

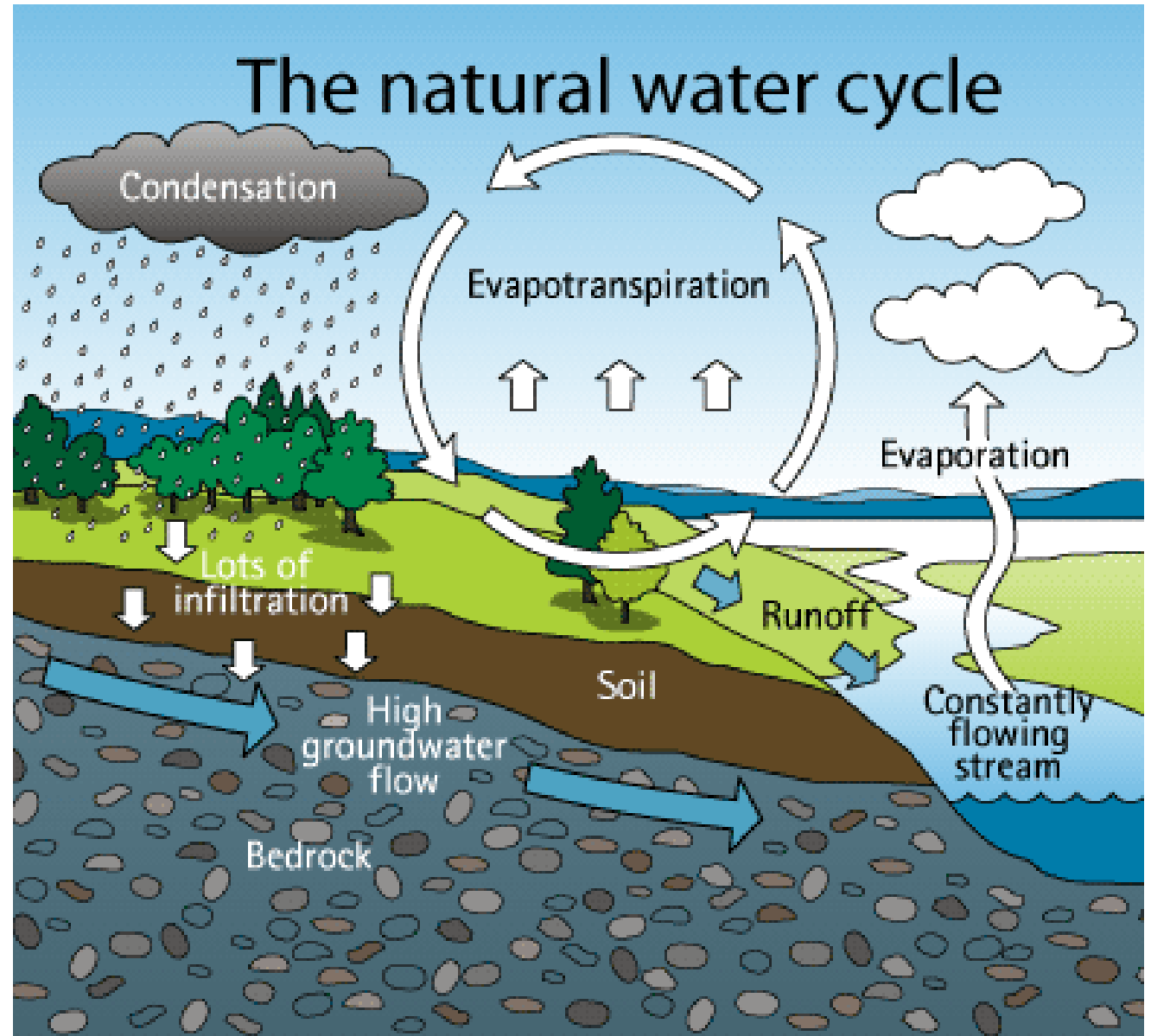


Sustainable Urban Drainage Systems



Surface Water Runoff

When rain falls on a natural landscape, it soaks into the ground infiltration, evaporates, is taken up by plants evapotranspiration and some of it eventually finds its way into streams and rivers.

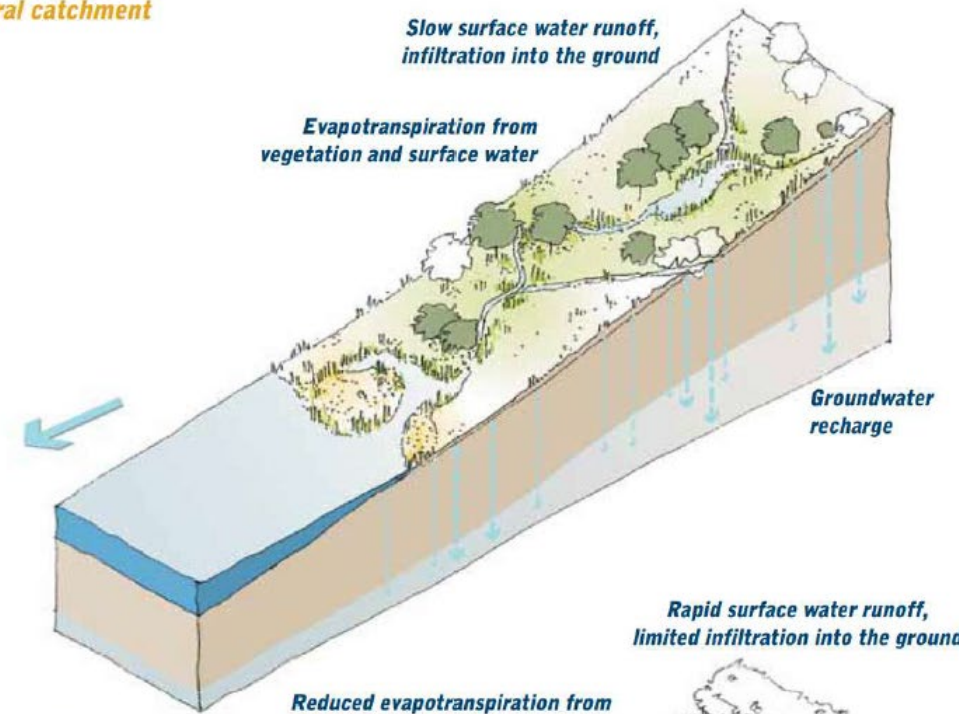


Surface Water Runoff

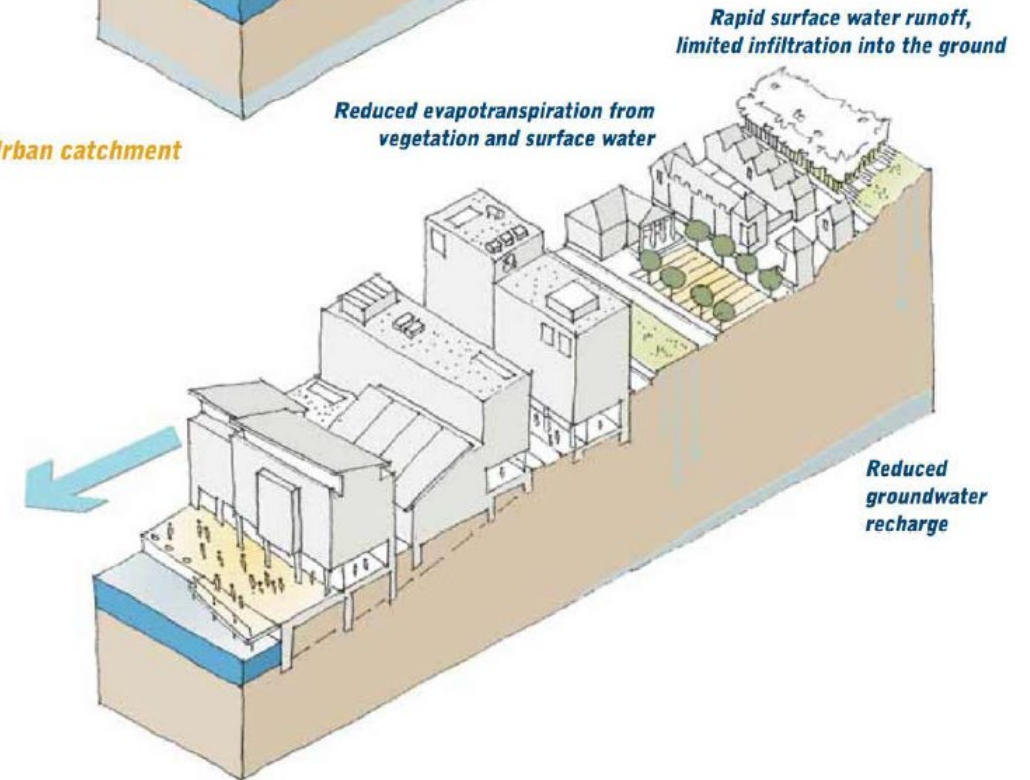
In urban areas, there tends to be less permeable ground available for infiltration and less vegetation for evapotranspiration.

When rain falls on impermeable surfaces, much more of it turns into surface water runoff.

Natural catchment



Urban catchment





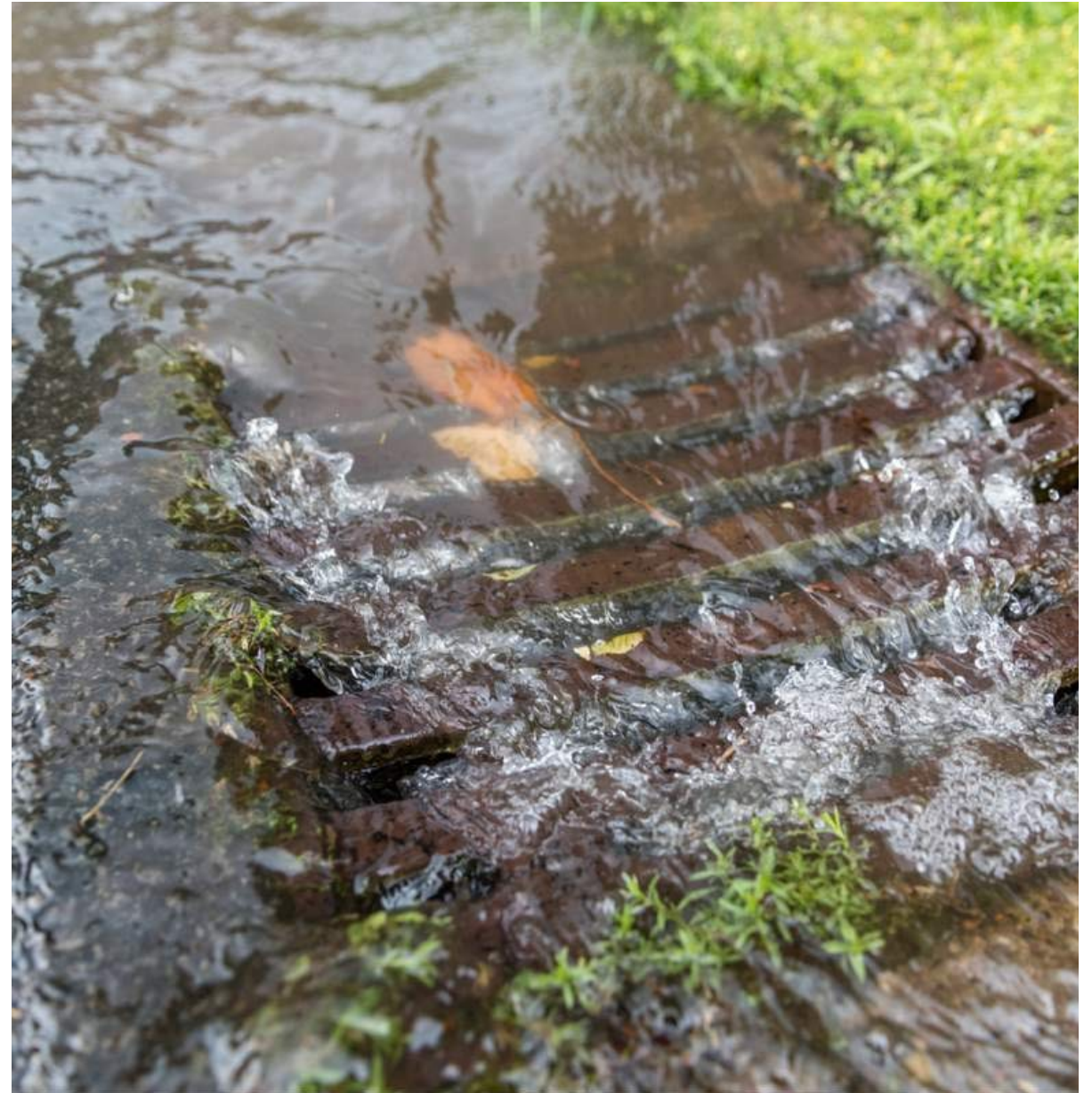
Traditional Drainage

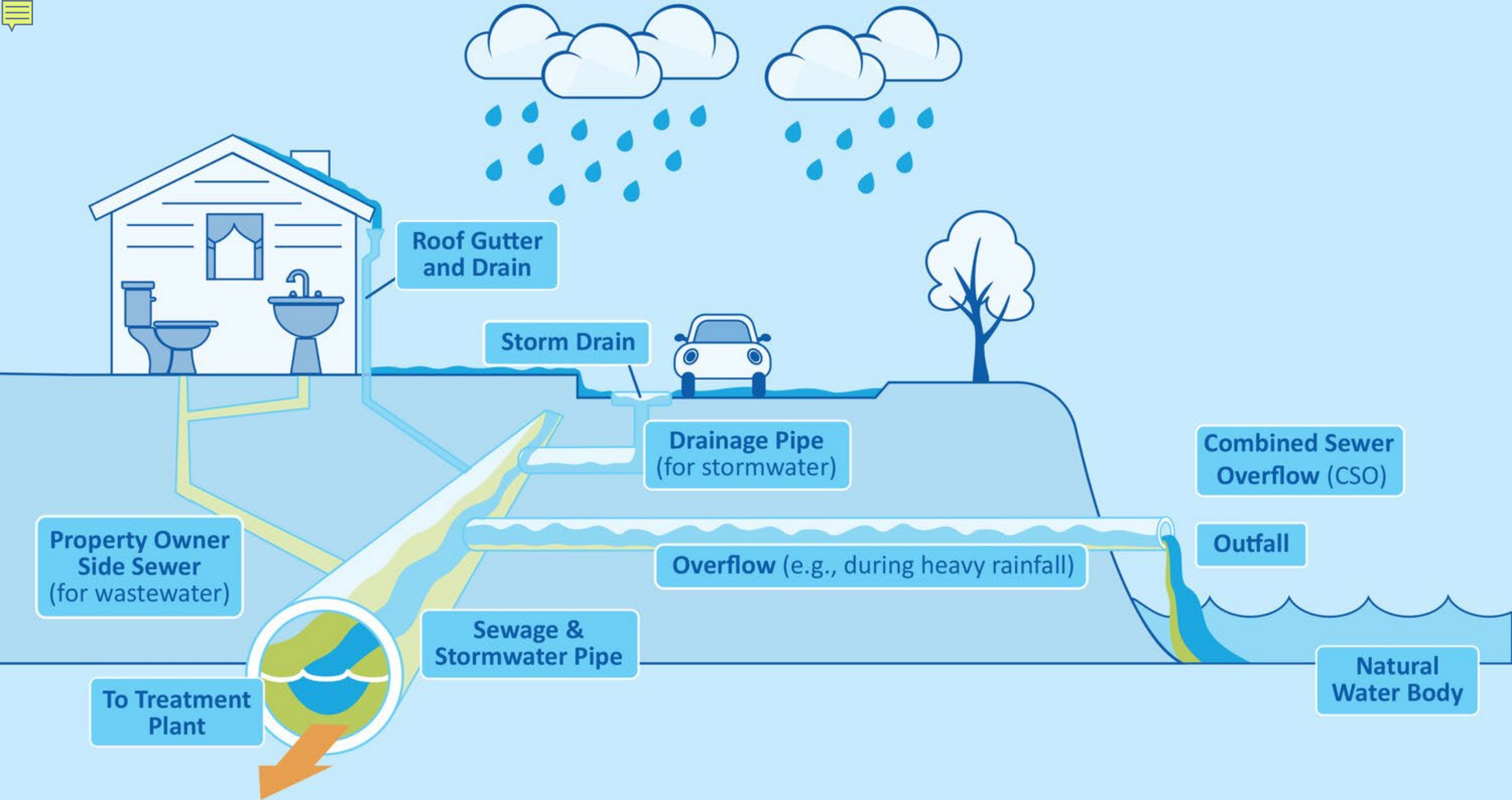
Surface water drainage has traditionally been designed using underground pipes.

