

# Sustainable stormwater management solutions

*This toolsheet introduces various different techniques for sustainable stormwater management. The purpose is to give an idea of different kinds of solutions and techniques available and commonly utilised. In practice, different techniques can be combined together and realised stormwater management structures can have features of several solutions. Each structure needs to be designed uniquely based on its location in the watershed, water quality, soil type, desired functions and available space.*

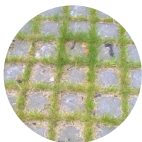
## On source management



Green roofs



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## Conveying



Canals and rills



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(Bio)swale

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URBAN  
RESILIENCE

POINT 2  
TECHNICAL  
OPTIMI-  
ZATION

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## Detention and infiltration



Stormwater tree trench



Stormwater planter



Rainwater cistern



Infiltration basin



Infiltration pit



Detention basin



Rain garden



Pond



Filter strip



Wetland



*London 2015*

## **Green roofs**

Green roofs comprise a multi-layered system, which covers the roof of a building or podium structure with vegetation cover/landscaping. Green roofs reduce most effectively the volume of run-off and attenuate peak flows through processes of retention and evapotranspiration from short, mild storm events. These roofs consist of a substrate or growing medium, plant materials, and a range of insulation and waterproofing membranes.

The quality of green roofs can vary from very thin moss roofs to intensive roof top gardens. Even if plants are chosen for their lower maintenance requirements, they still need occasional inspection, weeding and irrigation.

Furthermore, these roofs add additional thermal insulation as well as potentially lower the heating and cooling costs for buildings. They also significantly reduce the heat reflected by building rooftops compared to conventional roofing materials.

**Cost benefit ratio:** Multiple benefits provided by a green roof compensate very well the construction costs.



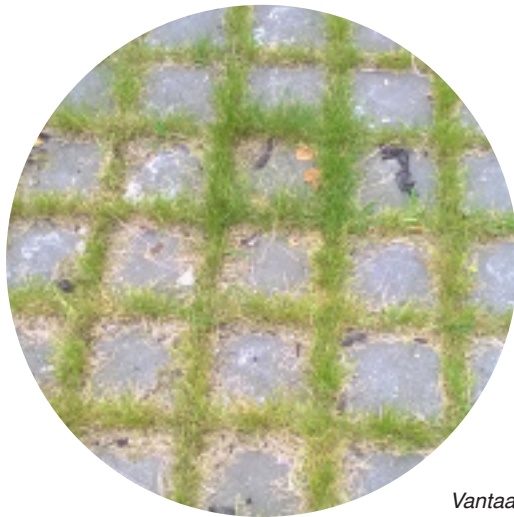
*London 2015*

## **Green walls**

Green wall is an all-encompassing term that is used to refer to all forms of vegetated wall surfaces. These include green facade (plants growing onto and over specially designed supporting structures) and living walls (distinct wall panels that include growing medium or liquid nutrient).

Green walls include most of the benefits of green roofs as they naturally absorb, filter and evaporate stormwater. These walls can also reduce sound reflection, air pollution and regulate microclimate through shading. Similar to a garden, a green wall requires constant maintenance. The most important aspect of the maintenance is ensuring that plants are not suffering under or over watering. Plants must be occasionally pruned, fertilized and weeded if necessary, and sometimes plants will need to be replaced.

**Cost benefit ratio:** Relatively high construction and maintenance cost might be compensated in very densely built environment by, for instance, the strong identity value.



Vantaa 2015

## Permeable surfaces

Permeable (or pervious or porous) pavement allows water to flow vertically through hard, paved surfaces. Permeable paving aids in run-off reduction by allowing for retention and infiltration. This system provides the structural support of conventional pavement and can be used in areas, such as parking lots, plazas, and walkways where hard surfaces are required. The water can be temporarily stored before infiltration to the ground, reused, or discharged to a watercourse or other drainage system. Surfaces with an aggregate sub-base can provide good water quality treatment.

There are many different types of porous surfaces, including pervious asphalt, pervious concrete, and interlocking pavers. While pervious materials allow the water to penetrate through the paving, pavers are spaced apart with gravel or grass in between to allow for infiltration.

**Cost benefit ratio:** Enables the utilisation of areas that are programmed for human or vehicular use for run-off reduction and stormwater management. Permeable paving can reduce the amount of site area needed for additional structural management facilities, and add value to a property by preserving buildable space.



Vantaa 2015

## (Bio)swale

Vegetated swales, also known as bioswales, are gently sloped, planted channels for treating and conveying stormwater. Vegetated swales convey stormwater away from the infrastructure, such as sidewalks, roadways, parking lots, and building foundations. They differ from conventional channelling systems as they combine conveyance with stormwater treatment. In contrast to concrete-lined swales and pipes, vegetated swales slow stormwater velocity, allow for evapotranspiration, and remove debris while enhancing sediment dropout and infiltration.

