LID INTEGRATED MANAGEMENT PRACTICES GUIDE

Definition of Terms/Glossary

Low Impact Development (LID): an innovative approach to storm water management that attempts to duplicate the hydrologic regime of an undeveloped watershed.

Integrated Management Practices (IMPs): engineering measures used in low impact development that compensate for the reduced infiltration and storage characteristics of developed sites.

Conservation and Minimization: IMPs that reduce the generation of runoff by preserving the natural conditions and limiting the aerial extent of impervious surfaces.

Storage: IMPs that retain or detain rain water to prevent or delay the generation of runoff.

Conveyance: IMPs that convey runoff throughout the site while providing opportunities for infiltration or treatment.

Landscaping: IMPs that alter the terrain and vegetation cover to minimize and treat runoff.

Infiltration: IMPs whose primary function is to allow runoff to infiltrate into the soil.

Narrowing of Residential Streets

Description

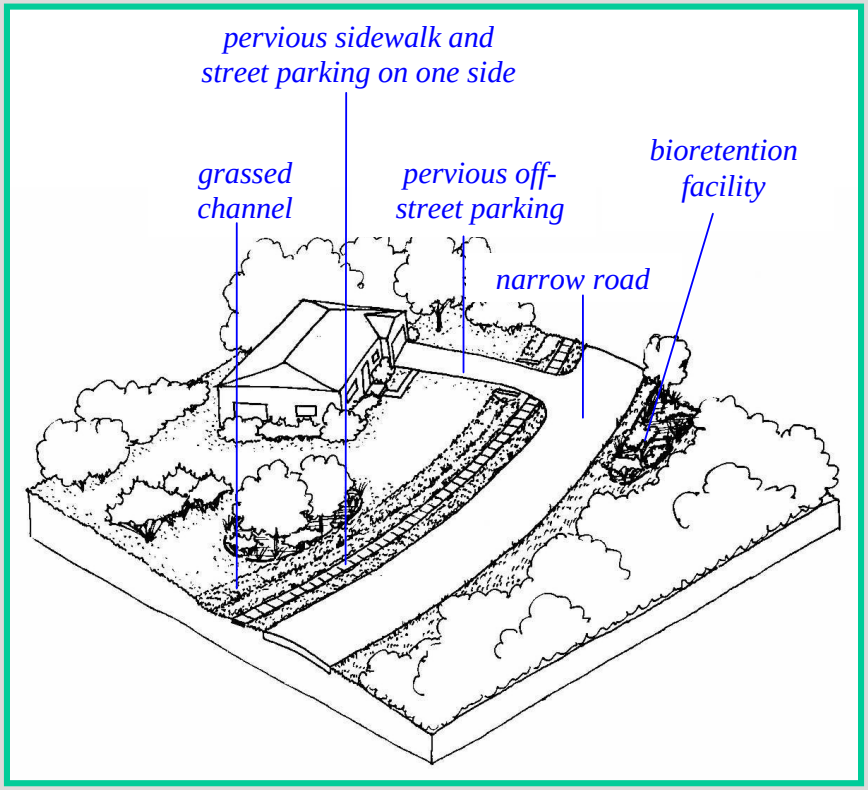
- Narrowing streets increases green space
- Space gained can be replaced with pervious areas, bioretention facilities, or vegetated channels
- Can reduce vehicle speed

Design Characteristics

- Streets can be narrowed to 25 feet
- Consider off-road parking, sidewalk location and traffic densities

Applicability

- New, low-density residential areas
- Higher density areas if municipal parking and safety requirements can be met



Concave Medians

Description

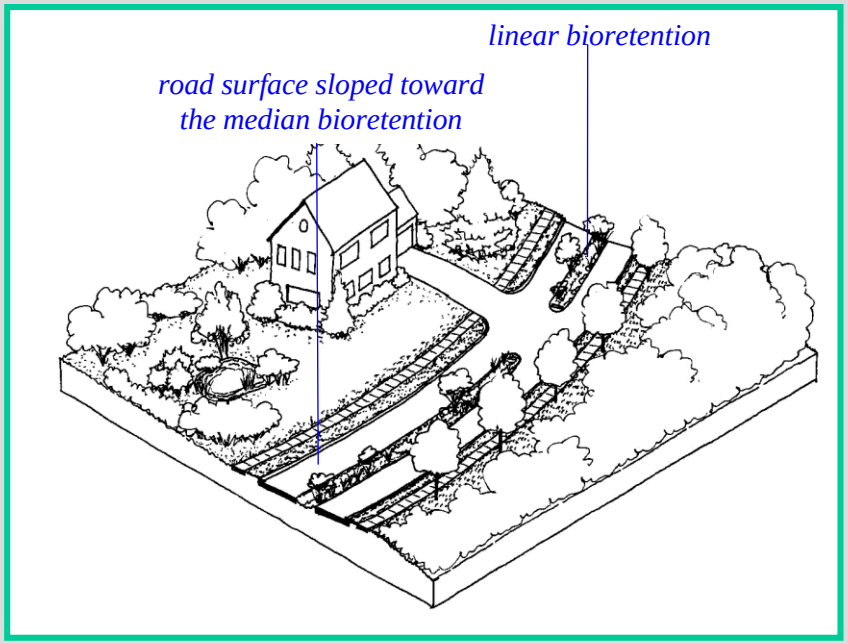
- Gently sloping vegetated channels allow for additional storage and infiltration
- Avoid potential problems with grassed channels (parking and pedestrian obstacles)
- Narrowed travel lane slopes toward median
- Linear IMP treats runoff

Design Characteristics

- Residential configuration usually part of overall infrastructure design
- Consider off-road parking, sidewalk location, traffic densities, driveway access and conveyance for runoff

Applicability

- New, low-density residential development
- Higher density areas if municipal parking and safety requirements can be met



Reduction of Impervious Sidewalks

Description

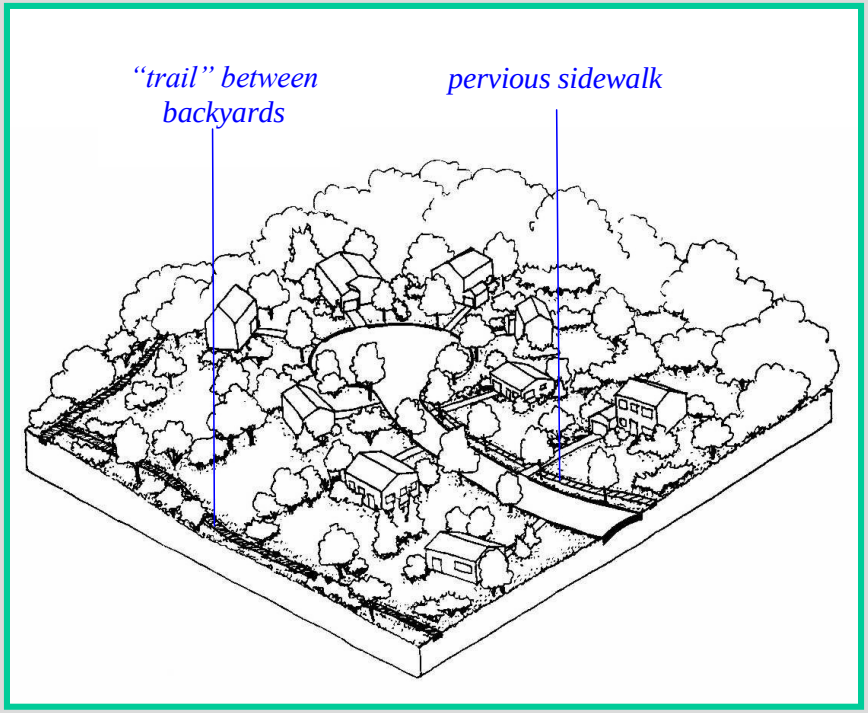
- Less impervious sidewalk reduces amount of runoff
- Space gained allows for linear IMPs adjacent to road