These were designed to improve public health and protect properties from flooding.

However, many older surface water systems drain to combined sewers which were not designed to accommodate today's volume of rainwater.

When extreme rainfall occurs and the drains surcharge, foul sewage can flood urban areas.





Anglian Water fined £500k for sewage discharge in Essex river

26th November

South West Water told to deal with waste water discharges

Wild swimmers are getting sick from sewage, campaigners say

🕒 24 November

ENVIRONMENT

Half fall ill after surfing or swimming in British water

Southern Water 'dumps sewage 493 times in eight days at bathing beaches'

Campaigners condemning 'environmental vandalism' say equivalent of five months of discharges made so far in November

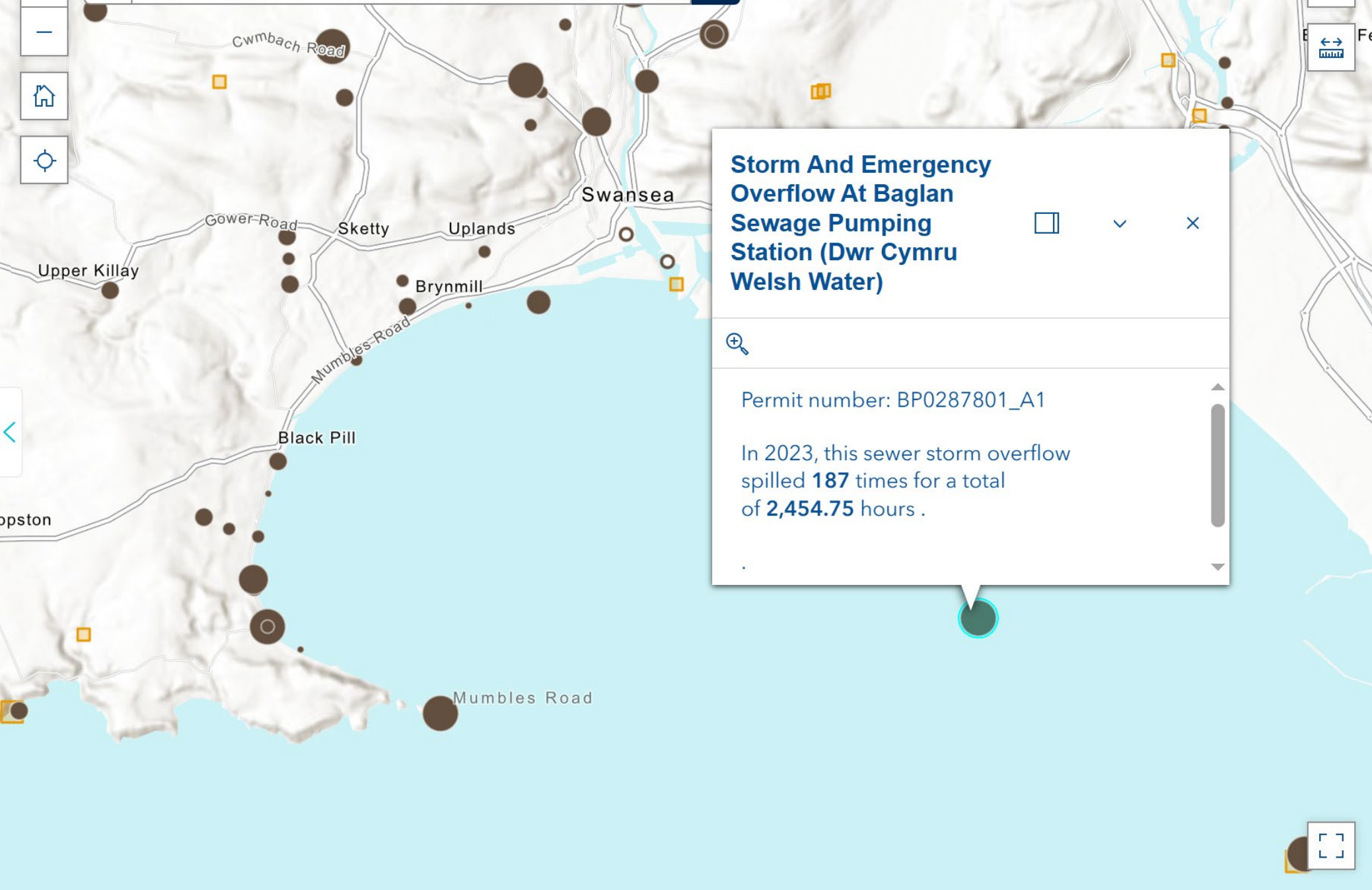


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Search by address, place name or permit number



Storm And Emergency Overflow At Baglan Sewage Pumping Station (Dwr Cymru Welsh Water)



Permit number: BP0287801_A1

In 2023, this sewer storm overflow
spilled **187** times for a total
of **2,454.75** hours .



opston



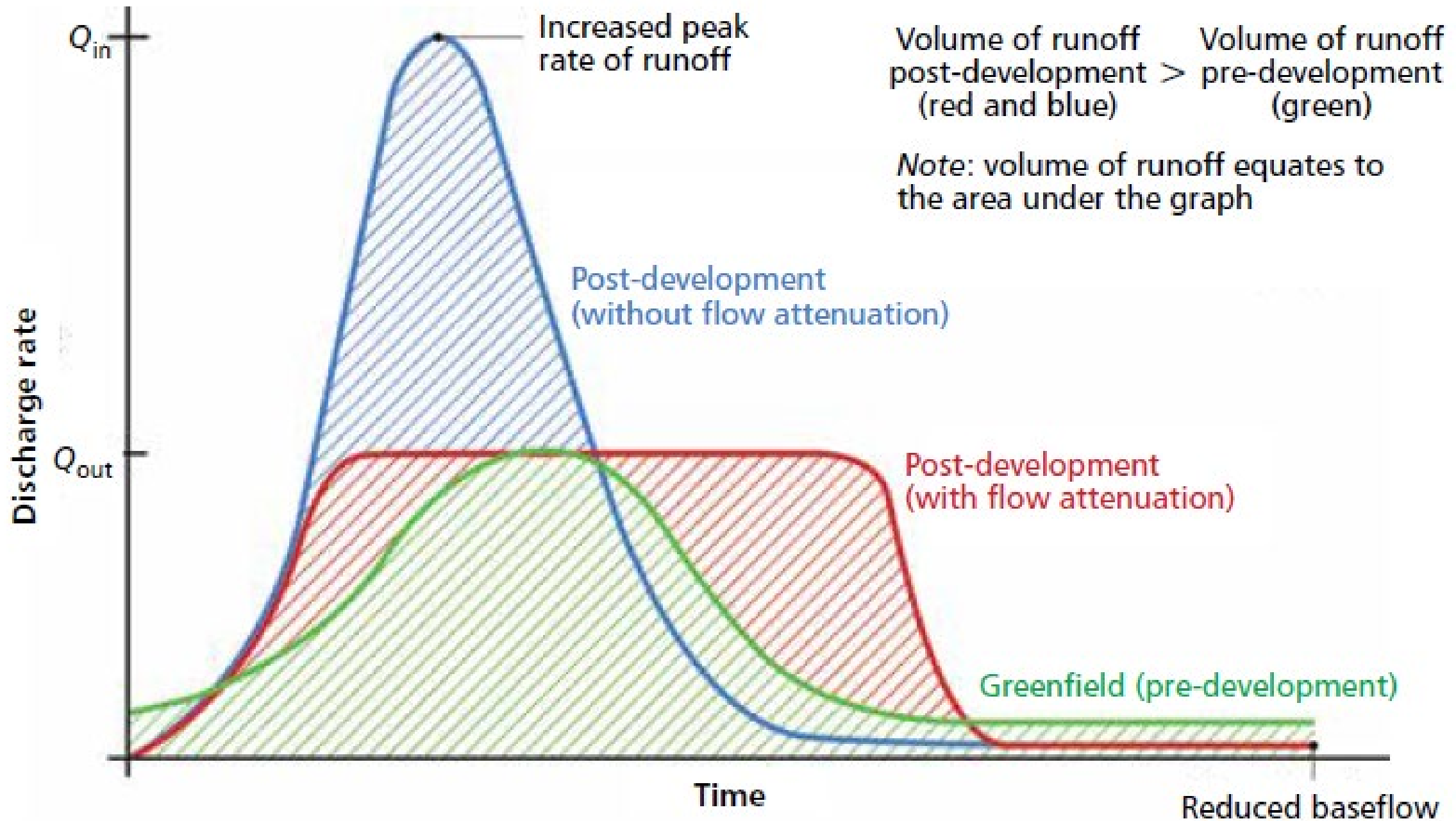
Principle of SUDS

SUDS is about managing runoff.

When rainfall occurs faster than water can infiltrate into the ground it becomes surface runoff.

The aim of SUDS is to return the post-development runoff, infiltration and evapotranspiration to as near natural conditions as possible, thereby minimising the adverse effects of built-up areas on the water environment.

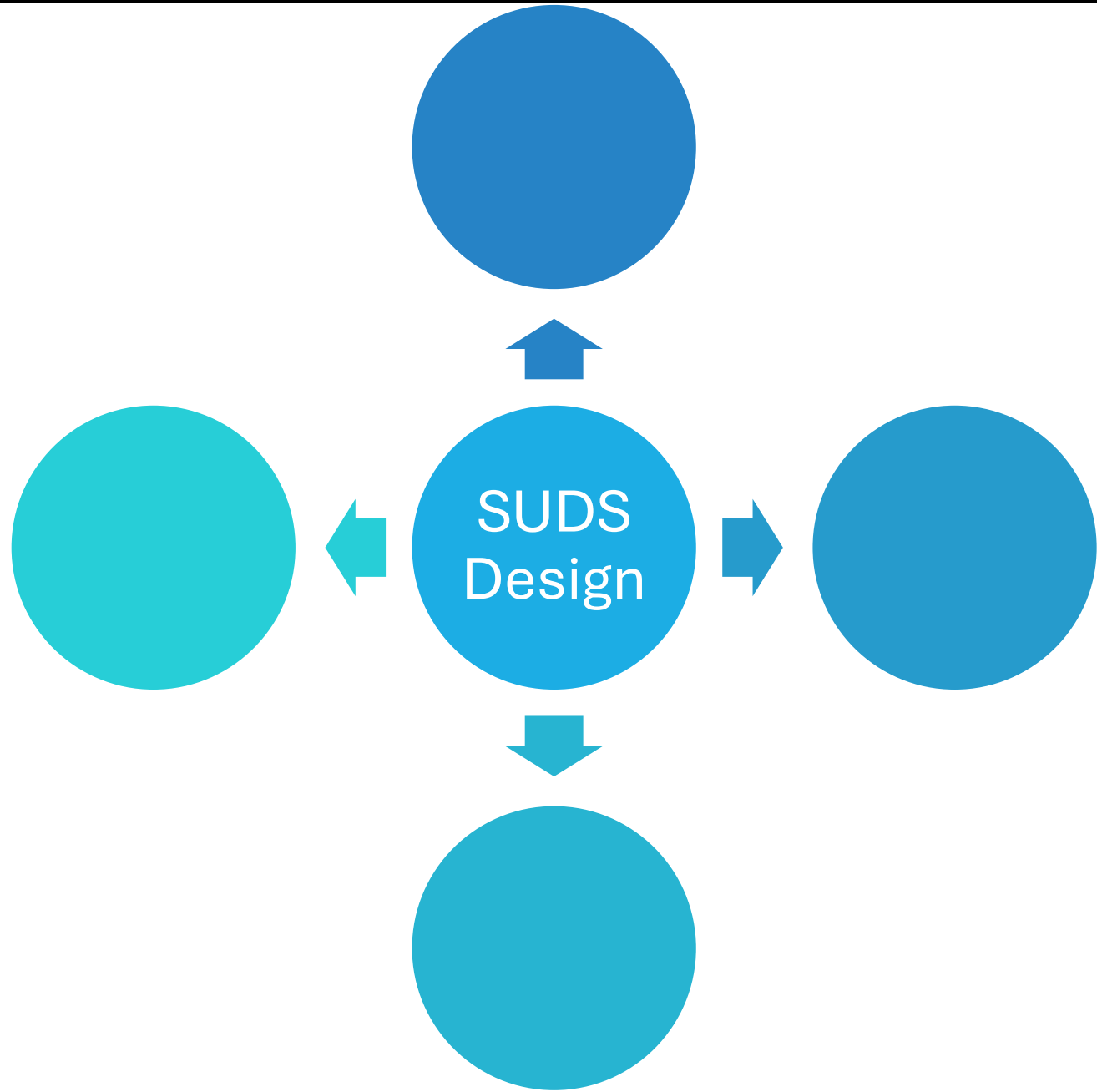






Benefits of SUDS

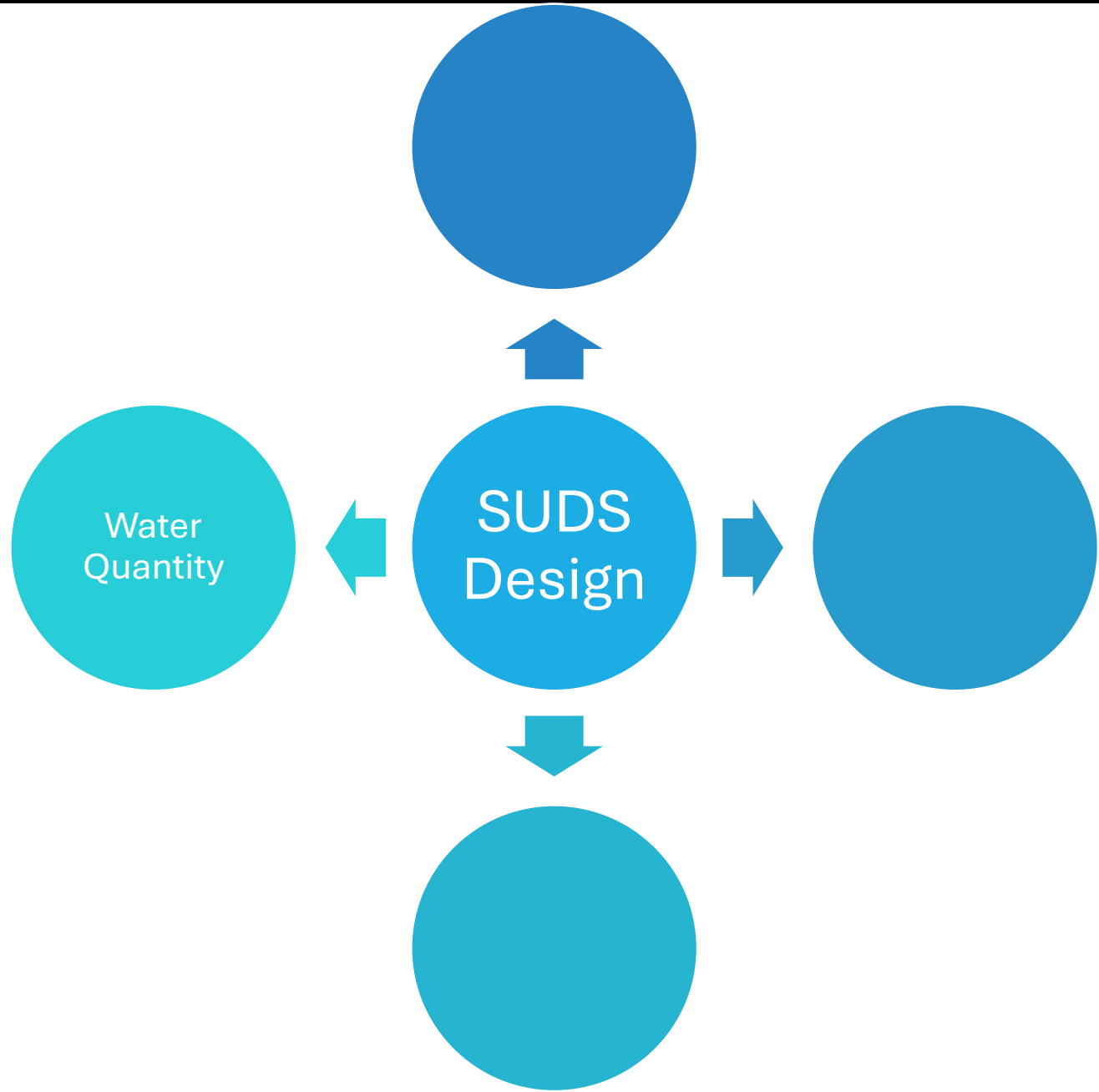
There are four main categories
of benefits that can be
achieved by SUDS:





Benefits of SUDS

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of benefits that can be
achieved by SUDS:



Water Quantity

- SUDS help manage surface water runoff by mimicking natural drainage processes.
- Instead of water flowing rapidly into sewers and rivers, SUDS slow down and control water movement, reducing the risk of overwhelming drainage systems.
- Techniques such as permeable pavements, retention ponds, and green roofs allow water to infiltrate the ground or be stored temporarily.
- This is especially important in urban areas, where impermeable surfaces (like concrete and asphalt) increase runoff and contribute to flooding.

