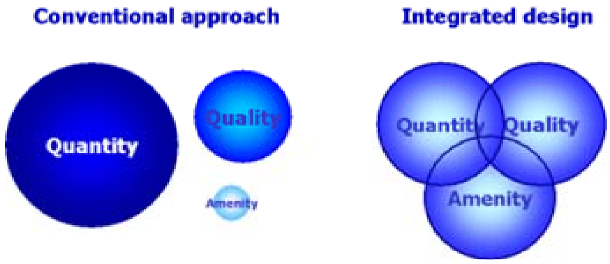
Briefing note: Sustainable Stormwater Management

prepared by the NTUA

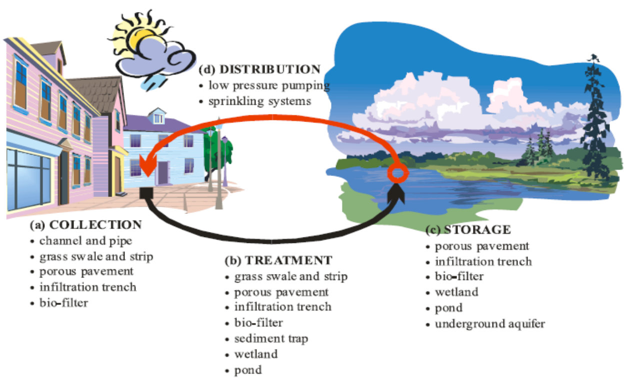
Sustainable drainage systems are cost-effective easy-to-manage solutions, designed to manage runoff flow rates, reduce the impact of urbanisation and the danger of flooding, provide water treatment, protect water resources from point and diffuse pollution, and create new habitats for wildlife and plant life. They can replace existing sewerage systems which are close to full capacity.



Conventional vs. integrated design in stormwater management

Introduction

Traditionally the drainage of built-up areas was done through underground pipe systems designed to prevent flooding locally by conveying the water away as quickly as possible. This alteration of natural flow patterns however can lead to problems throughout the catchment. Water quality issues have become increasingly important, as pollutants from urban areas are being washed into rivers or the groundwater. Once polluted, groundwater is extremely difficult to clean up. Conventional drainage systems cannot easily control poor runoff quality, and are not designed with wider considerations in mind such as the amenity, biodiversity, and public aspect. Continuing the drainage of urbanized areas with limited objectives, ignoring wider issues, has been recognized as an unsustainable long-term option that impacts on both the terrestrial and aquatic environments.



Stormwater cycle

Agenda 21 set the framework for local sustainability and boosted the adoption of sustainable drainage technologies, which are becoming increasingly popular for dealing with urban runoff.

Why sustainable stormwater management?

Sustainable urban drainage systems (SUDS) are cost-effective, easy-to-manage solutions that can replace existing sewerage systems close to full capacity. They are designed to manage runoff flowrates, reduce the impact of urbanisation and the danger of flooding, provide water treatment and protect water resources from point and diffuse pollution; additionally, they can potentially create new habitats for wildlife.

The sustainable stormwater management methods bear many benefits in comparison to conventional systems. They:

- Protect water & air quality
- Reduce stormwater treatment costs (capital infrastructure, maintenance and operating costs)
- Promote aquifer recharge
- Reduce peak flow and pipe capacity costs
- Reduce stormwater runoff/pollution/ flooding and erosion risk
- Reduce degradation of rivers, lakes, beaches and bays

- Reduce landscaping maintenance costs
- Enhance natural environment, community aesthetics and recreational opportunities
- Attract wildlife
- Promote a safer/healthier community and encourage social interaction.

SUD Systems

Different types of aboveground and underground SUD systems exist and their application is decided according to flow attenuation and water conveyance needs, land available, economic, and ecology parameters.

Ponds

Detention (dry) Ponds: *Storage facilities without permanent water, designed to store storm water during high peak flow events.* They are used for the removal of suspended solids, and do not provide biological treatment. The outlet is designed to drain the volume from the basin over every 24 or 12 hours. The pond also has a safety overflow for cases of storm events. Semiannual inspections for plant control repair of eroded areas, inlet and outlet repairs, are recommended.

Detention Pond

Retention (wet) Ponds: *Storage facilities, retaining permanent water.* They are used whenever biodegradable pollutants are present. They have a permanent water pool, two-metre depth detention storage above the permanent pool for peak flow control, and a shallow zone used as biological filter.

The pond is able to provide a 21days biochemical treatment of the runoff. 50% reduction in phosphorous rates can only be achieved when the pond is followed by water filtration.

Average pool depth is between 1.3-2.0 metres; the maximum recommended depth is 3.0 metres. Vegetation covers 25% - 50% of the pond surface area.