Design Characteristics

- Reduction done as part of overall infrastructure design (storm water and transportation)
- Replace sidewalks with pervious materials "trails" (pavers, gravel, mulch)
- Considerations include pedestrian traffic patterns

Applicability

- New developments

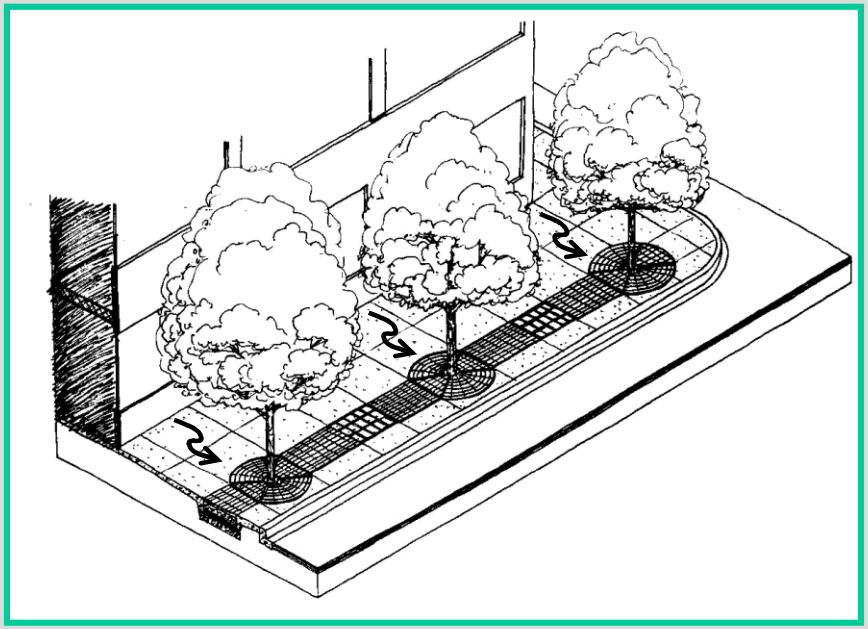


Grated Infiltration Systems

Description

Tree grates can be retrofitted to collect runoff

Can be placed over an infiltration system, crosswalk, and along parking lots



Design Characteristics

- Must be able to bear pedestrian and/or vehicular weight
- Should be removable to allow for maintenance

Applicability

- Where space is limited or landscaping not desired
- New development and retrofits

Porous Pavement

Description

Allows storm water to infiltrate and reach soil

Design Characteristics

Types include porous asphalt and concrete

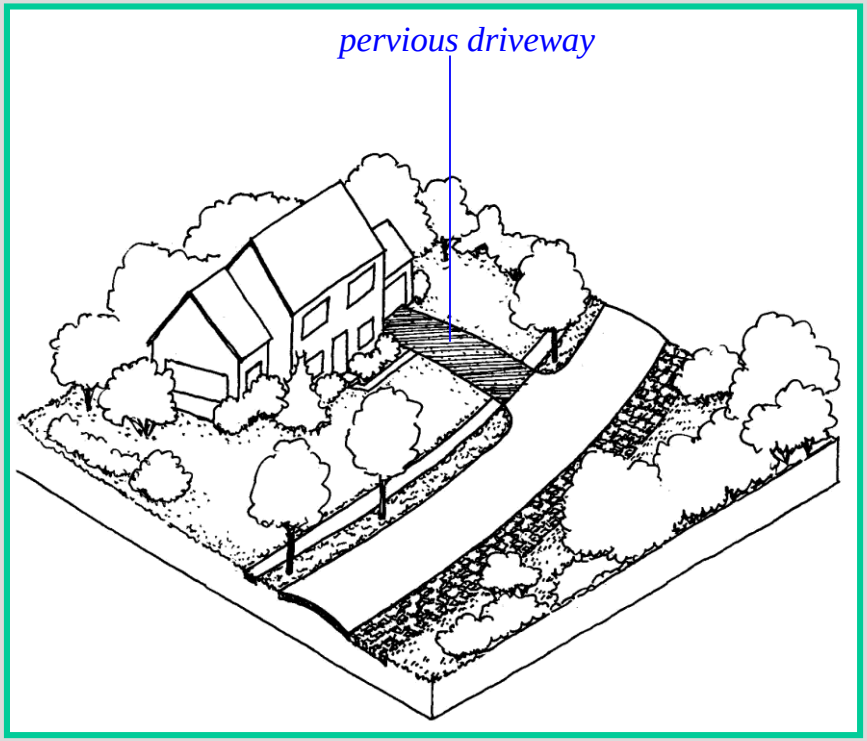
Can be used along shoulders or in parking areas adjacent to conventional asphalt or concrete in high traffic areas

Applicability

Office building, recreational facility and shopping center parking lots

Not recommended for industrial sites due to risk of groundwater contamination

As IMP retrofit option, consider potential for soil compaction



Landscaped Traffic Calming Features

Description

Used to slow or prevent traffic through residential areas

Increase pedestrian safety

Provide storm water management through use of bioretention areas or infiltration IMPs