In order to infiltrate stormwater in swales, the soil must be permeable. A swale does not require any other construction than the surface design, the growth layer and the installation of vegetation. An underground drainage layer is used to convey extra water forward if the soil is not permeable. The drainage layer is constructed at the bottom of the structure. Plants used in the swale should tolerate standing water at the bottom of the swale. Plants should be easily maintained. It would also be good to use a variety of different plant species, in order to establish enduring vegetation.

**Cost benefit ratio:** Low investment solutions, which are relatively easy to maintain and provide multiple benefits.



*London 2015*

## **Canals and rills**

Canals and rills are open surface water channels with hard edges. They can have a variety of design and materials to enliven urban landscape, including the use of planting to provide both enhanced visual appeal and water treatment. Simple canals made with hard materials can be very easy and cost effective to maintain.

Appropriately designed treatment channels collect water, slow it down and pre-treat water by removing silt and oil before water is conveyed into other SuDS components. The outlets can be designed to act as a mini oil separator; hence the channels can be very effective at treating pollution.

**Cost benefit ratio:** Construction costs depend highly on the design, but usually easy to maintain. Biological value is low but canals and rills are very useful elements as part of the stormwater system in the densely built environment.



*Tampere 2017*

## **Ditches and streams**

A ditch is a narrow channel dug at the side of a road or field, to hold or convey water away. It is deeper than a swale, but the structure offers similar possibilities for infiltration and detention. A ditch is easy to construct and maintain. However, it is seldom used in densely built areas, as it is visually and functionally difficult to integrate into an urban street or park environment.

Stormwater can also be conducted in a stream (that is constructed especially for that purpose). It is often wider and meanders more than a ditch. A stream can also include natural features such as stones, vegetation and shallows to slow down stormwater flow.

**Cost benefit ratio:** Usually low cost solutions that provide multiple benefits.



*Portland 2017*

### **Stormwater tree trench**

A stormwater tree trench is a system of trees that are connected by an underground infiltration structure. On the surface, a stormwater tree trench looks just like a series of street tree pits. However, under the sidewalk, there is an engineered system to manage the incoming run-off. This system is composed of a trench dug along the sidewalk, lined with a permeable geotextile fabric, filled with stone or gravel, and topped off with soil and trees.

Stormwater run-off is infiltrated into the rooting area of the trees through a special inlet (storm drain). The run-off is stored in the empty spaces between the stones, watering the trees and slowly infiltrating through the bottom. If the capacity of this system is exceeded, stormwater run-off can entirely bypass it and flow into an existing street inlet.

**Cost benefit ratio:** Street trees are a long term investment the value of which increases in time.



*Portland 2017*

### **Stormwater planter**

A stormwater planter is a specialized planter installed in the sidewalk area that is designed to manage street and sidewalk run-off. The planter is lined with a permeable fabric, filled with gravel or stone, and topped off with soil, plants, and sometimes trees. Distributed planters collect and retain stormwater run-off, which is then infiltrated, biologically treated, and evapotranspired by trees and other vegetation within the cells.

Run-off is directed to the planter by curb cuts and drain pipes that may be designed as part of a planter. Excess run-off is directed into an overflow pipe connected to the existing combined sewer pipe. High velocity water entering the cell may dislodge plant material and cause erosion. Therefore, planters are most effective when located close to the source of stormwater run-off. If the planter is not rectangular, but rather curvy, it may be called stormwater bumpout.

**Cost benefit ratio:** Construction and maintenance costs for designed elements can be high, but vegetated planters provide valuable greenery in the street scape.



*Portland 2017*

### **Rainwater cistern**

Rainwater from roofs and hard surfaces can be stored in rainwater cisterns for later use as a water supply. If designed appropriately, the cistern can also be used to reduce the rates and volumes of run-off.

Rainwater harvesting cisterns may be located above or below ground, and in some cases are located within a building. Some projects feature cisterns as iconic design elements to call attention to this practice. Cisterns located above ground are the easiest and most common means of harvesting rainwater, although they are primarily designed for small-scale use, such as in gardens. However, rainwater cisterns can also be integrated into large-scale commercial or industrial buildings. Collected stormwater can be used, for example, to flush toilets, hence reducing the use of fresh water.

**Cost benefit ratio:** Low cost solution, which is relatively easy to instal and maintain. Good solution when water is needed for gardening or other purposes.



*Vantaa 2017*

### **Infiltration pit**

An infiltration pit is a sub-surface run-off detention and infiltration system. It is usually located close to the downspout from the roof collecting stormwater in an underground storage space. The storage space is composed of large rocks, geocellular system or other material, that infiltrate stormwater and allow detention.

**Cost benefit ratio:** Low cost solution. The benefits are mostly related to the water retention and infiltration capacity.