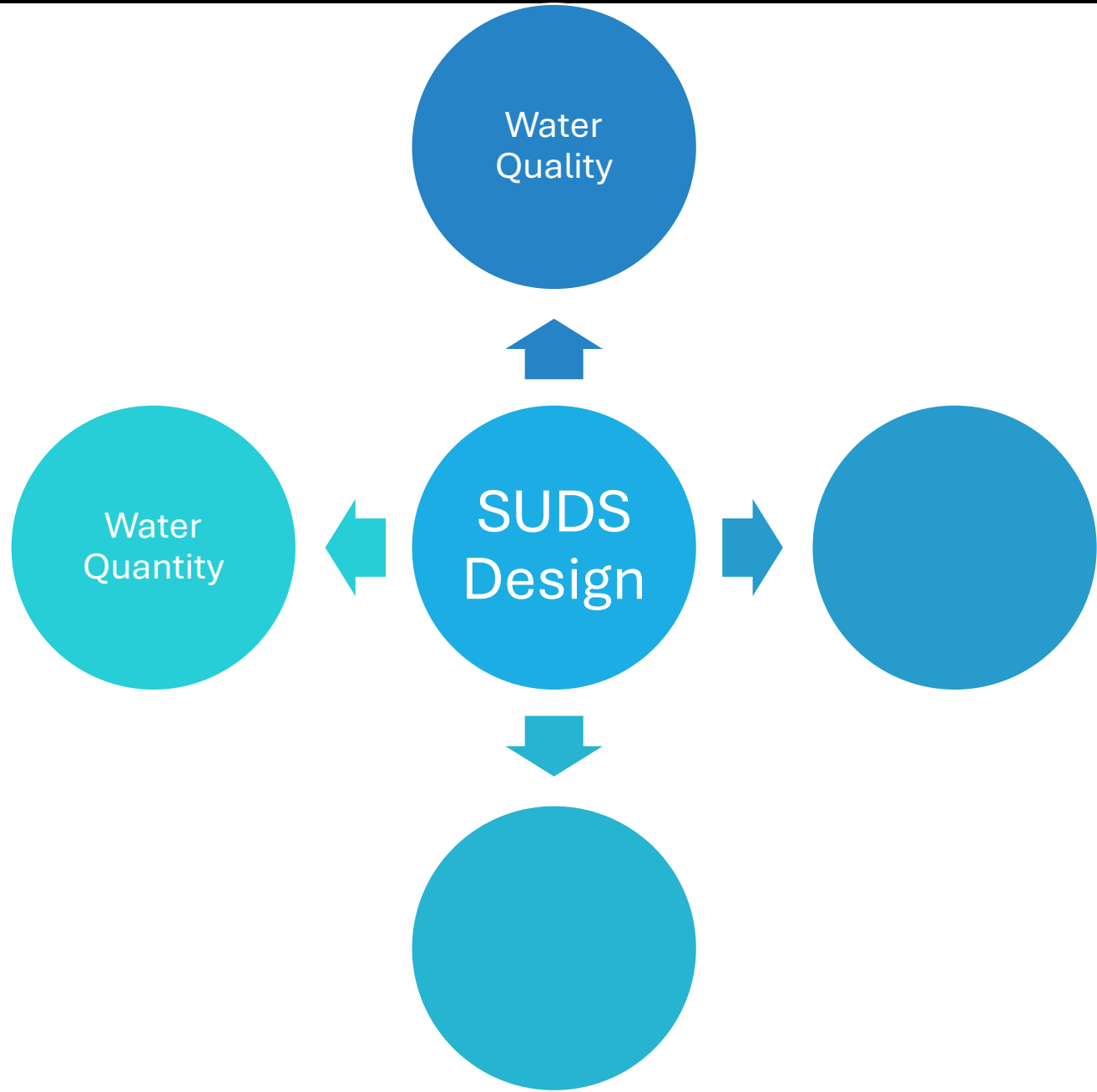
Water Quantity





Benefits of SUDS

There are four main categories
of benefits that can be
achieved by SUDS:



Water Quality

- Urban runoff often contains pollutants such as oils, heavy metals, and chemicals from roads and industrial areas.
- SUDS systems filter and break down contaminants before the water reaches rivers, lakes, or groundwater supplies.
- Features like wetlands, reed beds, and bio-retention basins help remove sediments and absorb pollutants naturally.
- This leads to cleaner water entering the environment, benefiting both human populations and aquatic ecosystems.

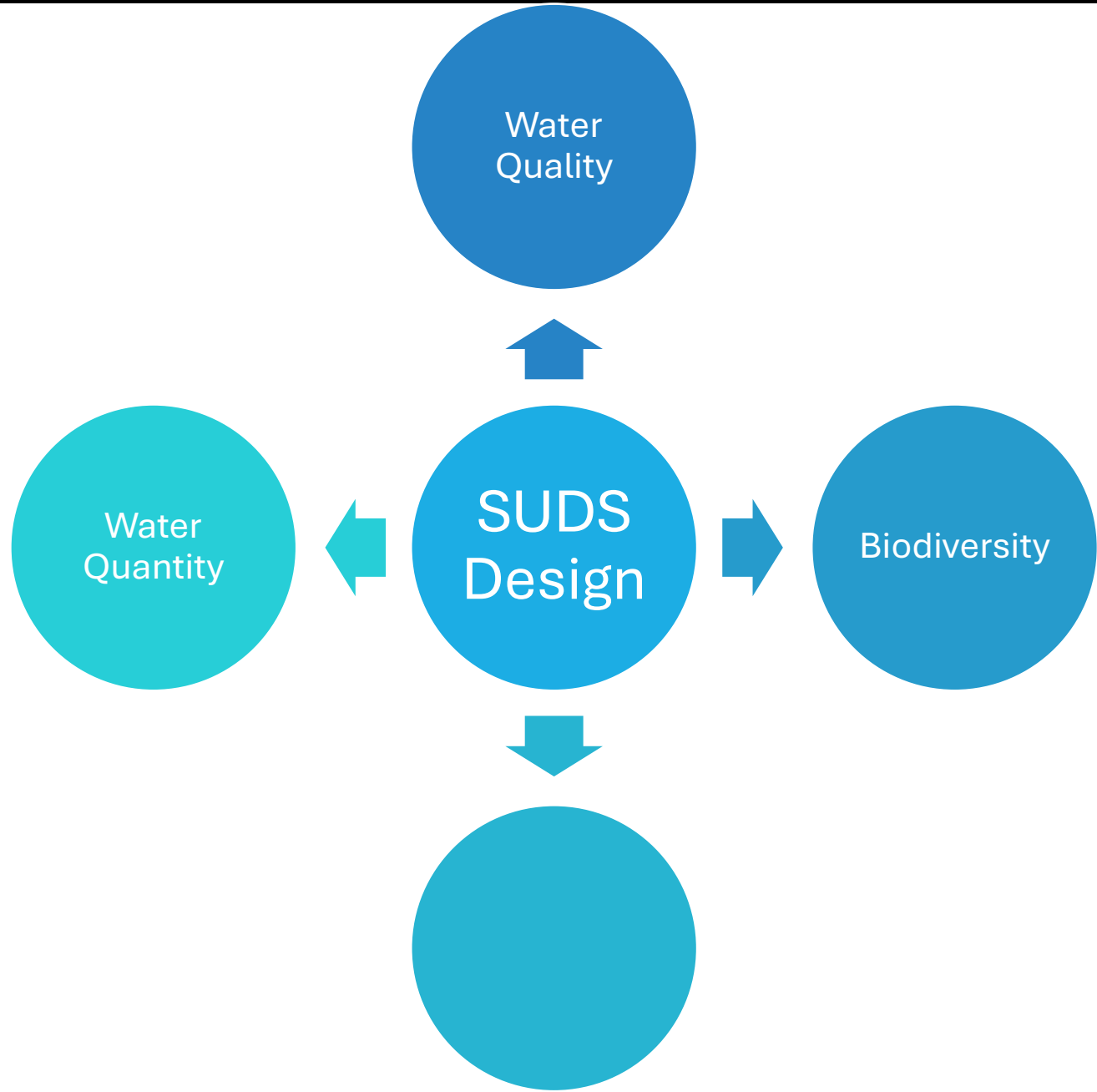
Water Quality





Benefits of SUDS

There are four main categories
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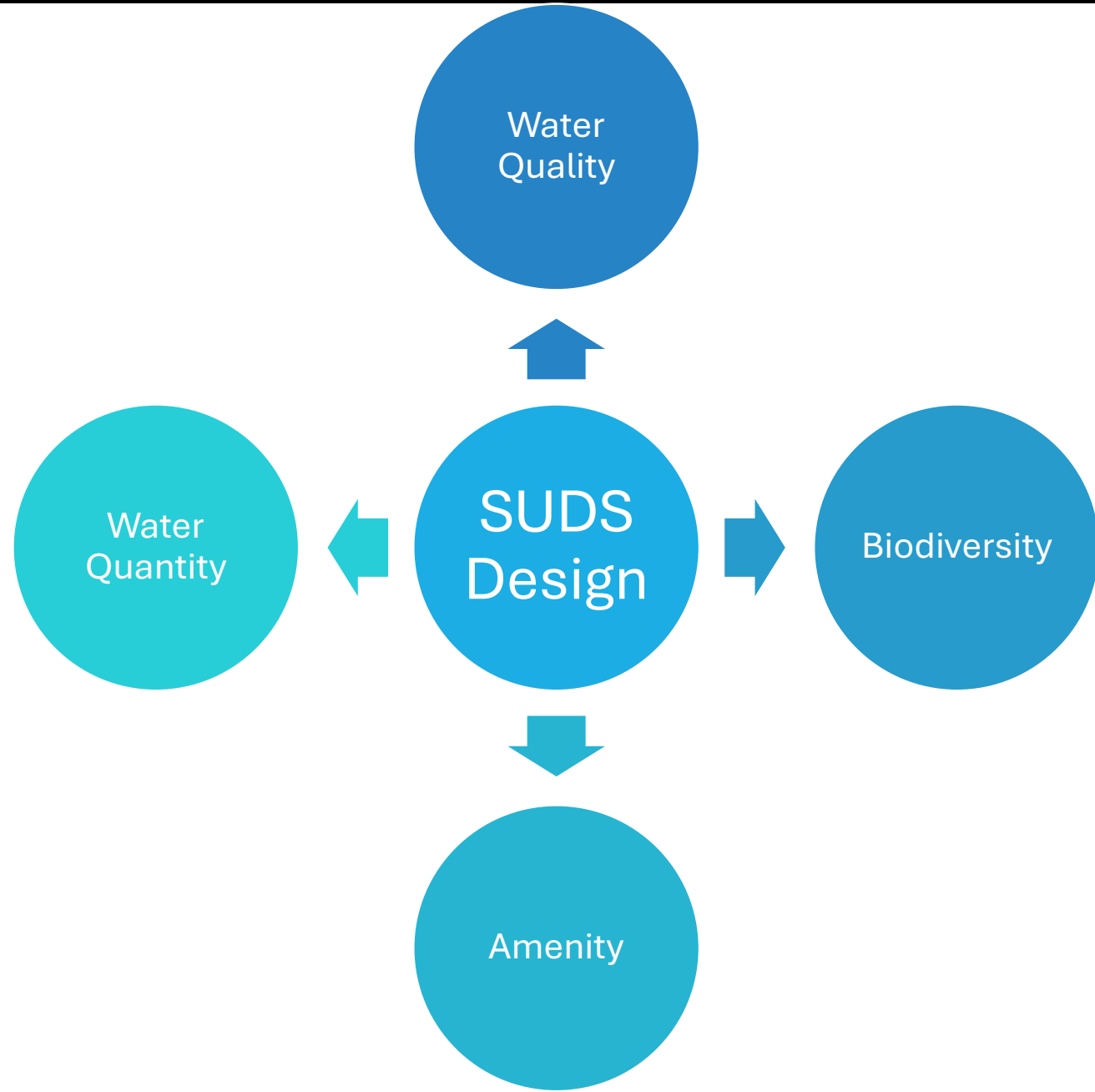
Biodiversity

- By incorporating green infrastructure, SUDS provide new habitats for plants, insects, birds, and aquatic life.
- Wetlands, ponds, and vegetated swales create rich ecosystems that support a wide range of species.
- These features enhance biodiversity in urban areas, which often suffer from habitat loss due to development.
- They also help connect green spaces, allowing wildlife to move more freely and improving ecological resilience.



Benefits of SUDS

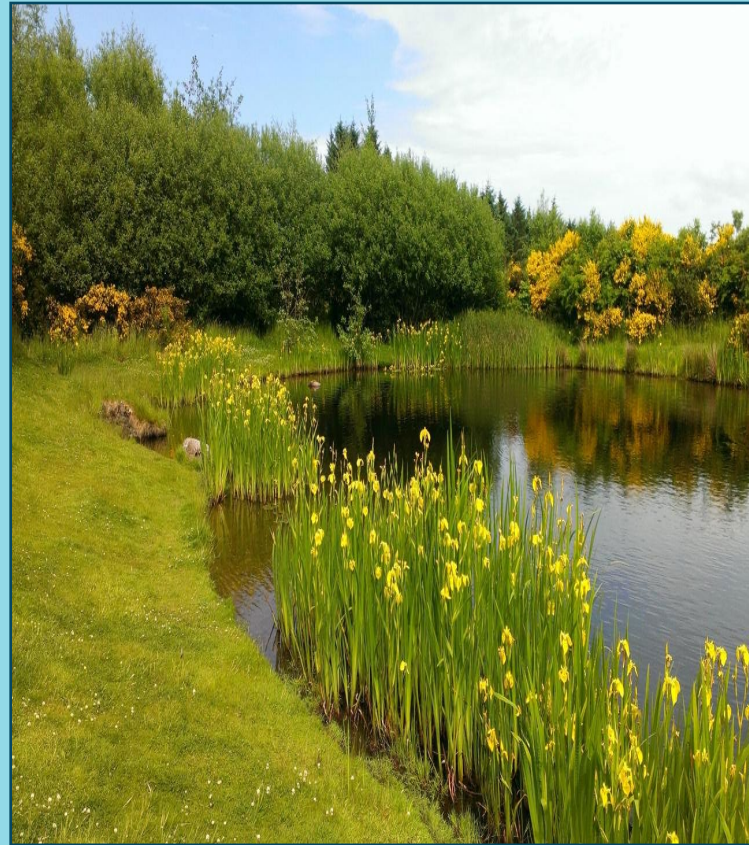
There are four main categories of benefits that can be achieved by SUDS:



Amenity

- SUDS contribute to more attractive and enjoyable urban environments by integrating greenery and water features into the landscape.
- Features like rain gardens, ponds, and swales create pleasant spaces for people to relax, exercise, and enjoy nature.
- Green infrastructure has been shown to reduce stress, improve mental health, and increase social interaction in communities.
- Additionally, well-designed SUDS can increase property values and attract businesses by making areas more visually appealing and desirable.