Design Characteristics

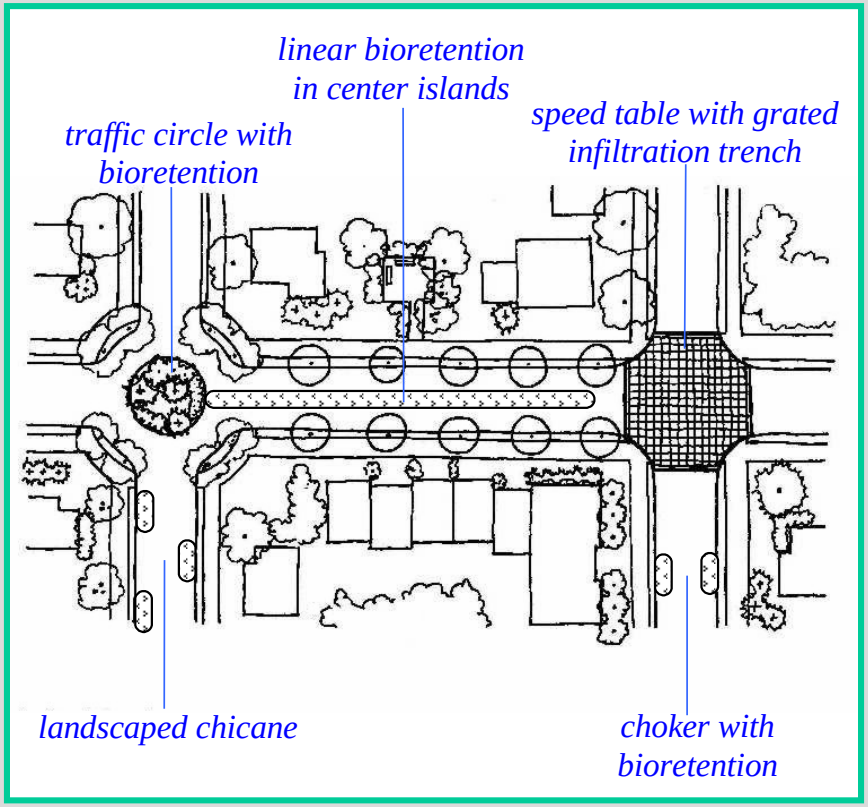
Bioretention - traffic circles, chokers, etc.

Infiltration facilities - crosswalks, speed tables and speed humps

Pervious materials may be used as infiltration trenches or porous layers

Applicability

Where traffic management is desired and where soils have adequate infiltration capacity



Parking Area Conversion

Description

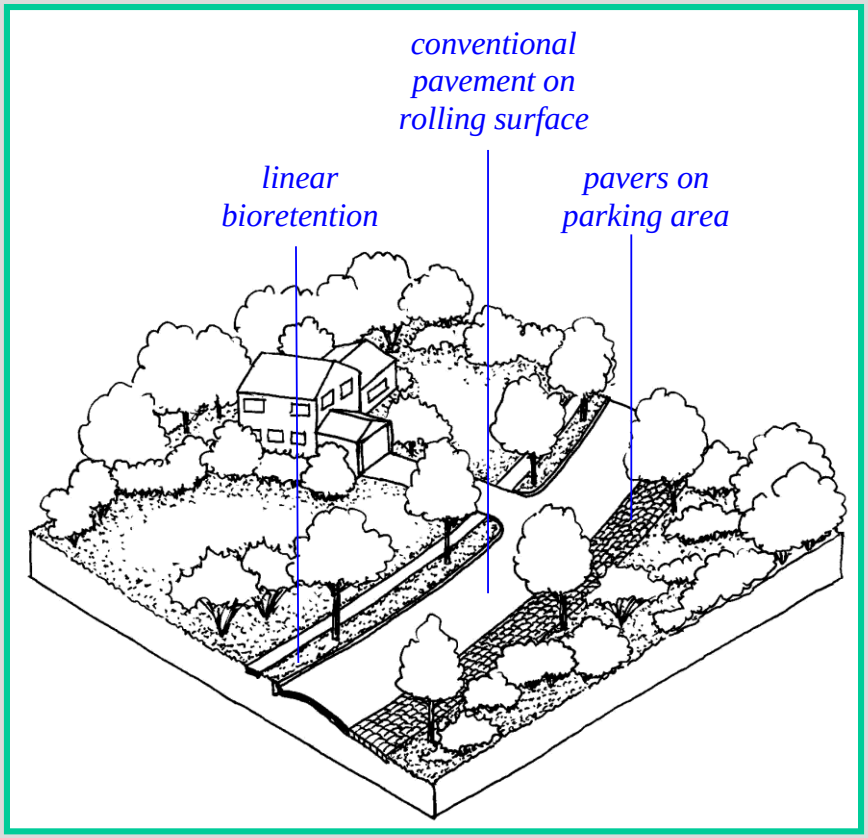
- Impervious materials can be replaced with pervious materials in on-street parking areas
- Conversion can be done along with landscaped traffic-calming feature

Design Characteristics

- Selected pervious material must withstand expected traffic volume
- Consider snow removal in design
- Runoff storage may be provided under pervious layer

Applicability

- New development
- Existing neighborhoods with extensive retrofits



Parking Groves

Description

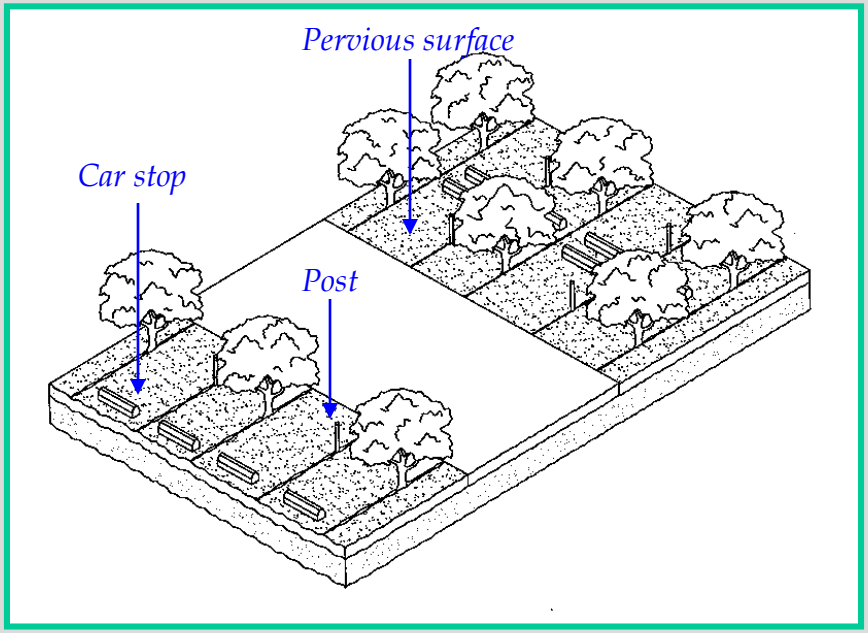
- Individual parking stalls covered with pervious surface
- Stalls lined with trees for shade and aesthetics

Design Characteristics

- Choose pervious material according to traffic volume and speed
- Stall width must accommodate mature trees
- Additional water storage can be provided under pervious layer
- Consider snow removal in design

Applicability

- New commercial or institutional parking lots
- Can use to retrofit existing lots
- Native soils must have adequate drainage