Well-established retention pond

Frequent maintenance inspections for monitoring of aquatic growth, shore erosion, inlet and outlet performance should be carried out, especially during the first year of operation and until the pond is well-established.

Wetlands

Storage facilities with permanent water for the treatment of dissolved biodegradable pollutants. They cover wider areas than the ponds and resemble natural wetlands; sizes vary and can reach a surface of even some square kilometres. Water depth also varies throughout the year; average depth is 0.5-0.75m. Vegetation (hydrophytes), introduced by wetland ecologists, covers about 75% of the surface area, while wetlands with their rich flora provide wildlife habitats.

During the 'active' growing season maximum pollutant reduction is achieved (in northern climatic conditions, this period is between May and September). Maintenance is important for keeping wetland performance up to a high level. It includes inspections by wetland ecologists for erosion, for inlet and outlet blockage and for vegetation control.

Inland Marsh Wetland

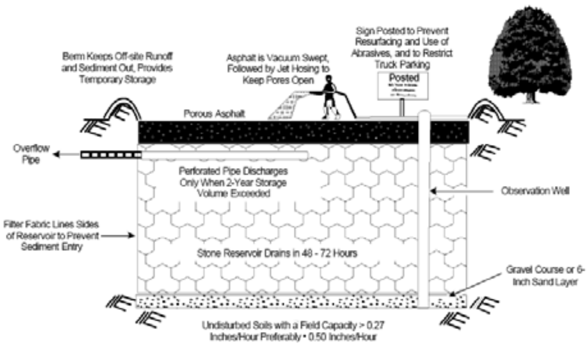
Swales

Grassed man-made channels allowing small water storage. They are considered the most cost efficient and effective way of water conveyance, and are used for areas less than 10 acres. Swales have the ability to reduce the runoff speed and control high rates of runoff. Reduction of the runoff quantity is achieved through infiltration into the soil and runoff acceleration by the grass. The water depth should not exceed 0.1m. On average, swales have the ability to remove approximately 30% of pollutants. Vegetation used is turf grass, which also offers protection from side erosion. Inspections must take place at least semi-annually, for erosion control, odour control by channel cleaning, and litter and sediment removal to avoid blockage and malfunctions. Proper maintenance increases the lifespan of swales.

Road side swale

Porous pavement

High porosity man-made pavements, with a large underground storage capacity. They can be made either of asphalt or of concrete. The runoff is drained down the irregularly shaped rock pavement and led to underground pipes or to the underlying subsoil, while the sides



Schematic of porous pavement

Porous car park

and the bottom of the reservoir are covered with filter fabric for avoidance of mixing of the runoff with the soil.

Porous pavements are mostly used in car parks and paved park areas or even in roads, mainly pedestrian or light traffic roads. Porous pavements provide erosion control, by reducing the speed of runoff, pollutant reduction, and groundwater recharge. Their main disadvantages are that they may cause groundwater pollution, clogging and they have a high cost of maintenance. Vacuum cleaning is an advisable maintenance solution.

Infiltration trenches

Shallow excavated ditches 3 to 12 feet deep, filled with gravel, stone aggregates, or sand. Infiltration trenches allow water infiltration and underground storage or conveyance to underground pipes. Infiltration trenches are used for areas of 5 acres maximum surface; they cannot operate properly in soils with high clay content or in hardened soils with low water absorption.

They provide pollutant reduction, runoff attenuation for small sites, and groundwater recharge, while having short lifespan, relatively high capital and maintenance

Infiltration trench under construction cost, and might cause clogging and groundwater pollution.

The maintenance requirements for ensuring proper trench operation are high. Trench monitoring should be undertaken at least once per year or after every strong storm event. Maintenance includes the removal of debris and vegetation control.

Green Roofs

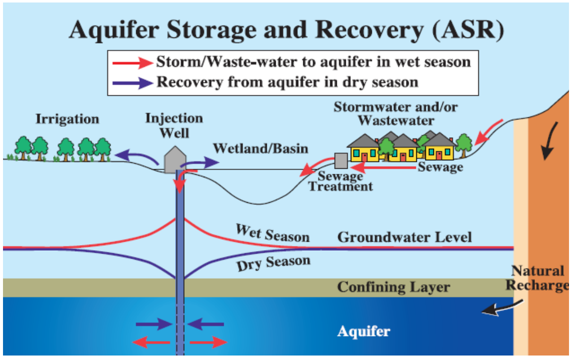
Extensions of the existing roof which involve high quality water proofing and root repellant systems, drainage systems, filter clothes, lightweight growing mediums and plants. Green roof systems may be modular, with drainage layers, filter cloth, growing media and plants already prepared in movable, interlocking grids, or each component of the system may be installed separately.