Amenity

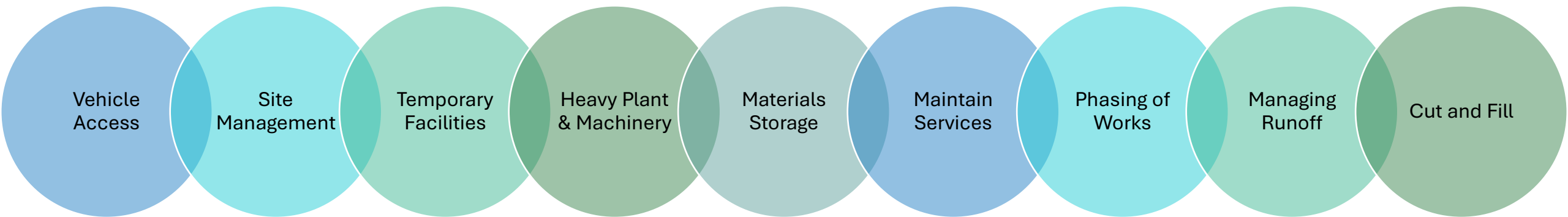




How construction planning affects SUDS?

Early consideration of SUDS in the construction planning process is important to ensure successful delivery.

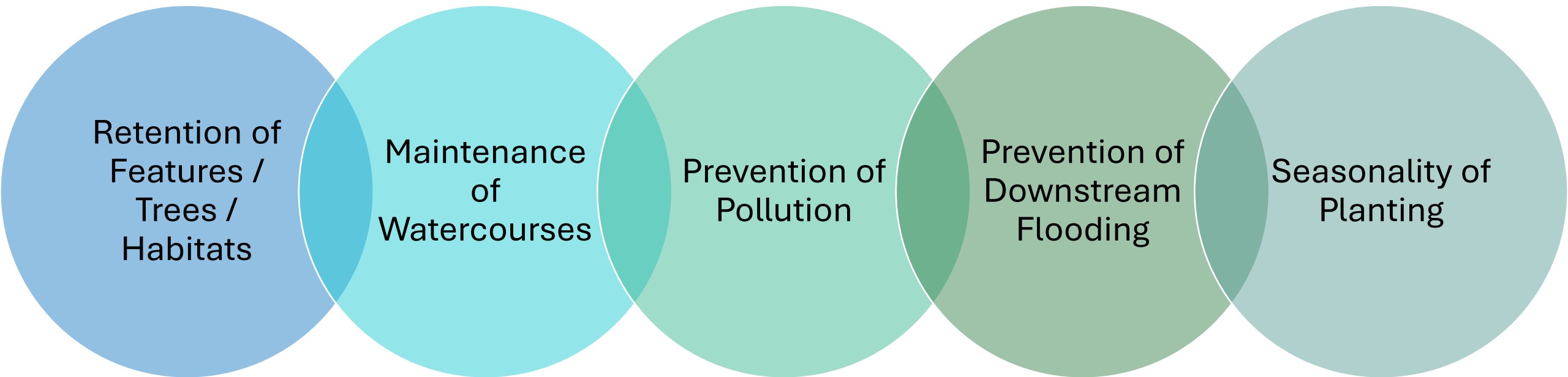
Construction planning on a site is influenced by many factors that are not necessarily linked to SUDS but could affect their construction or function.





How construction planning affects SUDS?

Environmental issues both on- and off-site can add further legislative and practical constraints so must be considered during the planning of SUDS construction





How SUDS affects construction planning?

Construction of traditional drainage follows well defined procedures.

It is usually constructed early in the construction process before superstructures are built.

This can therefore be used to help drainage on the site during construction.



How SUDS affects construction planning?

For SUDS that are surface components, the levels, slopes and soil structure are crucial for their performance.

Although SUDS can be installed early in a construction programme, they may have exposed surfaces, materials and vegetation that are prone to clogging by mud and silt.



How SUDS affects construction planning?

SUDS generally require the land they are constructed on to be isolated from the construction process to prevent damage.

Vegetated SUDS require the planting to be sufficiently established before being used.

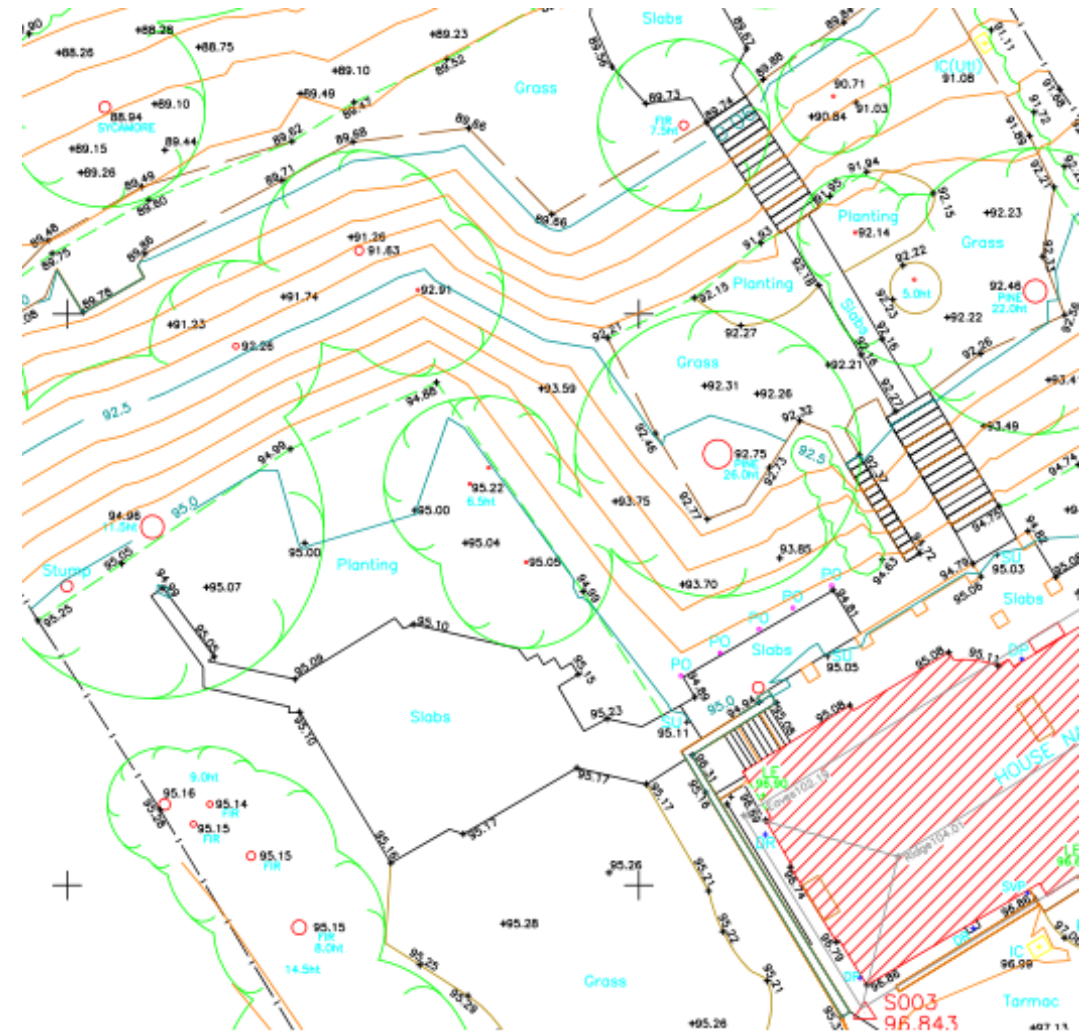
Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

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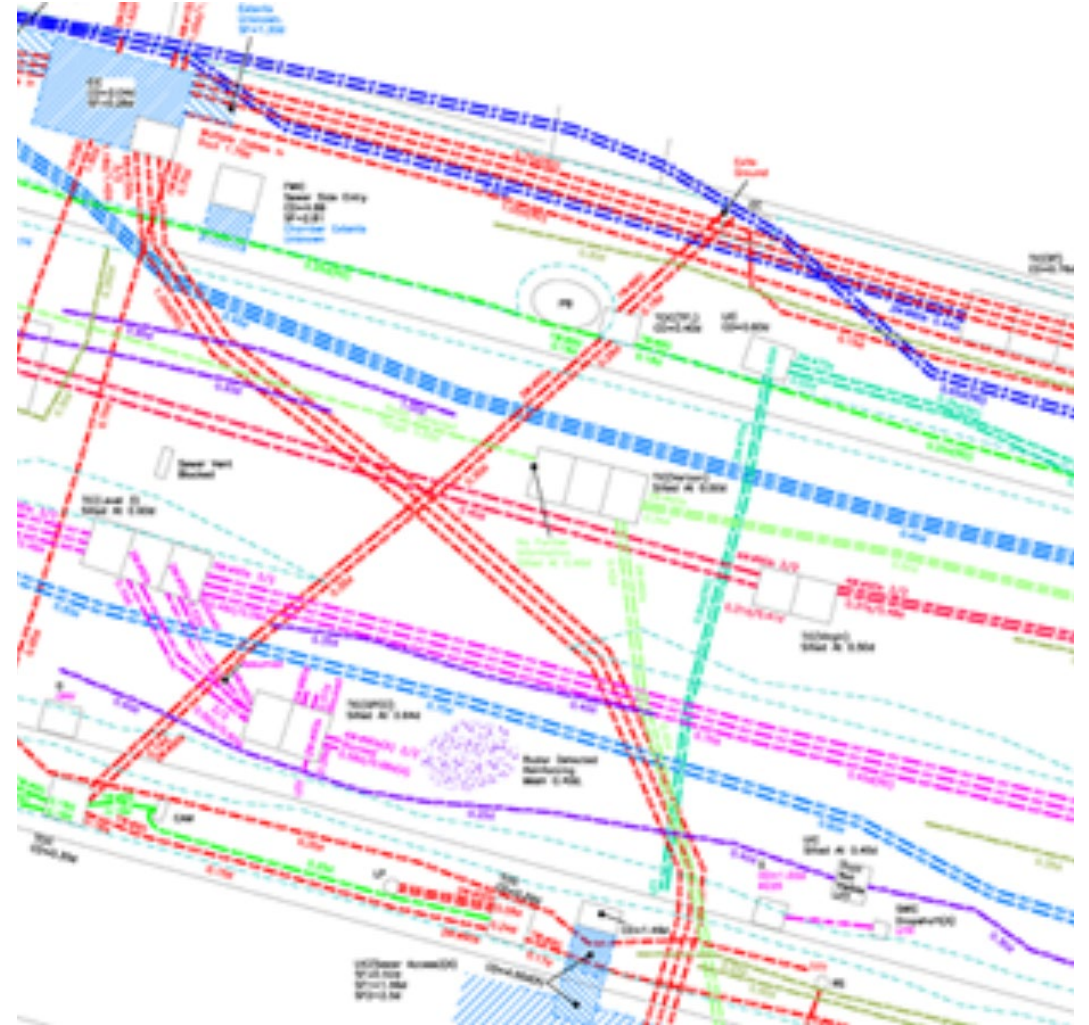
- Full topographic survey



Pre-construction

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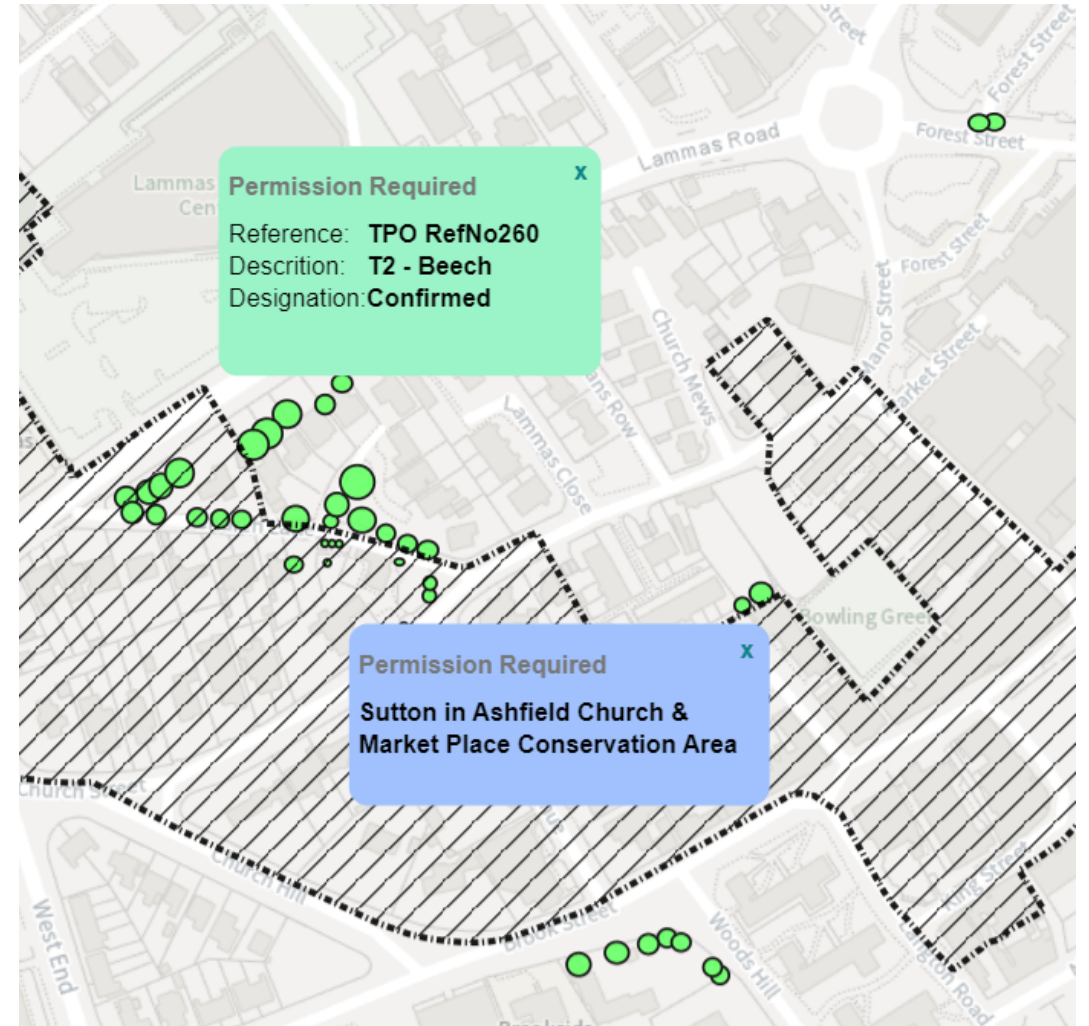
- Services information