Grid Pavers

Description

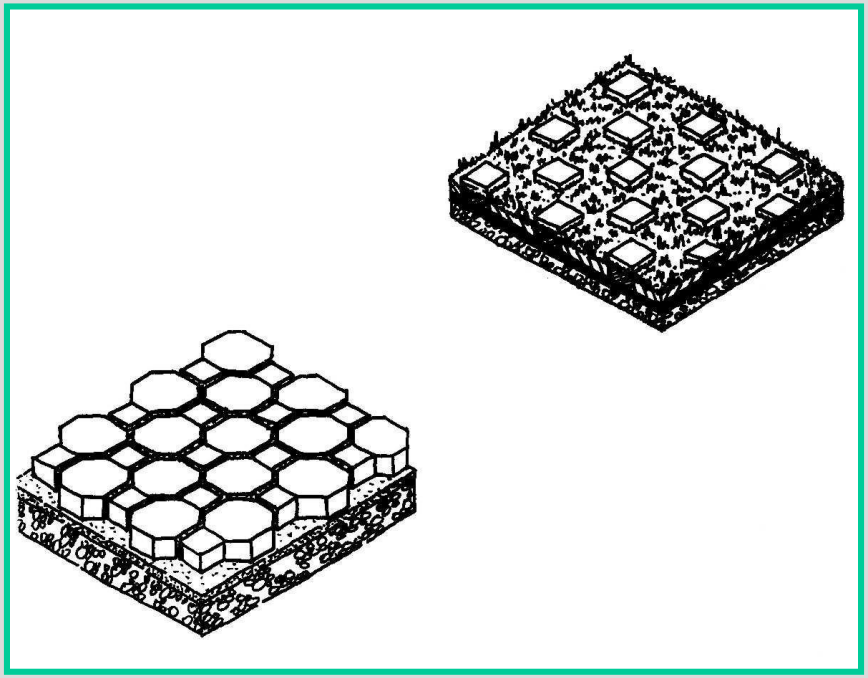
- Interlocking concrete blocks, brick, turf block, or stone used to replace impervious pavement
- Interstices between pavers allow for infiltration

Design Characteristics

- Consider traffic volume in material selection
- Turf blocks – good infiltration, limited vehicular traffic
- Concrete pavers – not as much infiltration, more durable

Applicability

- Ideal for walking surfaces
- Replacement for impervious pavement in areas with low to moderate traffic



Pedestal Sidewalks

Description

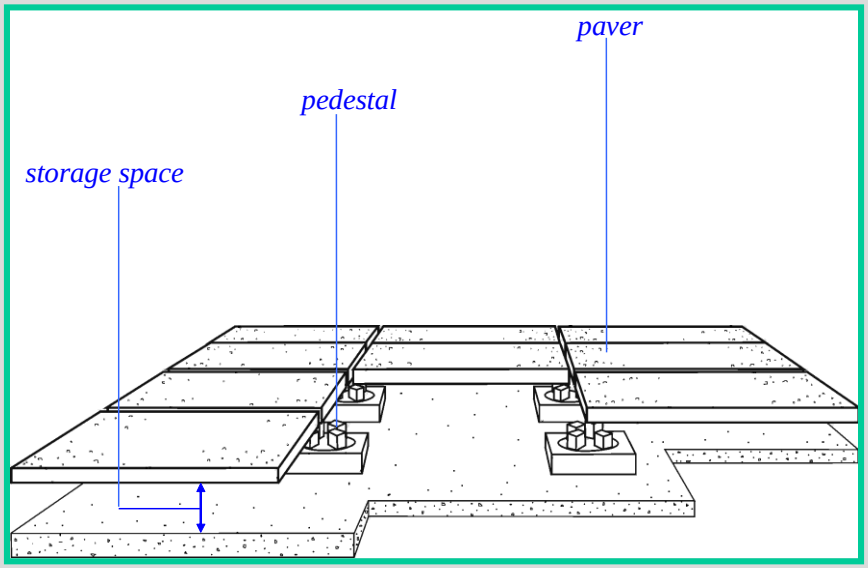
- Pedestals support sidewalk paving units over the subgrade
- Storage provided where water flows between pavers and fills space below
- Release of water is slowed at discharge point

Design Characteristics

- Pedestals should allow for at least one inch of storage
- Enough pedestals must be provided for stability
- Overflow outlet can be installed to control water level
- Remove pavers periodically for inspection and maintenance

Applicability

- Use wherever pavers are used

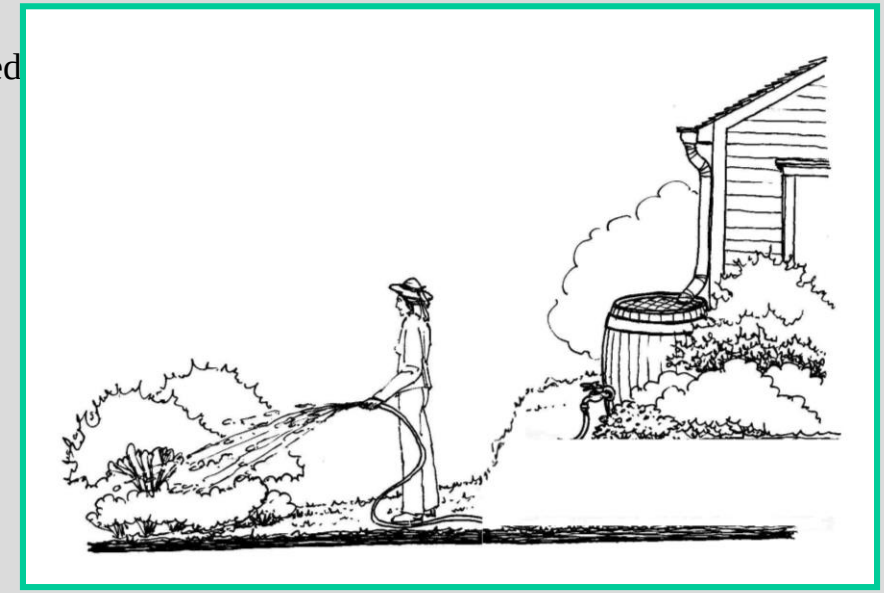


Rain Water Capture and Use

Description

Roof water cisterns are storage devices to collect roof storm water

Water can be released, infiltrated, or reused



Design Characteristics

Install above ground (rain barrels) or underground (concrete structures with pump or gravity drainage)

Size depends on roof area

Can be incorporated into landscaping features

Applicability

Commercial, residential or anywhere there is space for containers

Roof Top Detention

Description

Temporary detention and gradual controlled release of rain on flat rooftops

Design Characteristics

Water ponds behind perforated weirs around inlets of roof down drains and is slowly released

Water above the maximum depth is released to the down drains so that they operate at maximum capacity.