Green roof
in stormwater management

Green roof development involves the creation of "contained" green space on top of a human-made structure. Water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation. In summer, depending on the type of plants and depth of growing medium, green roofs retain 70-90% of the receiving precipitation; in winter they retain between 25-40%. A grass roof with a 4-20 cm (1.6 - 7.9 inches) layer of growing medium can hold 10-15 cm (3.9 - 5.9 inches) of water. Green roofs do not only retain rainwater, but also moderate its temperature and act as natural filters for occasional water run-off. By reducing the amount of stormwater runoff and delaying the time at which it occurs, they decrease stress on sewer systems at peak flow periods.

Benefits, Constraints and Implementation issues

The benefit of the SUDS approach is that it takes account of water quantity, water quality, environmental and amenity issues. SUDS mimic natural systems. They should be integrated into the environment as visually attractive features, which on top of obvious environmental and societal benefits they can also provide habitat for wildlife that would otherwise be scarce in the built environment., and promote aquifer recharge.



Storm and wastewater use for aquifer recharge

The main constraints associated to the use of sustainable urban drainage systems include the high landtake requirement which is often seen as a deterrent by developers, the cost of retrofitting the systems into established residential areas, the need for frequent maintenance, and the public acceptability of open-water above-ground stormwater management systems - a concern for planners.

Sustainable drainage systems were initially designed and constructed for urban runoff treatment in the U.S.A. Many States have nowadays adopted sustainable drainage systems as common practice for runoff management.

Such systems were soon introduced to other countries facing similar problems with water runoff, such as Britain, Switzerland, Sweden, Germany, France, Japan, Australia, and South Africa. In more recent year more countries including Malaysia, China, Thailand, and Singapore have begun studying and applying such systems. Stormwater can also be used directly for aquifer recharge.

In the Rio Earth Summit 1992, sustainable drainage options have received agreement of the international engineering community as part of sustainable development strategy. Nowadays there is growing interest in such systems.

Good Practice Example: Dunfermline Eastern Expansion, Scotland

The Dunfermline Eastern Expansion (DEX) is a 550ha (5.5km2) site, of low permeability clay soil, which is planned to be developed over the next 20 years as a mixture of industrial, commercial, residential and recreational areas.

The enormous size and long timescale for the development of DEX has meant that an overall SUDS design was essential.

Much of the residential roads and the spine road system is drained using ***infiltration trenches*** *and* ***swales****, which discharge into extended detention* ***basins*** *and* ***wetlands*** *also serving adjoining housing areas. Treatment of surface water run-off from the development and roads is achieved through a system of regional* ***ponds*** *and* ***wetlands*** *prior to discharge to the* ***watercourses****. Ponds and basins are widely used to achieve maximum attenuation of storm flows. The wetland is located in a public park area where informal public open space adjoins an existing forested area and an area set aside for football pitches, a rugby pitch and tennis courts.* ***Porous paving*** *has been used in car parks, also connected to the wetland through* ***attenuation/infiltration systems*** *.*

Sources and links

1. Campbell N.S., 2000, Best Management Practice in urban stormwater drainage practical implementation of the BMP approach, The IEI Water Course, Paper.
2. CIRIA, Sustainable drainage systems- Promoting good practice, World Wide Web URL address: http://www.ciria.org/suds/
3. Green Roofs for Healthy Cities, World Wide Web URL address: http://www.greenroofs.net/index.php?option=com_content&task=view&id=26&Itemid=40.
4. Jenssen P. D., 2005, Greywater treatment and reuse, Norwegian University of Life Sciences, Ecological Sanitation Symposium, Damascus, Syris, December 12 2005.
5. Krejci Vl. et al, Administrative aspects of stormwater infiltration in Switzerland, Swiss Federal Institute for Water Resources and Water Pollution Control (EAWAG).
6. Novotny Vl. & Olem H., 1994, New York, “Water Quality - Prevention, Identification, and Management of Diffuse Pollution, Van Nostrand Reinhold Publishing.
7. Truc D. V. & Canh D., Institute of Tropical Biology Ho Chi Minh City - Vietnam, Gradual application of sustainable urban-drainage system to reduce vulnerabilities to flood by overflow-rain and protect environment and resources in Ho Chi Minh City.
8. United States Environmental Protection Agency (EPA), 1999, Storm Water, Technology Fact Sheet, Porous Pavement.
9. Urbonas B. and Stahre P., 1993, Stormwater Best Management Practices and Detention for Water Quality, Drainage, and CSO Management, Prentice Hall, New Jersey.
10. Hatt B., Deletic A., Fletcher T., 2004, Cooperative Research Centre for Catchment Hydrology - Australia, Technical Report 04/1, Integrated stormwater treatment and re-use systems - Inventory of Australian practice.