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Protected features



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Drainage information



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Higher adjacent land



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

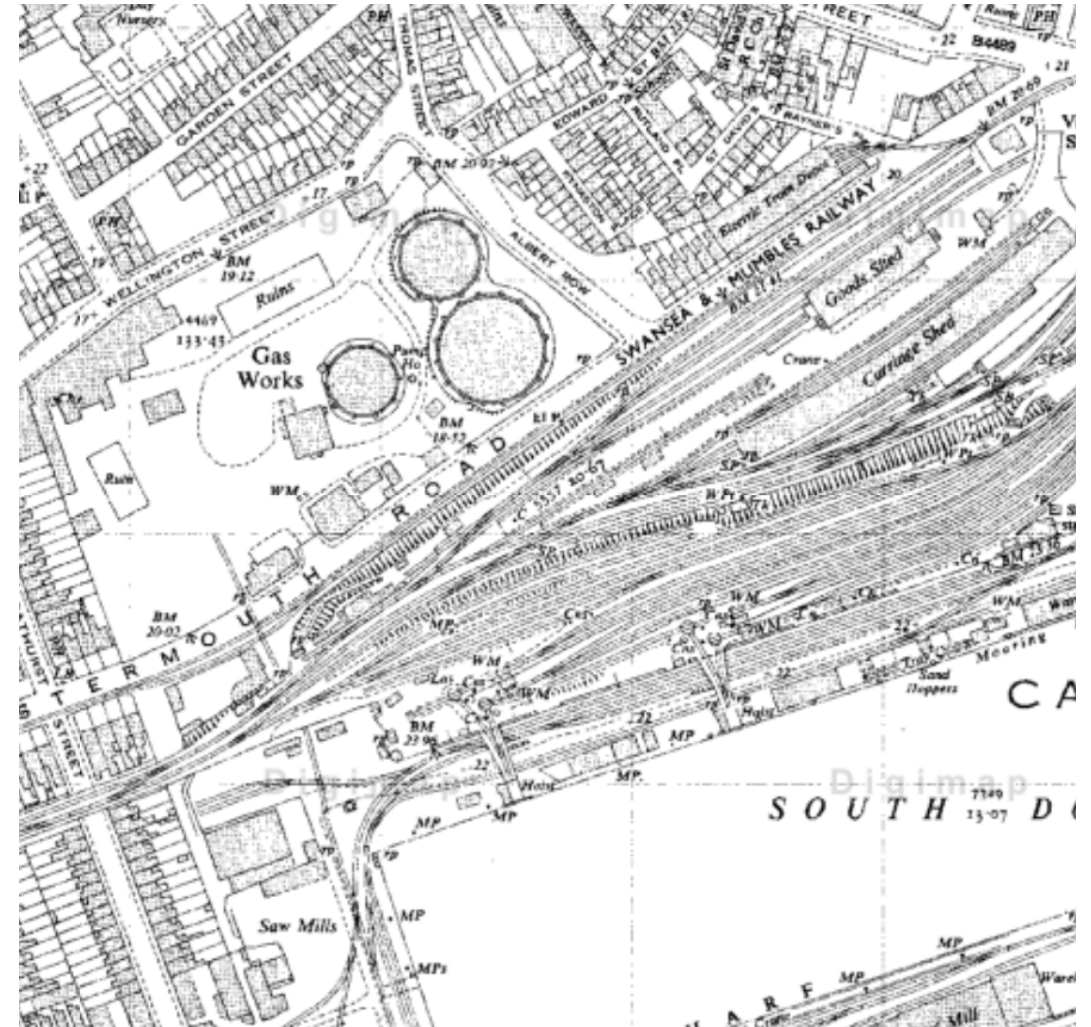
- Infiltration information



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Historic Information



Designing SUDS

Based on site characteristics and project goals, SUDS components can be selected. These typically fall into four categories:

Prevention

- Living Roofs
- Rainwater Harvesting
- Permeable Pavements

Infiltration

- Soakaways
- Infiltration Systems
- Rain Gardens

Conveyance

- Swales
- Filter Drains

Storage

- Detention Basins
- Retention Basins
- Constructed Wetlands

Living Roofs

Living roofs (often referred to as 'green' or 'brown' roofs) are rooftops planted with vegetation and provide habitat for insects and birds.

They can be used to reduce the volume and rate of runoff. There are two main types:

Living Roofs

Intensive living roofs: a deep layer of soil (up to 1.5 m) to support a variety of plants such as flowers and shrubs, but requiring regular maintenance.

Intensive roof gardens can grow a range of plants, even trees and shrubs can provide a rich habitat for wildlife.



Living Roofs

Extensive living roofs: lightweight, often with shallower growing material, requiring little maintenance (e.g. mosses, sedums, grasses, succulents and herbs).

The type of growing medium chosen affects the type of habitat created, which may reflect the building's surroundings.

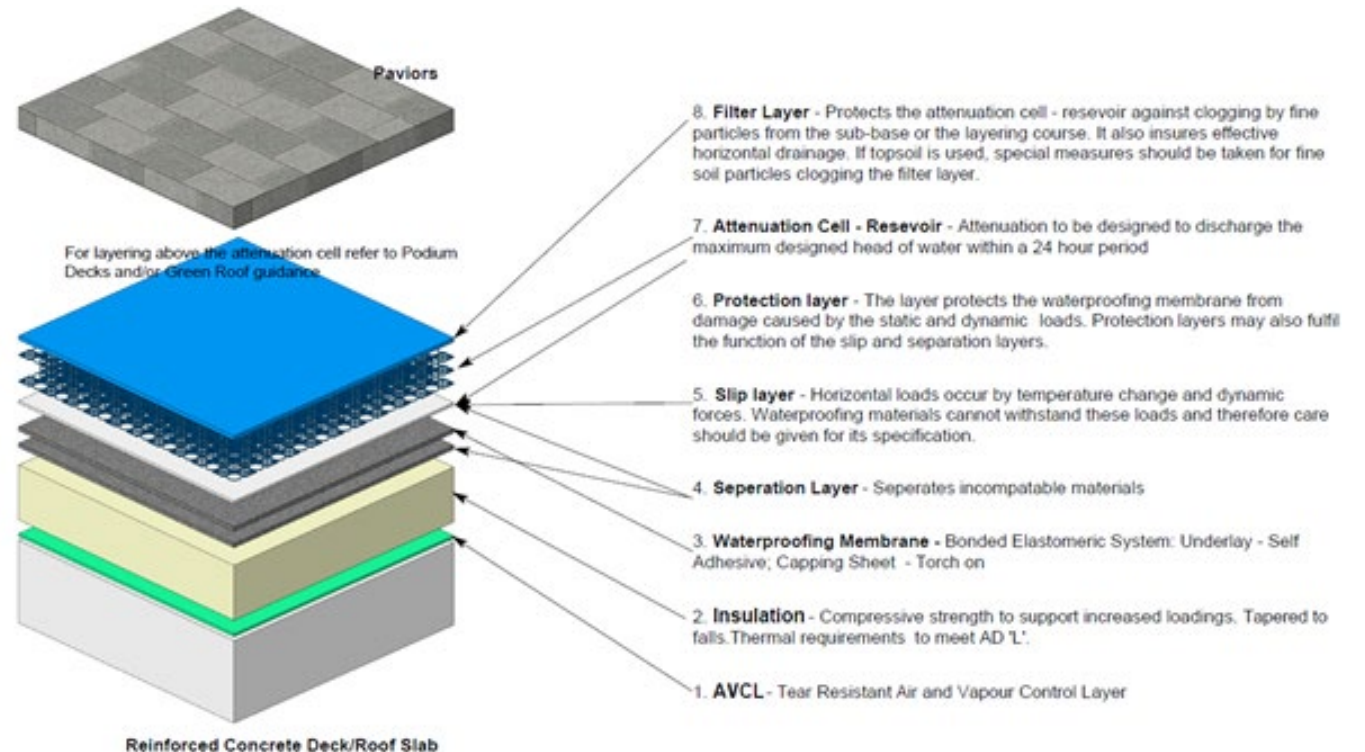


Living Roofs

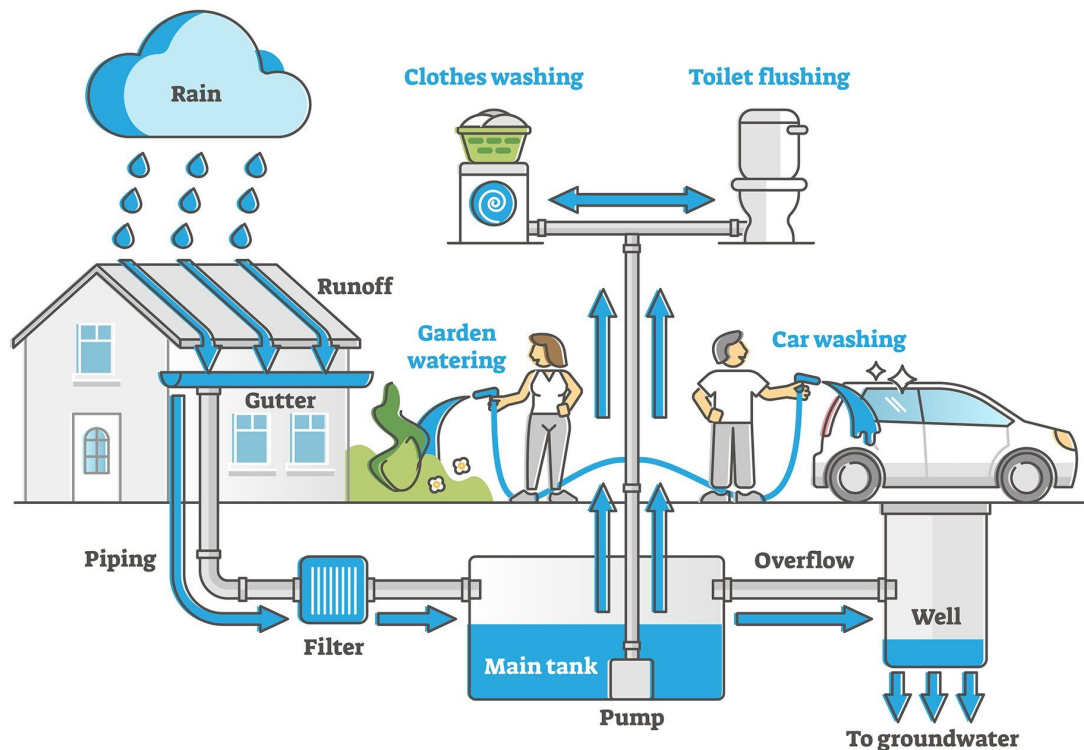
Roof type	Advantages	Disadvantages
Intensive (deep soil, irrigation system, more favourable conditions for plants)	Allows greater plants/habitat diversity Good insulation properties Simulates wildlife garden Diverse utilisation of roof	Heavy Requires irrigation and drainage Higher cost
Extensive (thin soil, little or no irrigation, stressful conditions for plants)	Lightweight Suitable for large areas and 0–30° slope Low maintenance More 'natural' Often does not require irrigation and drainage	Limited choice of plants Usually no access for recreation

Living Roofs

Blue roofs are specifically designed to provide attenuation of stormwater by allowing water to be held on the roof for a defined period, before slowly releasing the water into the drainage system.



Rainwater Harvesting



Rainwater harvesting is the collection of rainwater for use on site.

Water for use is normally collected from roofs, and other impermeable areas.

The water is collected in a tank, treated where necessary and then used as a supply of water.

Permeable Pavements



a Block permeable paving



b Porous asphalt



c Porous concrete



d Resin bound aggregate



e Reinforced grass

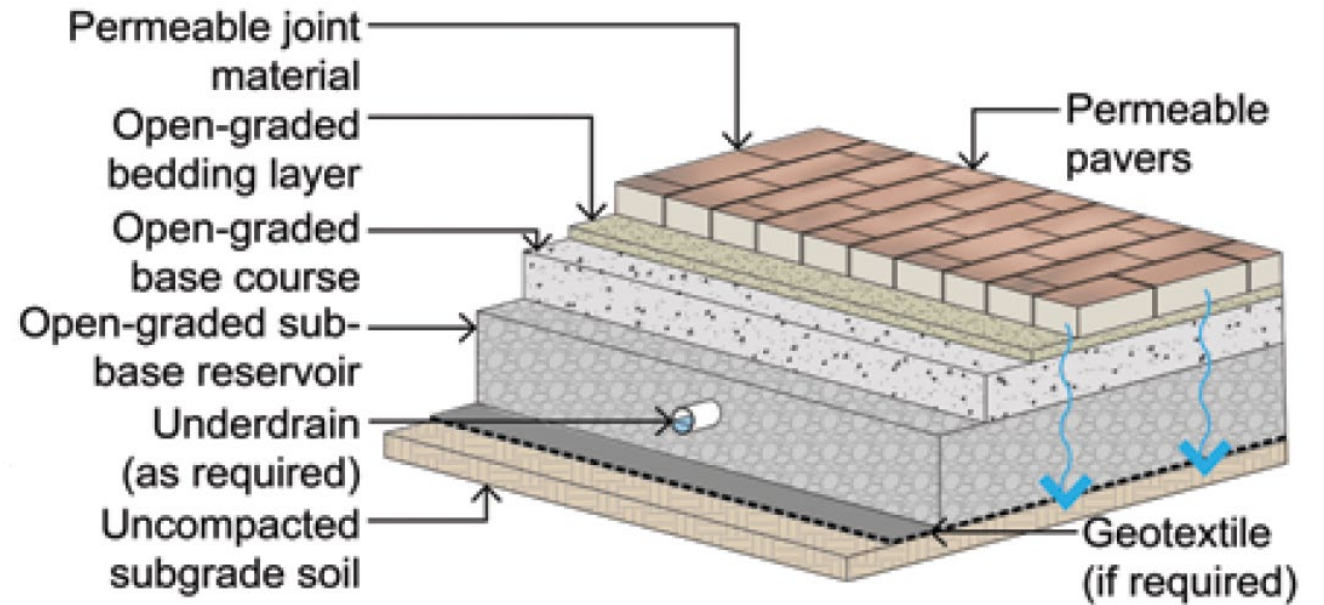
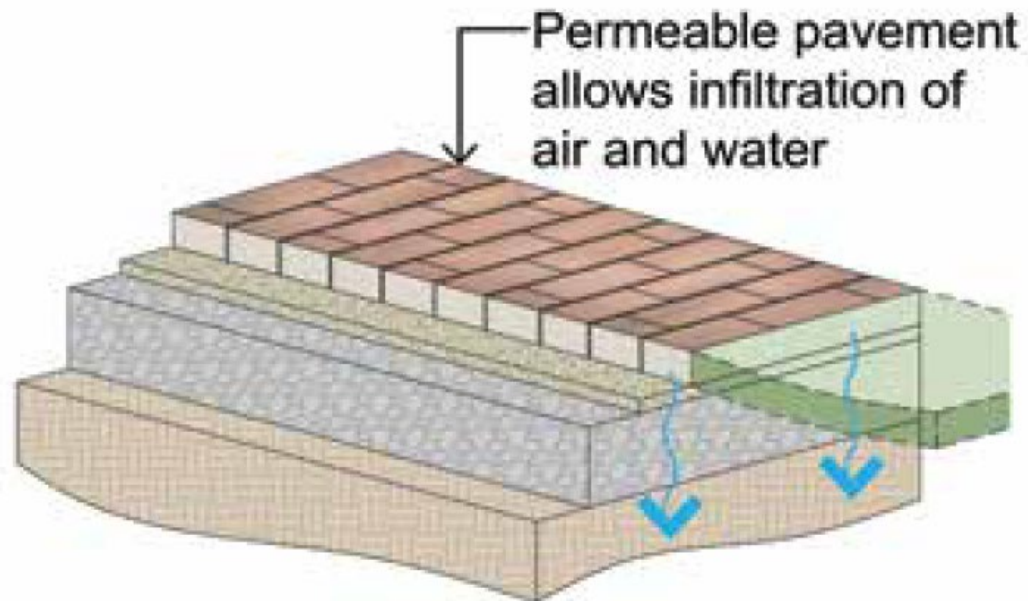


f Loose laid gravel

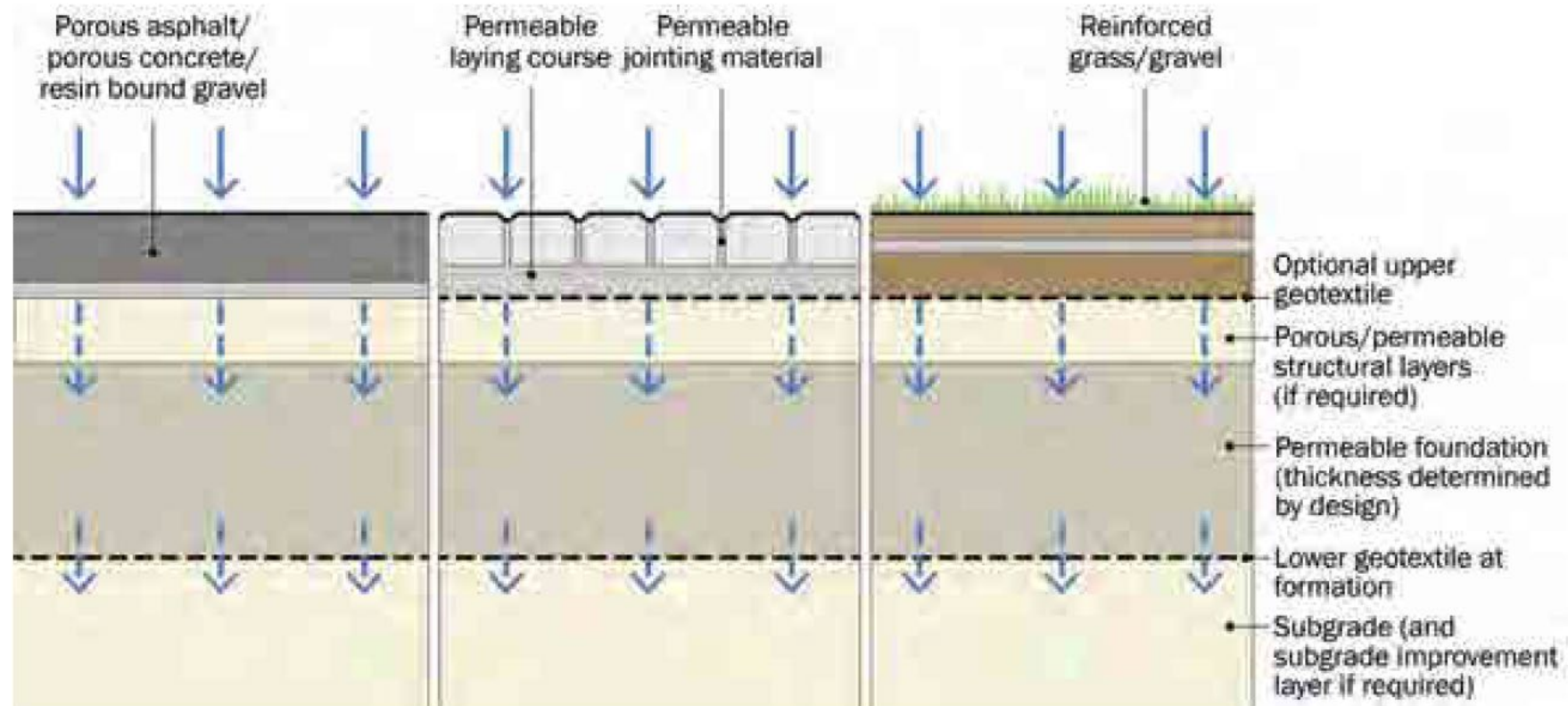
Permeable pavements is different to normal paving by allowing water to soak through gaps to the subsurface below.