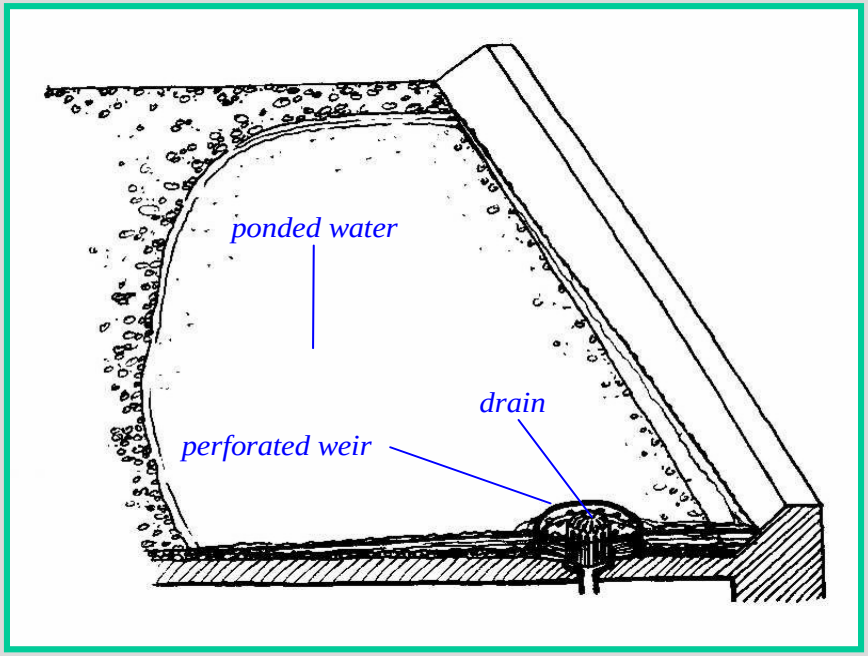
Structural capacity of roof and waterproofing must be considered during design

Applicability

Any flat roof

More efficient for commercial and industrial uses

Local municipal regulations may restrict use



Yard Storage

Description

Depressed area in front or back yard where water can pond for 1 – 2 hours after rainfall

Receives bypass flow from grassed channel

Water stored is slowly released back to channel with some infiltration

Design Characteristics

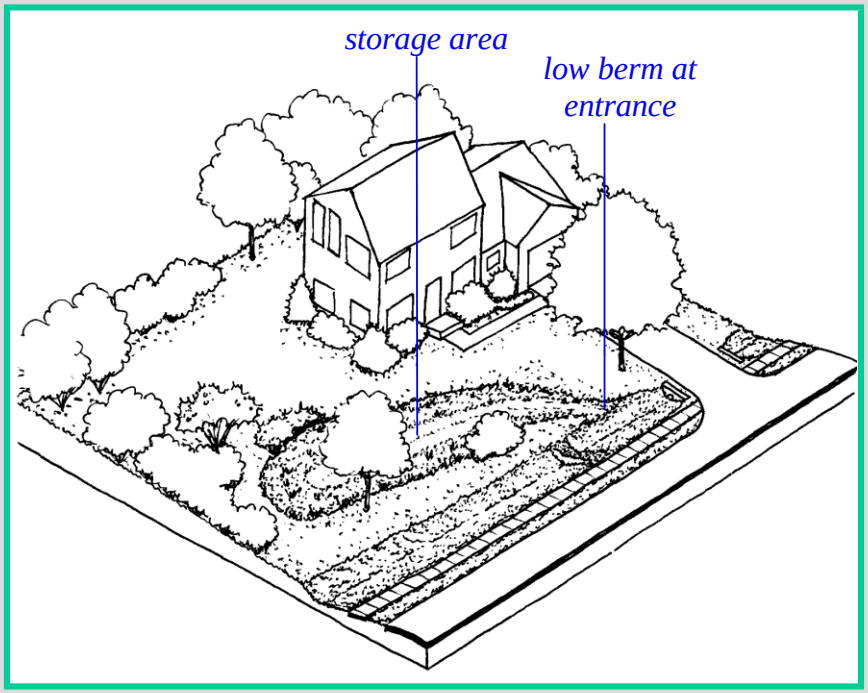
Need estimated storage volume from rainfall statistics and drainage area served

Need outlet for slow release back to grassed channel

Plant storage area with ground covers

Applicability

New and existing (retrofit) developments



Green Roofs

Description

Lightweight vegetated roof cover installed on existing buildings

Vegetation retains water later released through evapotranspiration

Design Characteristics

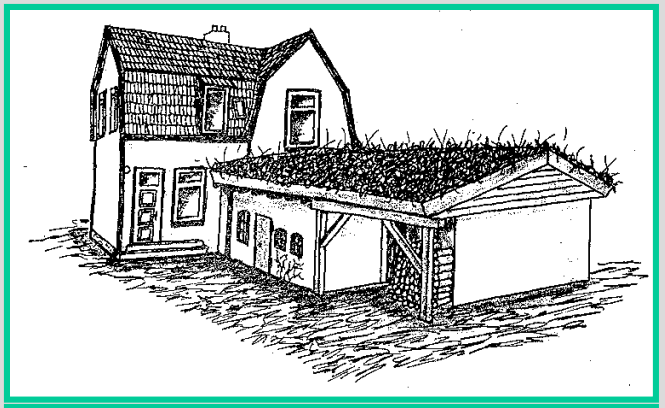
Design must include assessment of structural integrity and slope of roof

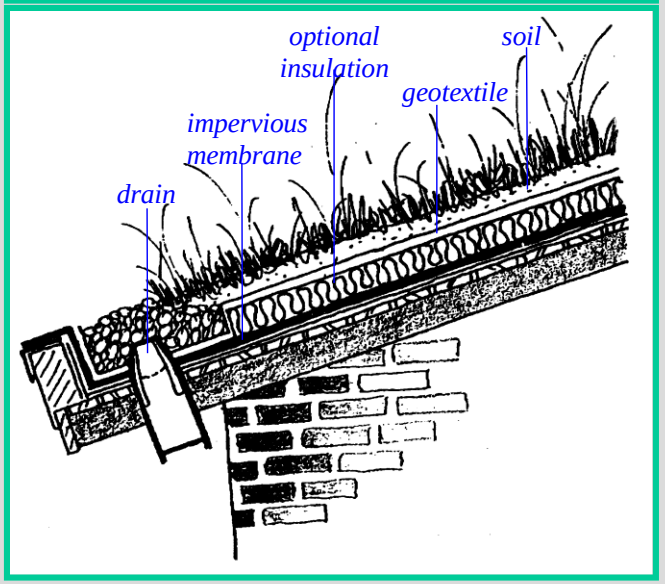
Flat roofs require drainage layer; pitched roofs drain by gravity

Excess water collected at pipe at roof edge leading to other IMPs.

