be contaminated from pollutants washed off impermeable surfaces. Different areas have a variety of risks of pollution, so they will require a corresponding level of treatment. Thus;

- residential areas
- non-residential areas
- industrial areas
- roads

all have a suggested level of water quality control. These may be amended in light of local factors. The nature of the receiving water is an important factor. A precautionary approach has to be taken with groundwater as monitoring and remediation is difficult.



Design surface water drainage systems with all stakeholders considered equally

Design procedure

Two principles need to be considered when designing SUDS. The system should balance the requirements of all the stakeholders, so quality, quantity and amenity issues are considered equally.

Secondly, the selection of techniques should be inspired by the natural drainage system, with preference given to source control. Surface water drains naturally through a series of stages and this model can be used to design a drainage system, with each successive stage treating or attenuating the water. This is known as the surface water management train.

What next ?

There is information available on the design of SUDS and many systems have been designed, built and successfully operated around the country. The onus is now on planners, developers, designers and contractors to put the principles of sustainable development into action.

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