The water can either soak into the ground or can be collected by collected in perforated pipes.

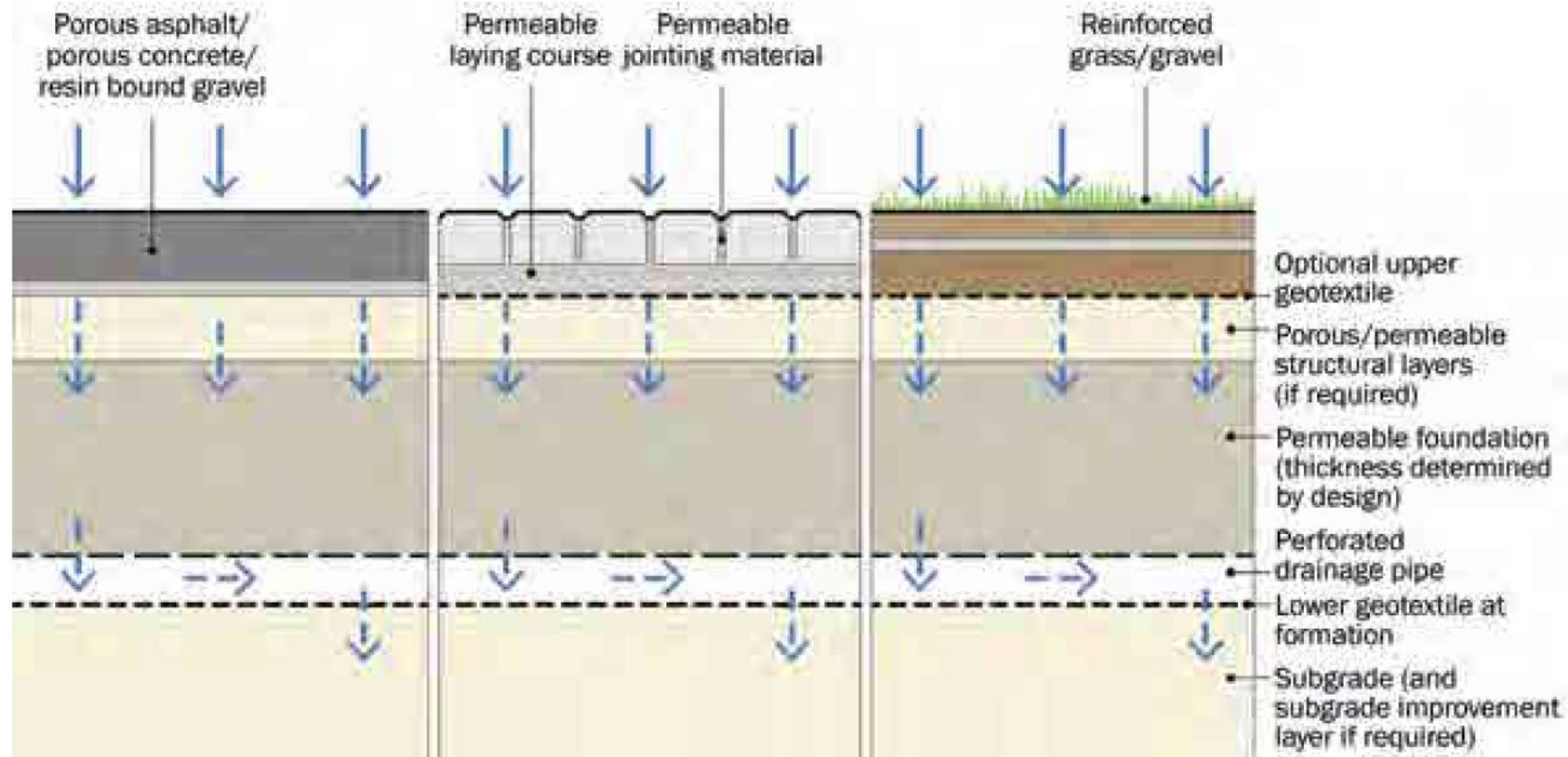
Permeable Pavements



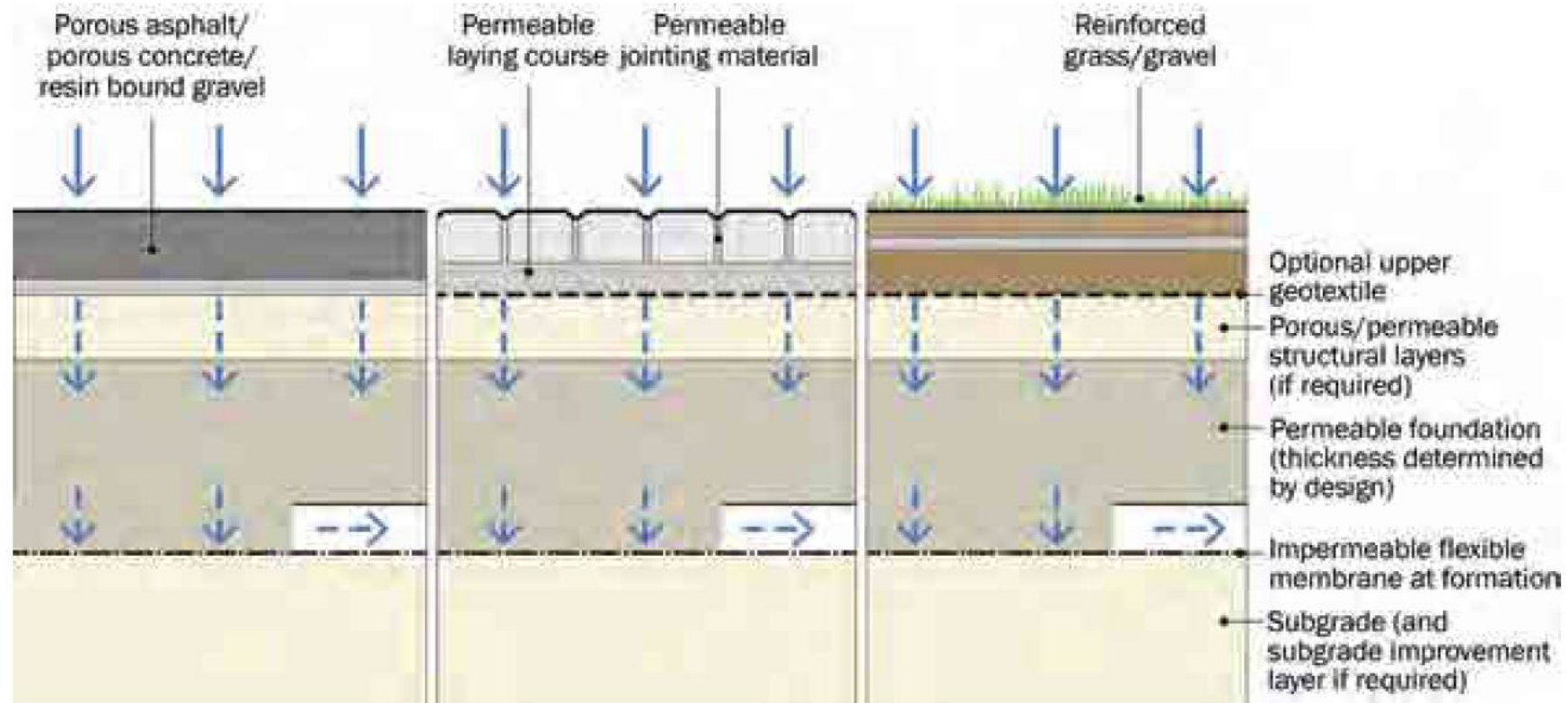
Permeable Pavements



Permeable Pavements



Permeable Pavements



Permeable Pavements

Ground characteristics		Type A: total infiltration	Type B: partial infiltration	Type C: no infiltration
Permeability of subgrade defined by coefficient of permeability k (m/s)	1×10^{-6} to 1×10^{-3}	✓	✓	✓
	1×10^{-8} to 1×10^{-6}	✗	✓	✓
	1×10^{-10} to 1×10^{-8}	✗	✗ (1)	✓
Highest expected water level within 1000 mm of formation level		✗	✗	✓
Pollutants present in subgrade		✗	✗	✓

Permeable Pavements

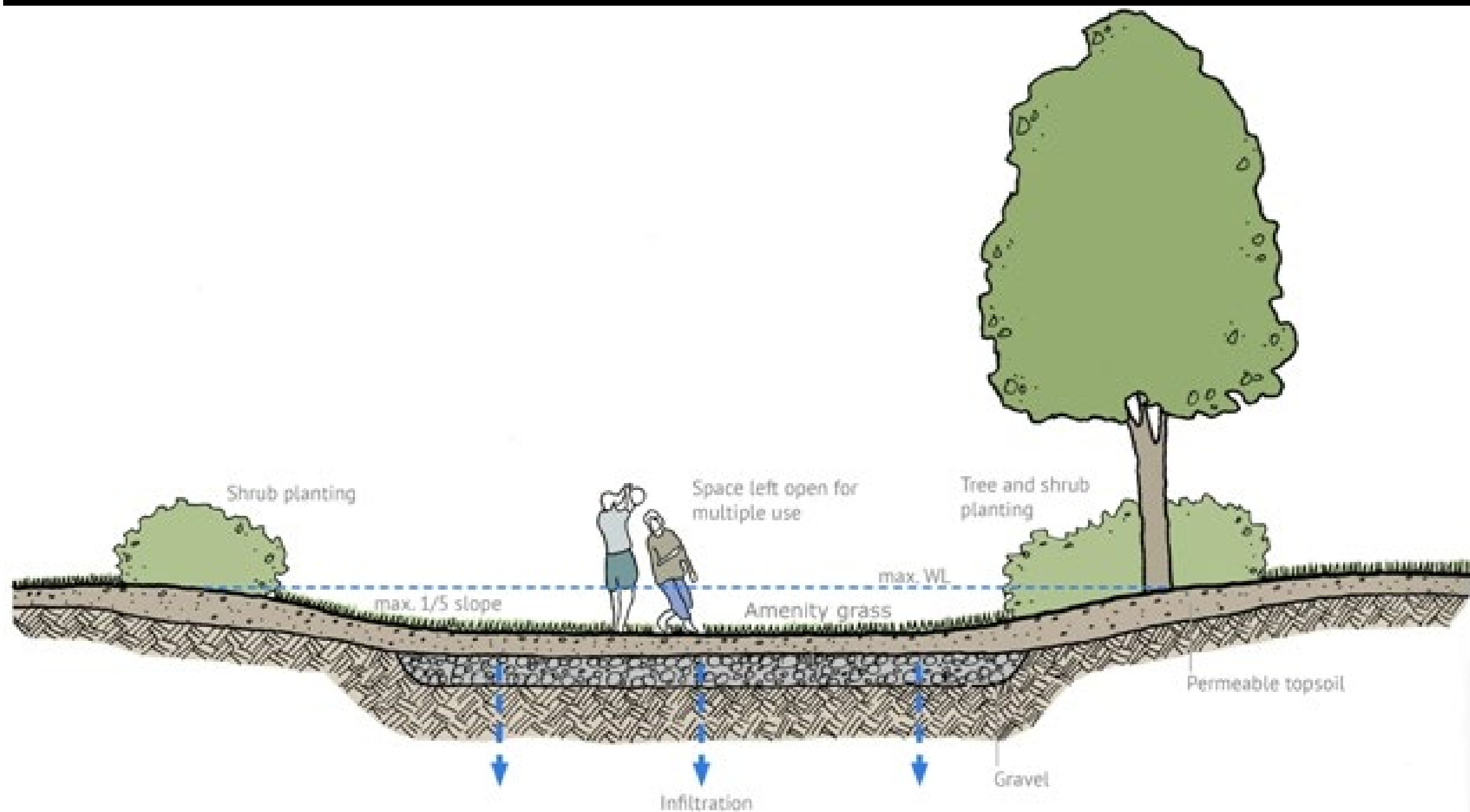
Typical Values of Coefficient of Permeability, K