Applicability

New or existing flat to moderately sloped roofs as long as roof can support additional weight

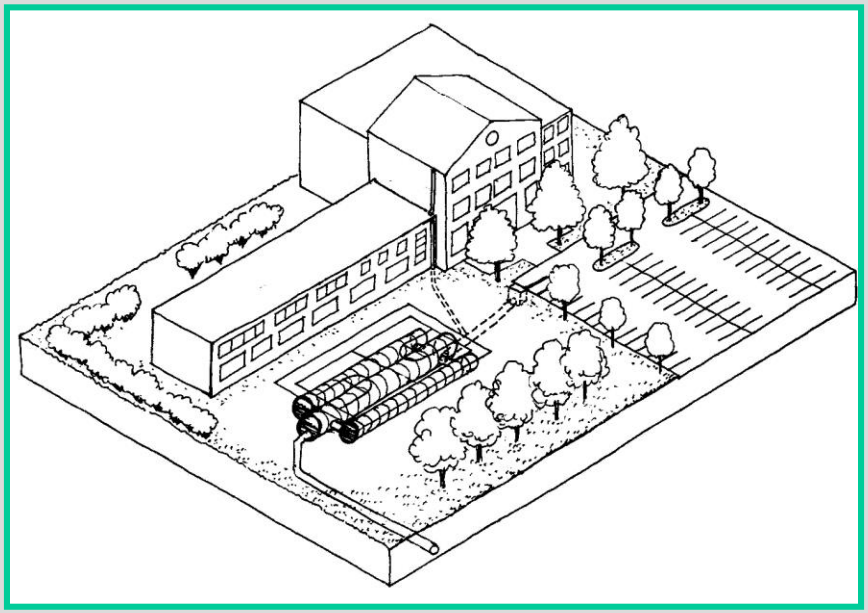




Subsurface Storage

Description

- Underground water detention devices installed to receive flow from rooftops, pavement or conveyance system overflow
- Types include tunnels, vaults, pipes, tanks, rock-filled cavities
- Does not impact area above the IMP



Design Characteristics

- Storage volume of device must be estimated from rainfall and drainage area served
- Outlet must be designed for slow release to storm drain with maximum water storage
- Overflow system required for excess runoff
- Devices need periodic cleaning

Applicability

- New development and existing (retrofit)
- Constraints, such as utilities, may limit use

Inlet Restriction

Description

Flow detained in parking areas by reducing inlet capacity

Design Characteristics

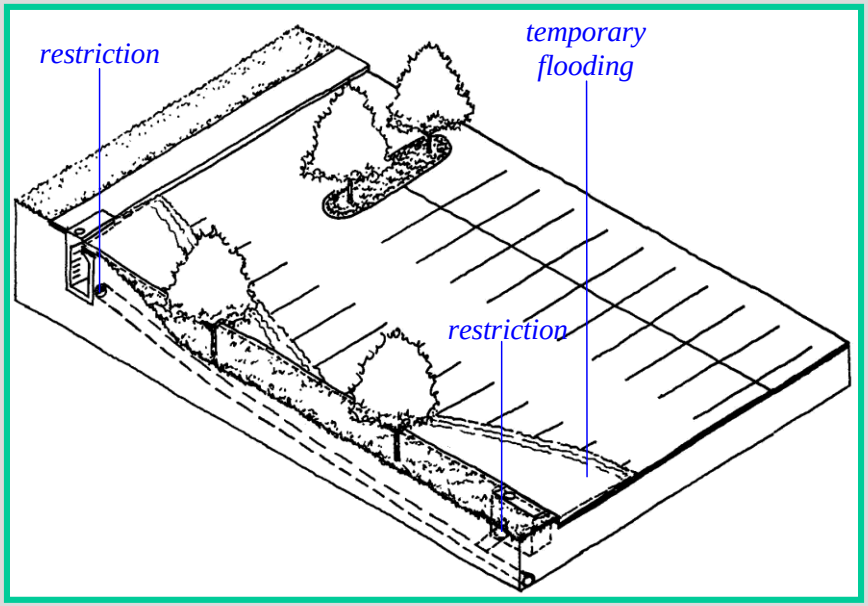
Restriction can be attained by partially blocking outflow from inlet

Restriction must be sized to prevent flooding depth greater than 6 inches

Applicability

Primarily used for retrofitting existing storm drain systems; can be used in new systems

Most suited for parking lots in less used areas



Curb Storage

Description

Combination of storage and infiltration features primarily used in parking areas

Grading diverts flow toward IMPs in parking islands and along edge of lots

Design Characteristics

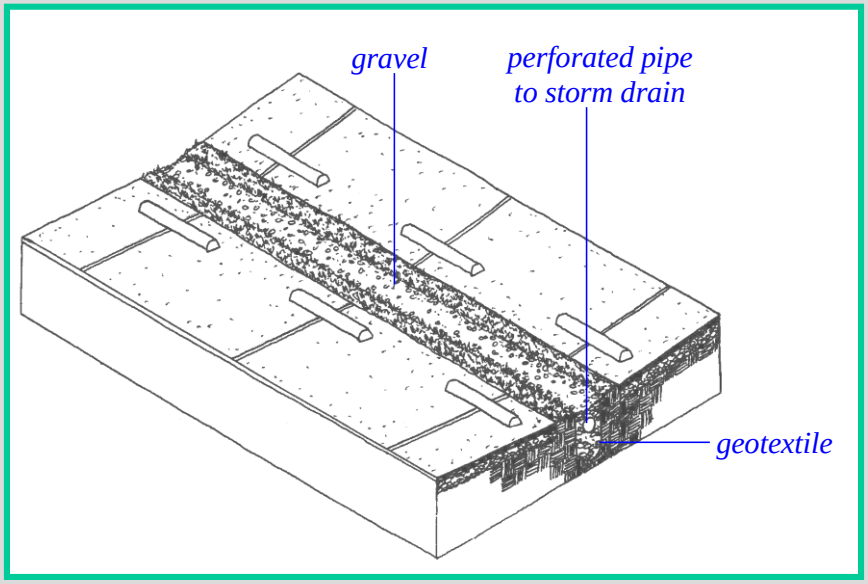
Graded parking lots create temporary detention areas around islands

Ponded water passes through infiltration trenches; excess water flows along trench to other IMPs or storm drain.

Must be designed to confine flooding to areas that cause minimal disruption

Applicability

Parking lots or other paved areas where temporary ponding is not problematic



Grassed Channel

Description

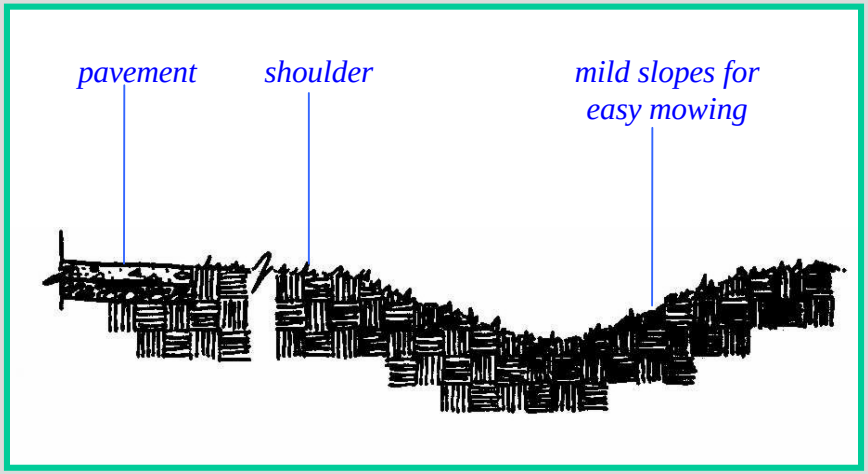
- Vegetated above-ground channels designed to replace pipes serving small drainage areas
- Slow storm water flows and increase infiltration