Portland 2017

## Rain garden

A rain garden is a garden designed to collect run-off from impervious surfaces, such as roofs, walkways, and parking lots, allowing water to infiltrate the ground. The garden is normally moderately depressed (lower than the surrounding ground level), with the bottom layer filled with stone enabling run-off to collect and pool within it. The site is graded appropriately to cause stormwater to flow into the rain garden area from the nearby impervious area. The water is used by the vegetation in evapotranspiration or it infiltrates into the sub-surface stone storage and soil. Rain gardens can be connected to sewer systems through an overflow structure.

Flexible and easy to incorporate into landscaped areas, rain gardens are suitable for many types and sizes of development and retrofits. Rain gardens are effective at removing pollutants and reducing stormwater run-off volume. Native plants are recommended for rain gardens because of their adaptation to local environmental conditions and synergies with soil microorganisms that enable biological treatment processes.

**Cost benefit ratio:** Relatively low cost solution, which provide multiple benefits. Needs regular maintenance.



Portland 2017

## Filter strip

Filter strips utilise gently sloping areas and vegetation to infiltrate, reduce stormwater velocity and allow suspended solids to drop out of stormwater run-off. These strips employ wide areas of dense, native vegetation to slow stormwater, allowing for sediment drop-out, filtration, and debris removal before the run-off enters receiving waters. They are designed to accept run-off as overland sheet flow from upstream development, such as parking lots or roads; they often lie between a hard-surfaced area and a receiving stream, surface water collection, treatment or disposal system often designed to attenuate water from specific impervious surfaces, such as parking lots, roads, or roofs. They may also be used in riparian areas to protect streams from high-velocity or high-temperature run-off.

**Cost benefit ratio:** Relatively low cost solution, which provide multiple benefits.



*Zürich 2016*

### **Detention basin**

Vegetated detention basins, sometimes referred to as dry ponds, are depressions designed to temporarily hold and pre-treat the first flush of stormwater before regulating discharge to a receiving waterbody. Vegetated detention basins detain large volumes of stormwater, aiding in peak flow reduction and mitigation of potential downstream flooding. After the rain event, they slowly release stormwater further on in the management chain, but do not infiltrate it.

Detaining stormwater in vegetated basins enables sediment removal as vegetation decreases stormwater velocity, allowing suspended solids to settle out. A detention basin is typically planted with vegetation that is easy to maintain by regular cutting and clipping, thus not offering high aesthetical landscaping values.

**Cost benefit ratio:** Simple and cost-effective to construct with changes in performance being easy to observe.



*Portland 2017*

### **Infiltration basin**

Infiltration basins are vegetated depressions and very similar to the detention basins. The main difference is that infiltration basins are designed to store run-off on the surface and infiltrate it gradually into the ground. They are dry except in periods of heavy rainfall. They reduce the volume of run-off from a drainage area and can be very effective at pollutant removal via filtering through the soils. Infiltration basins also contribute to groundwater recharge and base flow augmentation.

**Cost benefit ratio:** Simple and cost-effective to construct with changes in performance being easy to observe.



*Espoo 2015*

## **Pond**

A wet pond is a constructed basin designed to retain a permanent pool of stormwater with limited biological treatment. Wet ponds aid in peak flow reduction and promote sedimentation. Stormwater may enter the pond as sheet flow across a filter strip or via a pipe or swale. If stormwater enters through a pipe, it should pass through a forebay, allowing initial sedimentation and velocity reduction. Once water reaches the permanent pool storage, additional sediment settling and biological uptake occur as stormwater is slowly released over 24-72 hours.

**Cost benefit ratio:** Construction costs depend highly on the design solution. A pond can deliver high aesthetic values to the site and host a large variety of vegetation and wildlife. However, it requires regular maintenance and the need for this is increased by the complexity of the design.



*London 2015*

## **Wetland**

Constructed wetlands are shallow, vegetated depressions with permanent standing water that offer a spectrum of ecosystem services to manage and treat stormwater. Constructed wetlands offer the many benefits of natural wetlands and marshes: they aid in peak flow reduction and provide conditions for sediment drop-out. Their high biodiversity of plants, animals, and microorganisms enhance evapotranspiration, filtration, and biological and chemical stormwater treatment. The natural aesthetic quality and high potential for habitat render constructed wetlands an excellent choice for educational opportunities.

Stormwater wetlands are an effective tool for removing pollutants from stormwater run-off. Similar to a pond, stormwater wetlands collect run-off and store it in a permanent pool; however, wetlands are shallow and populated by marshland vegetation that enhances the water treatment and allows pollutants to settle to the bottom.

**Cost benefit ratio:** Very cost-effective solution for areas with a lot of space. Wetland provide multiple benefits and they might even be called ecosystem services hotspots.

# References



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