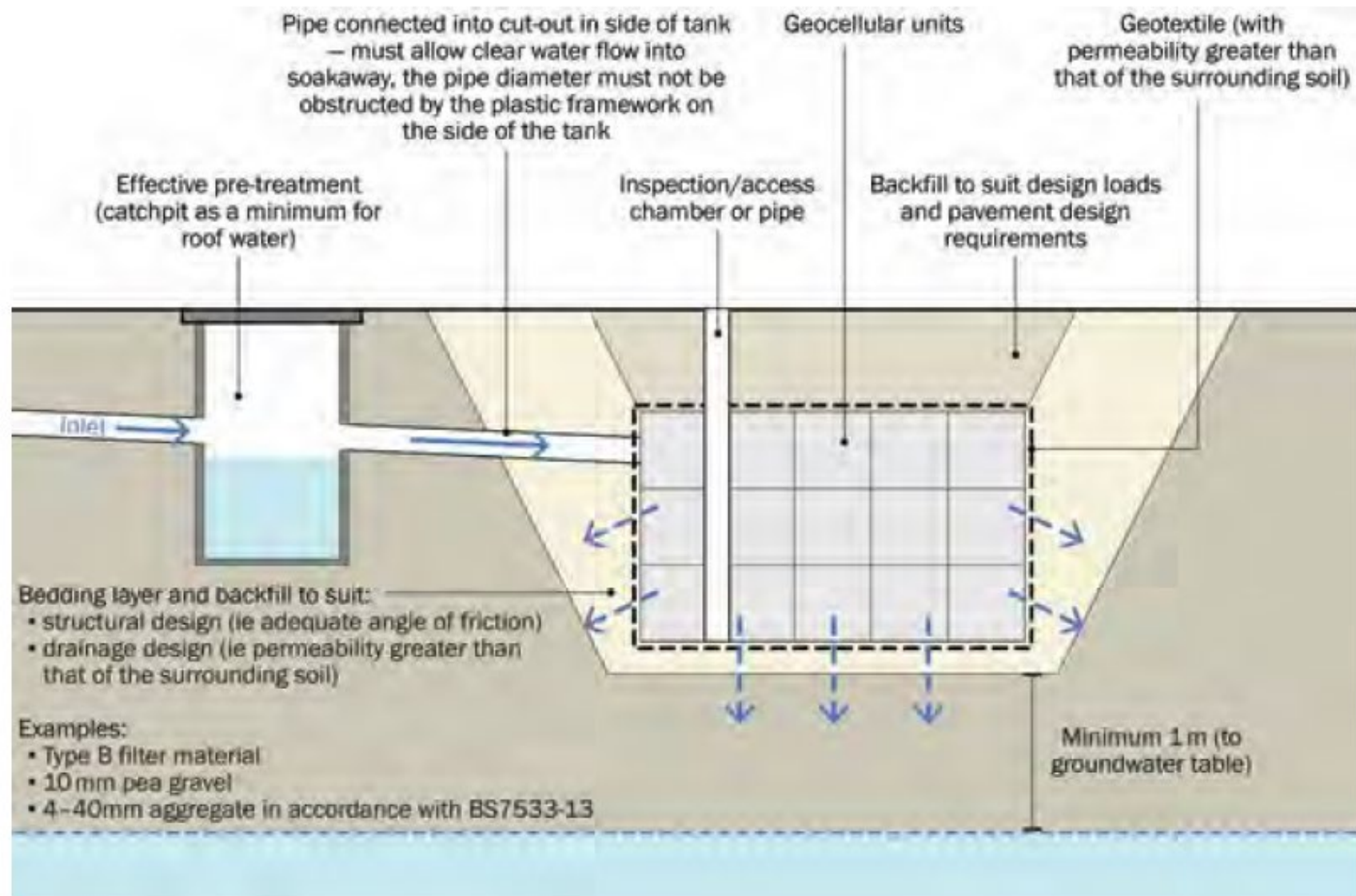
S. No	Soil type	Coefficient of Permeability, K	Drainage properties
1	Clean Gravel	10^{+1} to 10^{+2}	Very Good
2	Medium and Coarse sands	10^{-2} to 10^{+1}	Good
3	Loose Silt, Fine sands	10^{-4} to 10^{-2}	Fair
4	Dense Silt, Clayey Silts	10^{-5} to 10^{-4}	Poor
5	Silty clay, Clay	10^{-8} to 10^{-5}	Very Poor

Soakaways and Infiltration Systems



Infiltration components are used to capture surface water runoff and allow it to infiltrate (soak) and filter through to the subsoil layer, before returning it to the water table below.



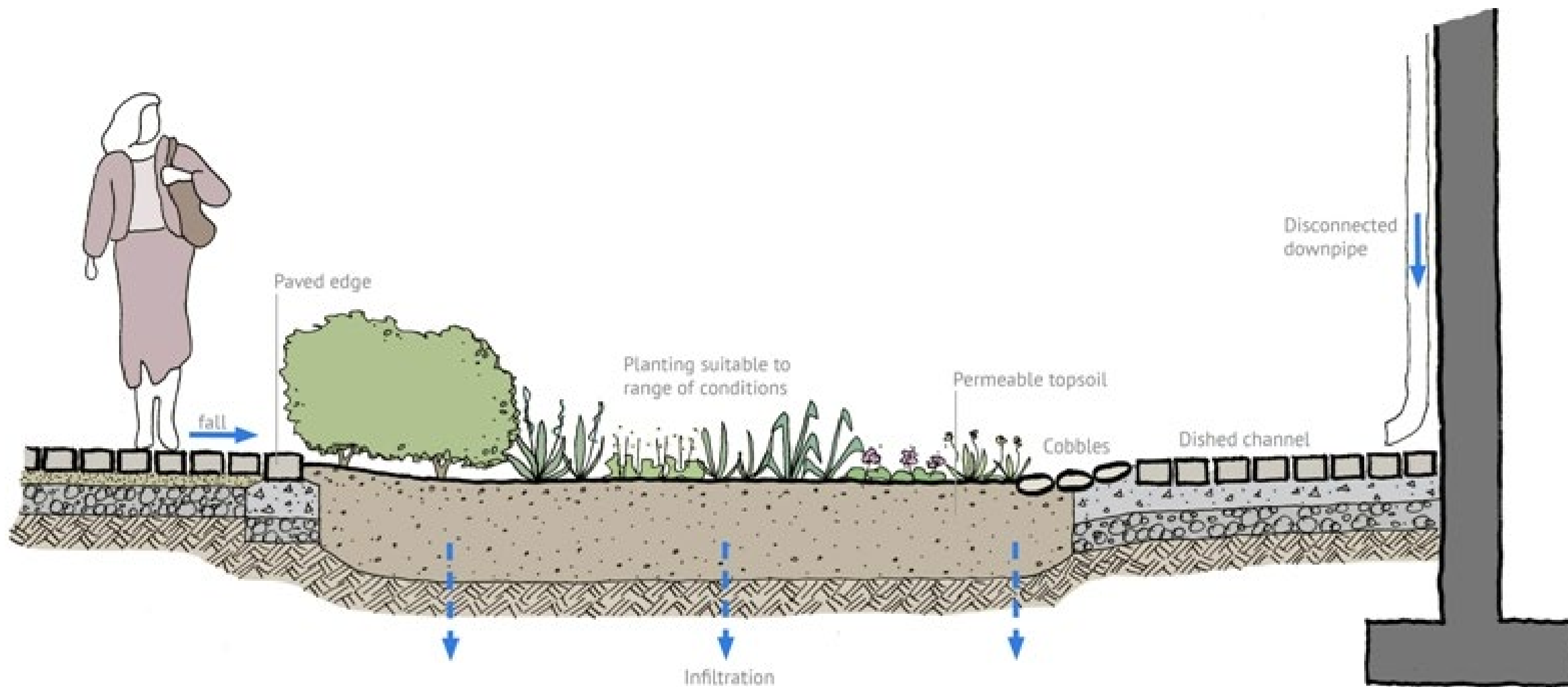


Rain Gardens



A rain garden is a shallow, landscaped depression designed to capture, slow, and filter rainwater runoff from roofs, driveways, roads, and other hard surfaces.

It allows water to infiltrate into the ground naturally, reducing flooding, erosion, and pollution while supporting biodiversity.



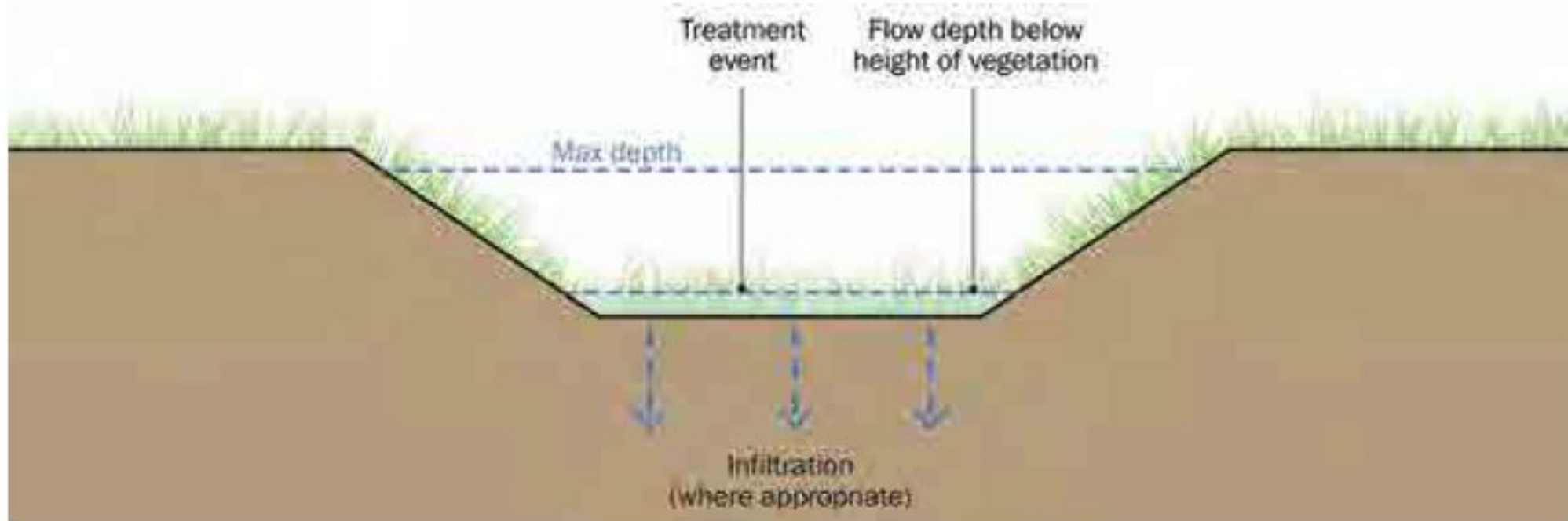
Swales



Swales are shallow, flat bottomed, vegetated open channels designed to convey, treat and often attenuate surface water runoff.

The standard swale channel is broad and shallow and covered by vegetation, usually grass, to slow the water, facilitating sedimentation, filtration through the root zone and soil matrix, evapotranspiration and infiltration into the underlying soil.

Swales



Swales



(courtesy Ilman Young)



(courtesy Essex County Council)



(courtesy Ilman Young)



(courtesy Terra Firma)



(courtesy Simon Bunn)

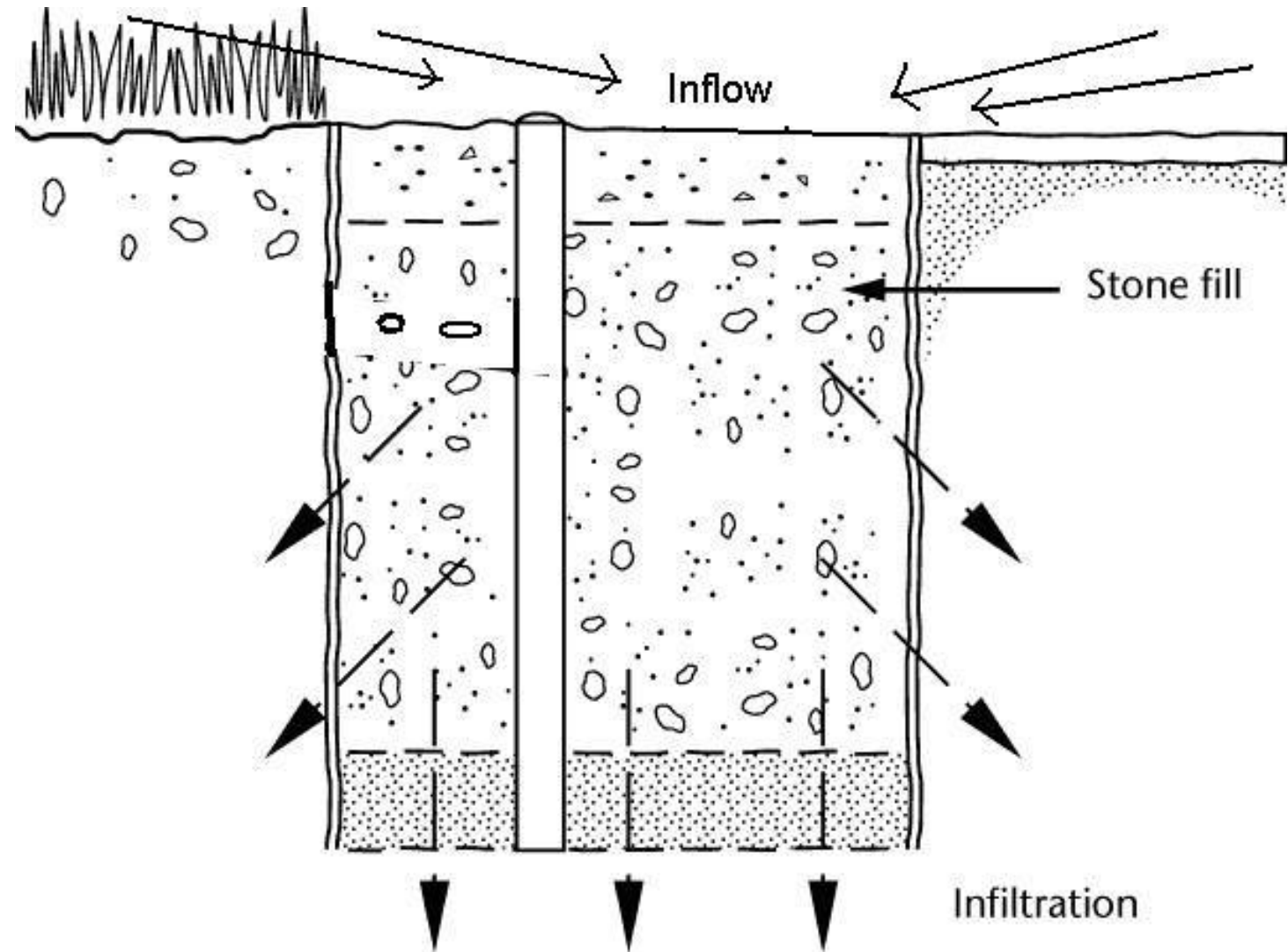
Filter Drains



A filter drain is a trench-based drainage system, typically filled with gravel or other porous materials, and equipped with perforated pipes that help collect, filter, and redirect surface water runoff.

The water is filtered as it passes through the gravel, which helps remove contaminants (like oil, debris, and pollutants) before the water is released into a drainage system or natural environment.

Filter Drains



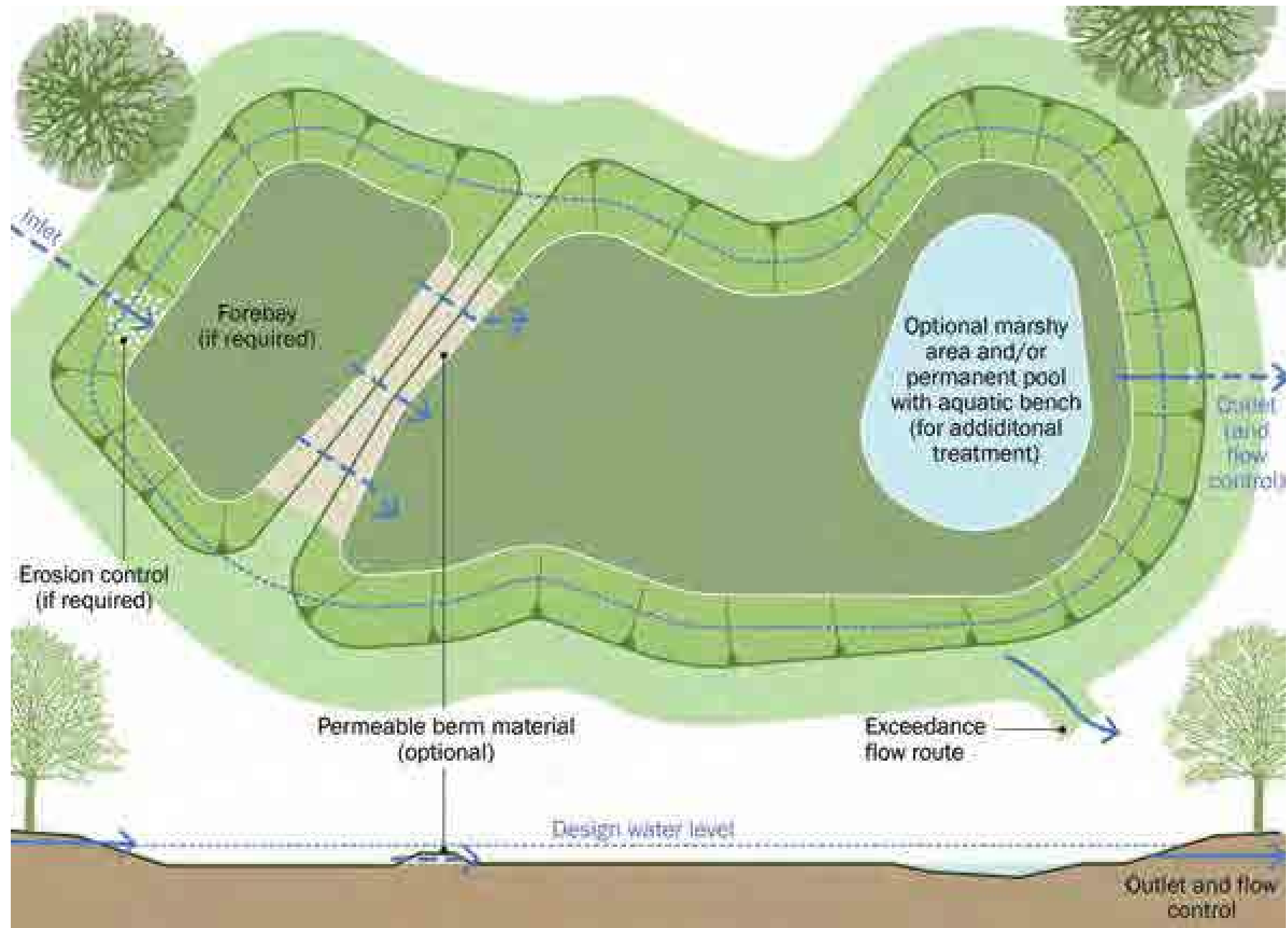
Detention Basins



A detention basin is a type of stormwater management facility designed to temporarily store and control the release of stormwater runoff.