Design Characteristics

- Install on mild slopes
- Add check dams to increase sediment removal and further slow down flow
- Should not be constructed in area too wet or shady to support grass growth

Applicability

- Any land-use type where space is available
- Use in single-family or low-density residential housing areas could be restricted by maintenance and space issues



Underdrained Grassed Channel

Description

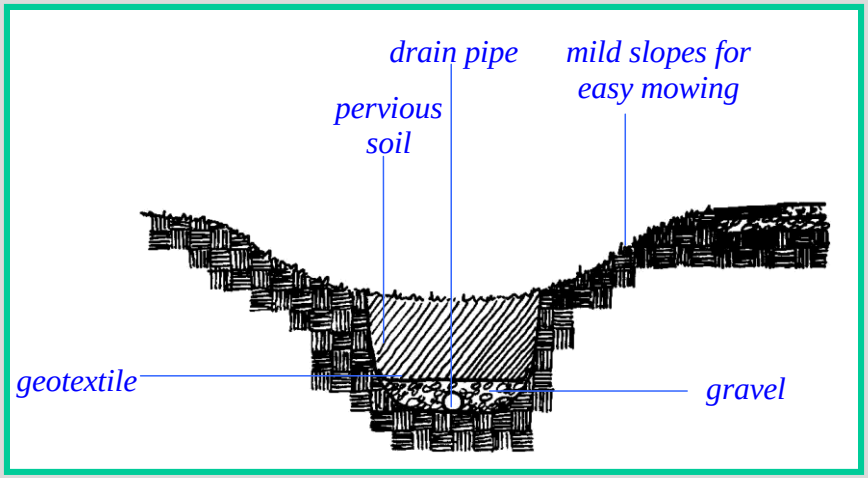
- Gently sloping vegetated channels designed to convey and treat flow from small drainage areas
- Reduces velocities, increases infiltration and filters water

Design Characteristics

- Contains gravel layer protected by filter fabric below soil layer
- Check dams can be used to increase on-site detention and allow longer infiltration times
- Should not be constructed in area too wet or shady to support grass growth

Applicability

- Any land-use type where space is available
- Use in single-family or low-density residential areas could be restricted by maintenance and space issues



Exfiltration Grassed Channel

Description

Conventional grassed channel underlain by perforated pipe

Pipes are connected to surface inflows with drop manhole and catch basin in channel

Used to avoid problems related to poor infiltration

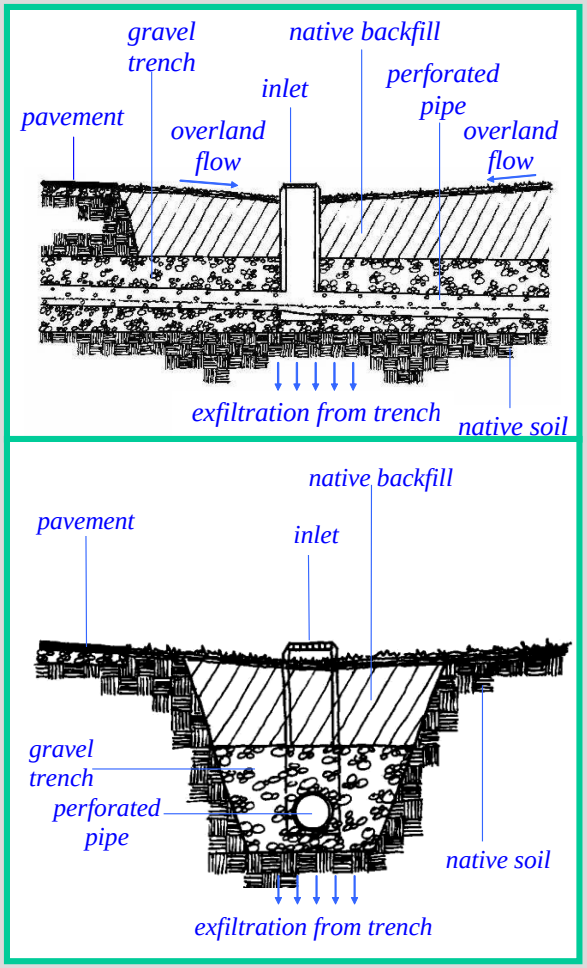
Drainage Characteristics

Perforated pipe drainage system increases year-round reliability

Applicability

Any land-use type where space is available

Maintenance and space considerations may restrict use to single family or low-density residential areas



Bioretention Channel

Description

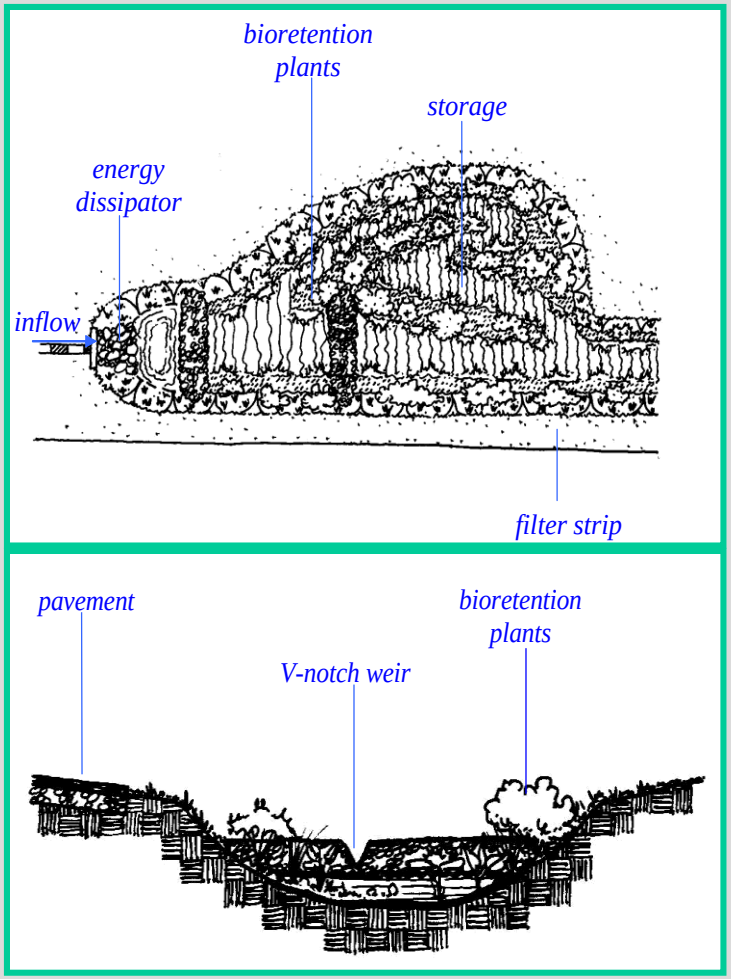
- Similar to dry channels
- Water can pond for extended periods of time
- Reduces velocities and filters water as runoff flows in channel