A detention basin only holds water for a short period (typically a few hours) before it is gradually released to prevent flooding and erosion downstream.

The goal of a detention basin is to slow down the flow of stormwater and provide time for excess runoff to be safely released into a drainage system or natural waterway.





Retention Basins



A retention basin is a type of stormwater management facility designed to temporarily store and manage excess stormwater.

It holds water for an extended period, allowing it to slowly release or infiltrate into the ground, reducing flood risk and improving water quality.

Unlike detention basins (which only temporarily store water), retention basins typically maintain a permanent pool of water.

Wetlands



Ponds and wetlands are features with a permanent pool of water that provide both attenuation and treatment of surface water runoff.

They can support emergent and submerged aquatic vegetation along their shoreline and in shallow, marshy (wetland) zones, which helps enhance treatment processes and has amenity and biodiversity benefits.



Technique	Best For	Water Quantity	Water Quality	Biodiversity	Amenity	Cost	Maintenance
Green Roofs	Urban Areas	Medium	Medium	High	Medium	High	Medium
Rainwater Harvesting	Residential & Commercial	Low	High	Low	Low	Medium	Low
Permeable Pavements	Roads / Car Parking	High	Medium	Low	Low	Medium	Low
Soakaways	Gardens & Small Sites	Medium	Medium	Low	Low	Low	Medium
Infiltration Systems	Roadsides & Car Parking	High	Medium	Low	Low	Medium	Mediun
Swales	Roadsides & Car Parking	High	Medium	Medium	Medium	Low	Low
Rain Gardens	Urban Areas	Medium	High	High	High	Medium	Medium
Retention Basins	Large Scale Projects	High	High	High	High	High	High
Constructed Wetlands	Large Scale Projects	High	High	High	High	High	High

		Development settings		
		<i>High density</i>	<i>Medium density</i>	<i>Low density</i>
<i>Most suitable SuDS components</i>	Integrated buildings	- green roofs - rainwater harvesting.	- green roofs - rainwater harvesting.	- green roofs - rainwater harvesting.
	Streetscapes	- permeable paving - road-side bioretention components.	- road-side swales - permeable paving - road-side bioretention components - filter strips.	- road-side swales - permeable paving - road-side bioretention.
	Public realm and open space	- permeable paving and underground storage - rills and channels - hardscape pools - micro-wetlands or bioretention components in squares, courtyards or hard paved spaces.	- micro-wetlands or bioretention components in squares, courtyards or hard paved spaces - open space integrated ponds and wetlands.	- ponds and wetlands - swales.

Key

- 1 Urban square with permeable paving
- 2 Retention pond with integrated seating
- 3 Rill within pedestrianised shopping street
- 4 Brown roofs within town centre
- 5 Rain garden/planted bioretention element
- 6 Green roofs
- 7 Roof gardens
- 8 Permeable paving within street
- 9 Bioretention tree pits within square

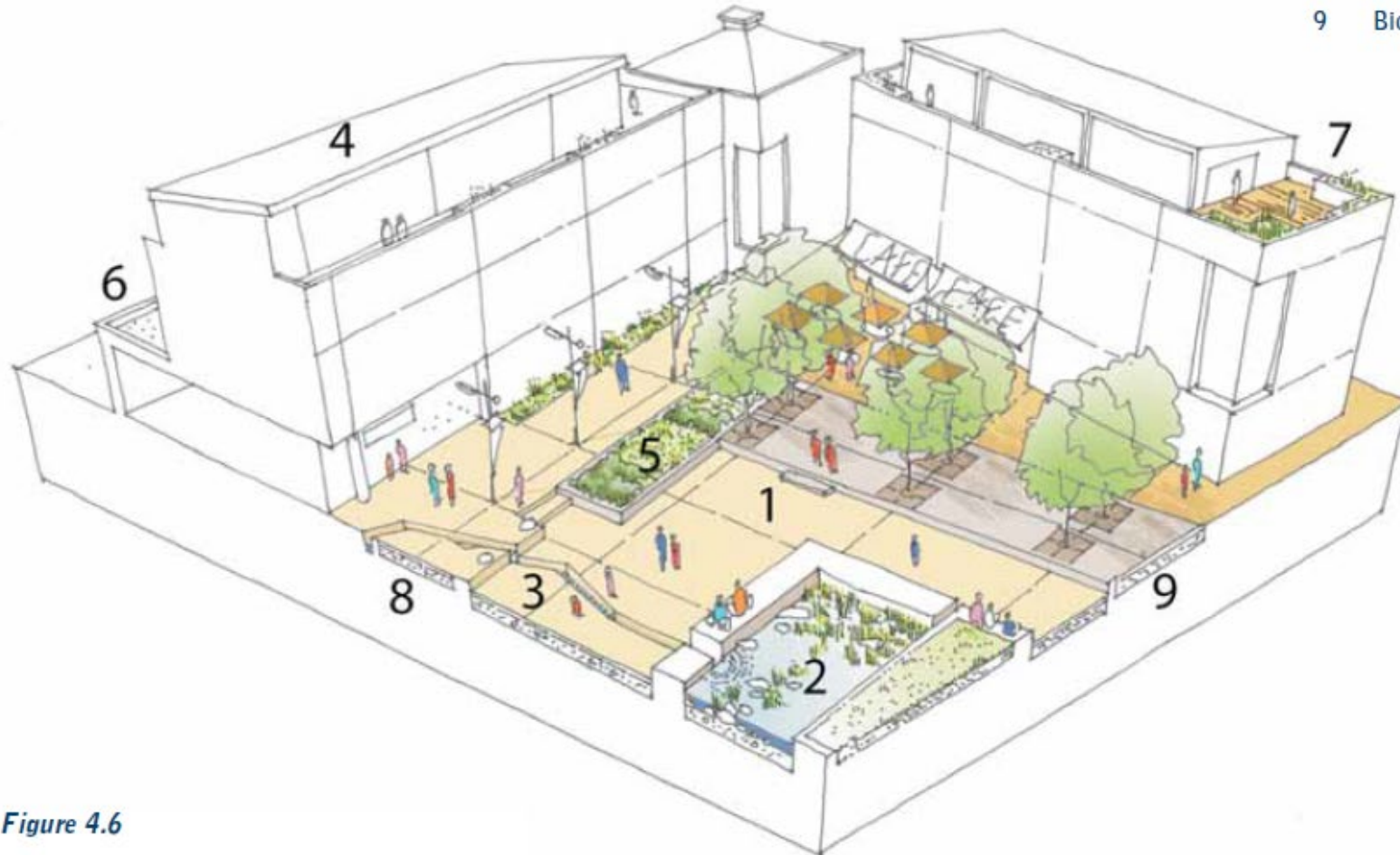
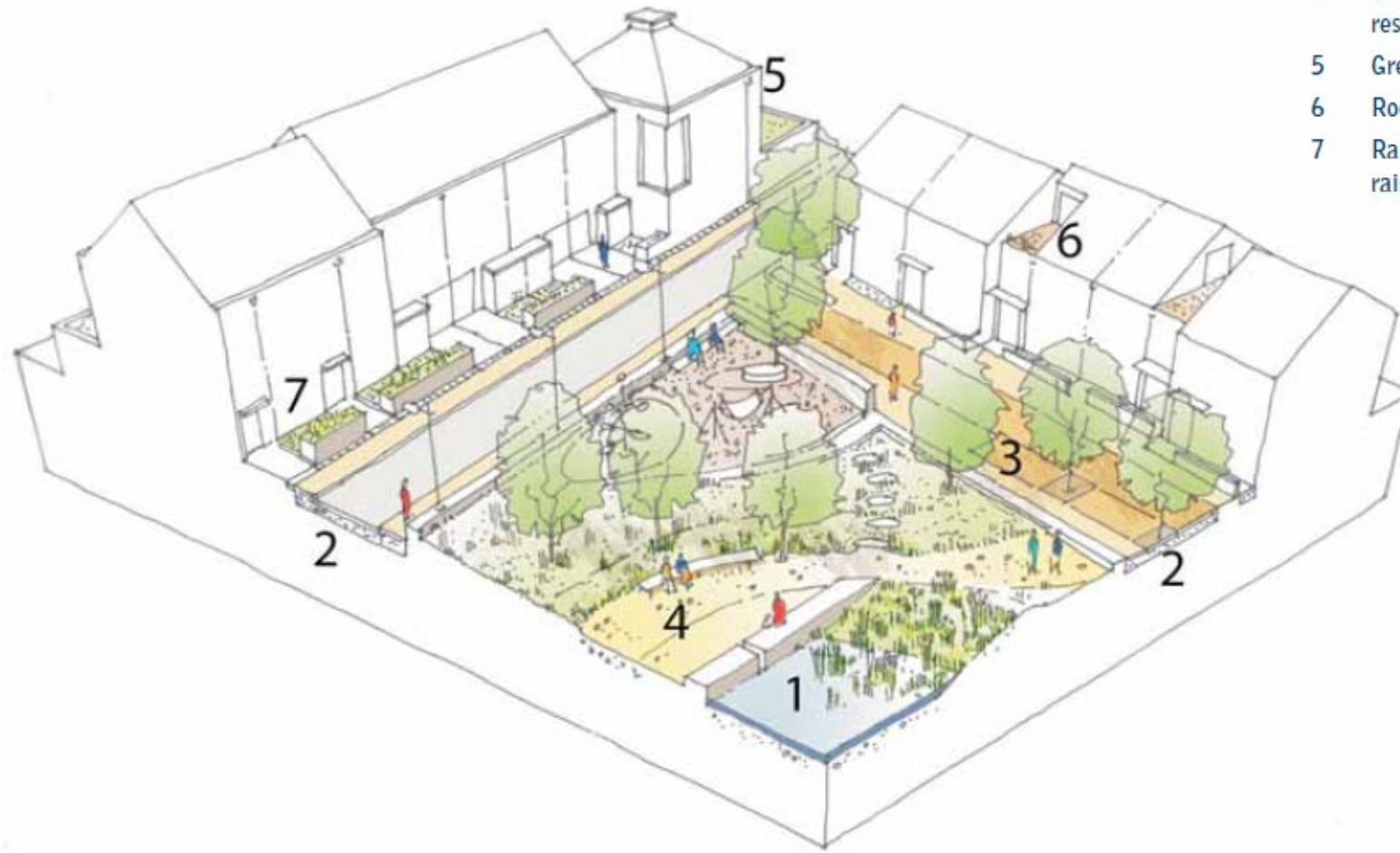


Figure 4.6

SuDS in a high density development setting

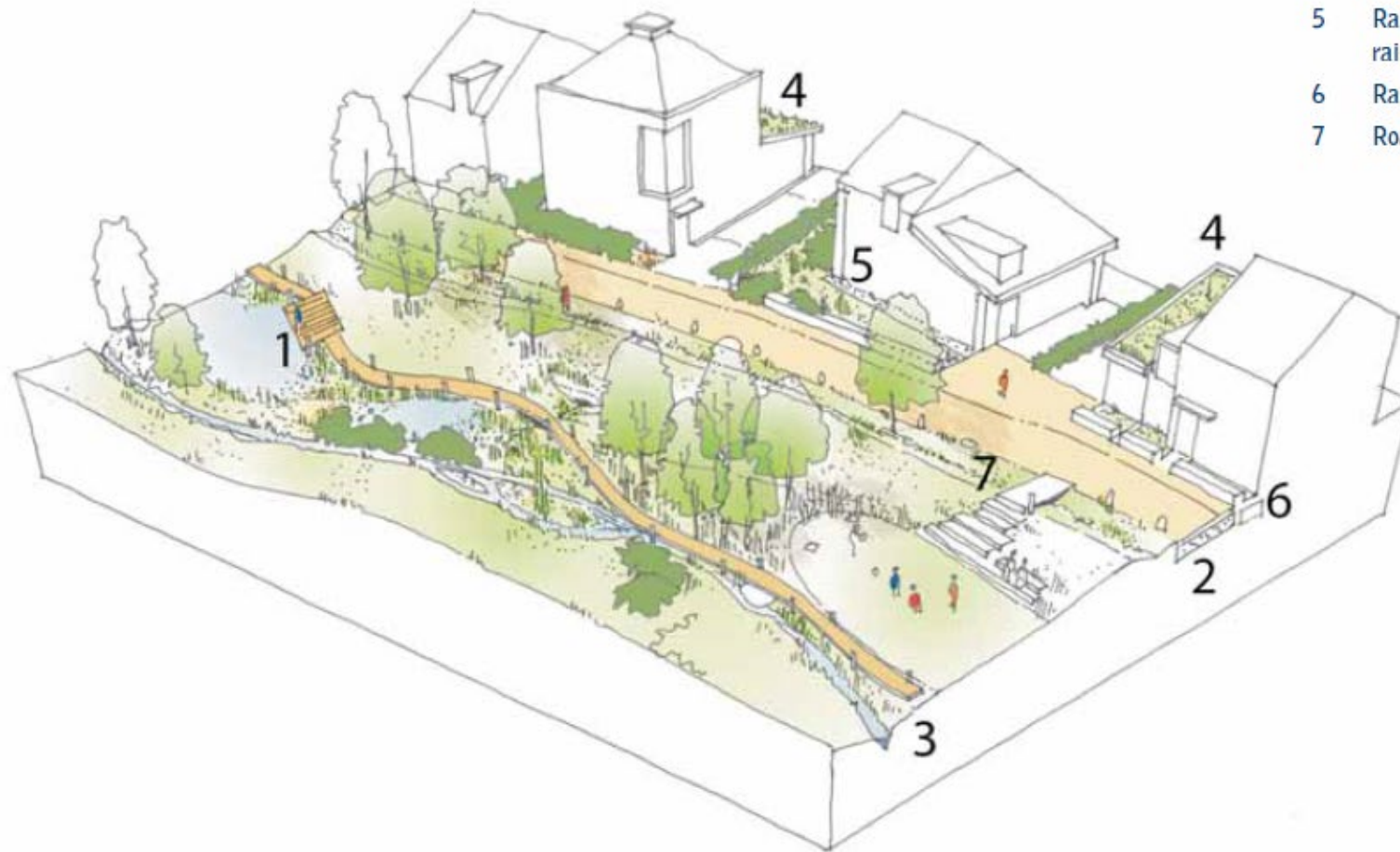


Key

- 1 Filter strip and retention pond within residential square
- 2 Permeable paving within residential street/mews
- 3 Roadside bioretention tree pits
- 4 Gravel/permeable surfaces within residential square
- 5 Green roofs
- 6 Roof gardens
- 7 Rainwater collection from roofs in front rain gardens/ water butts

Figure 4.7

SuDS in a medium density development setting



Key

- 1 Wetland areas within large open space
- 2 Permeable paving within residential street/ mews
- 3 Natural waterway
- 4 Green roofs
- 5 Rainwater collection from roofs in front rain gardens/water butts
- 6 Rainwater harvesting
- 7 Roadside swale

Figure 4.8

SuDS in a low density development setting