Design Characteristics

- Used to create wetland-type conditions on sites with high water tables supporting simple emergent wetland communities
- Pretreatment options such as riprap filters should be used

Applicability

- Suitable for retrofit options in areas with limited space, high water tables and minimal slopes
- Not recommended for residential areas due to potential problem with mosquitoes



Infiltration Trench Grassed Channel

Description

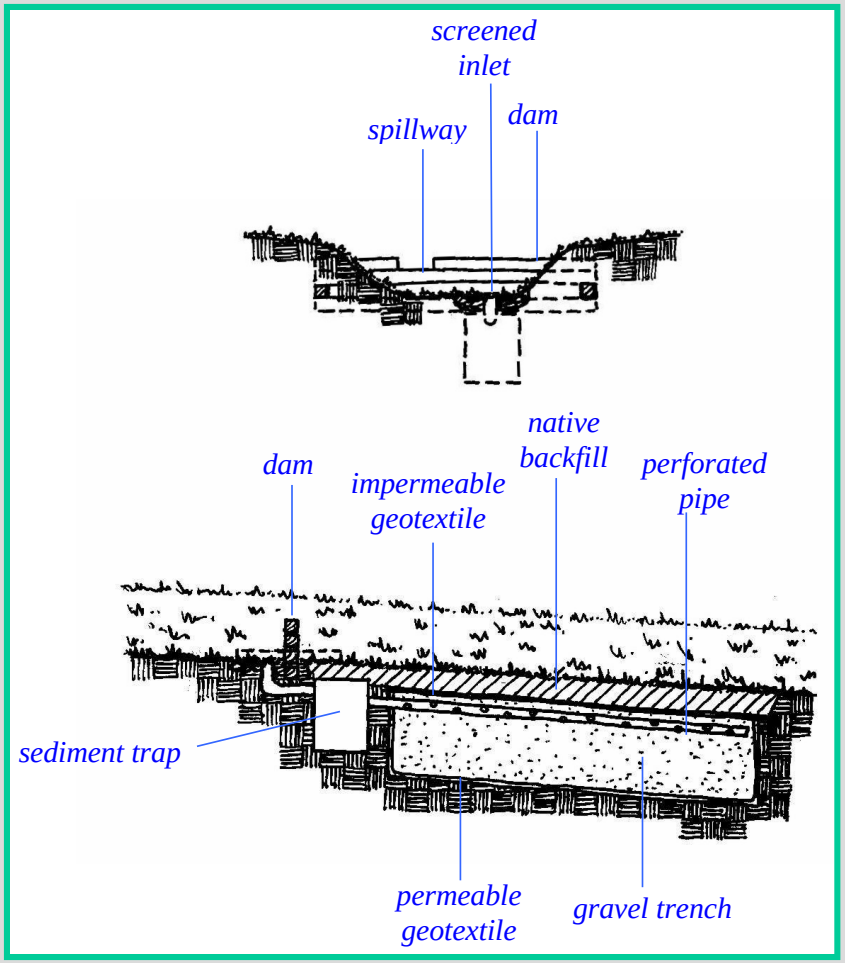
- Underground structures with vegetated cover
- More attractive than exposed gravel infiltration trenches
- Improve infiltration features of grassed channels on well-drained soils

Design Characteristics

- Timber weir across channel with inlet traps sediment
- Spillway allows large flows to pass
- Perforated pipe from barrel along top evenly distributes water
- Gravel trench wrapped in permeable filter on sides and bottom
- Impermeable filter fabric on top with soil medium
- Need grass filter strip to pre-treat storm water

Applicability

- Suitable in areas with well-drained soils
- Space limitations may limit use for retrofitting existing development



Disconnection of Impervious Areas

Description

Runoff redirected to graded green areas to reduce runoff by improving infiltration and evapotranspiration

Design Characteristics

Paved areas must be sloped towards vegetated areas

Width of vegetation depends on area of contributing pavement

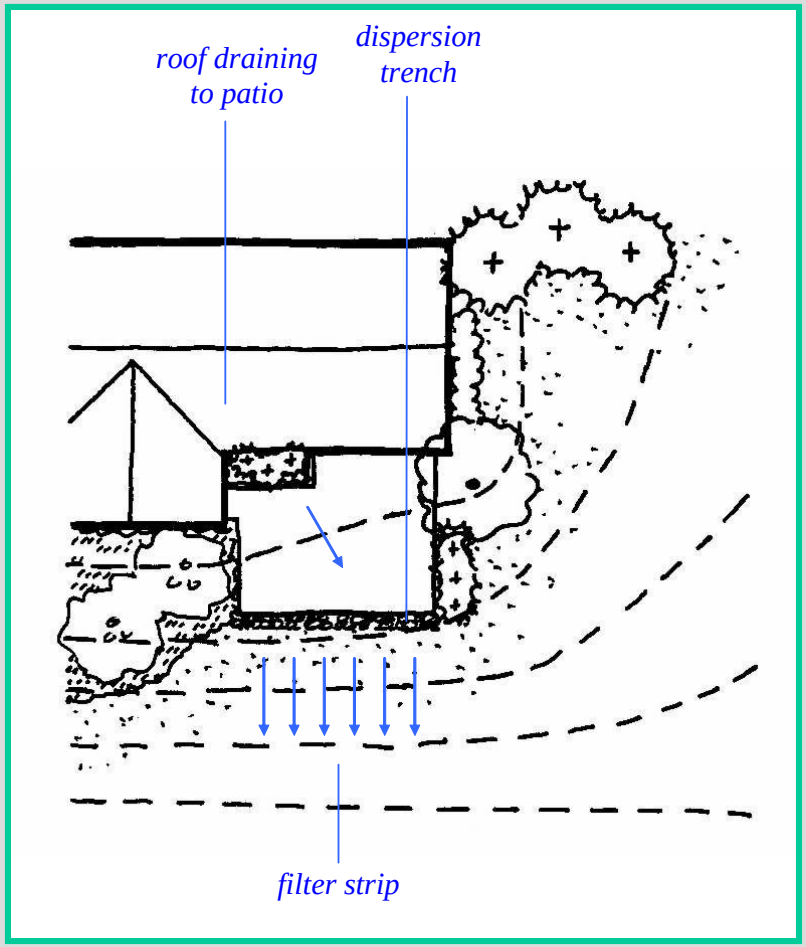
Sheet flow enters transition zone before flowing through vegetation

Concentrated flows from roofs and steep driveways must be diverted through dispersion trench

Applicability

Suitable for single family residential and commercial areas with enough space to accept dispersed storm water flows

Surfaces include moderately sloped driveways, sport courts, sidewalks and patios



Bioretention

Description

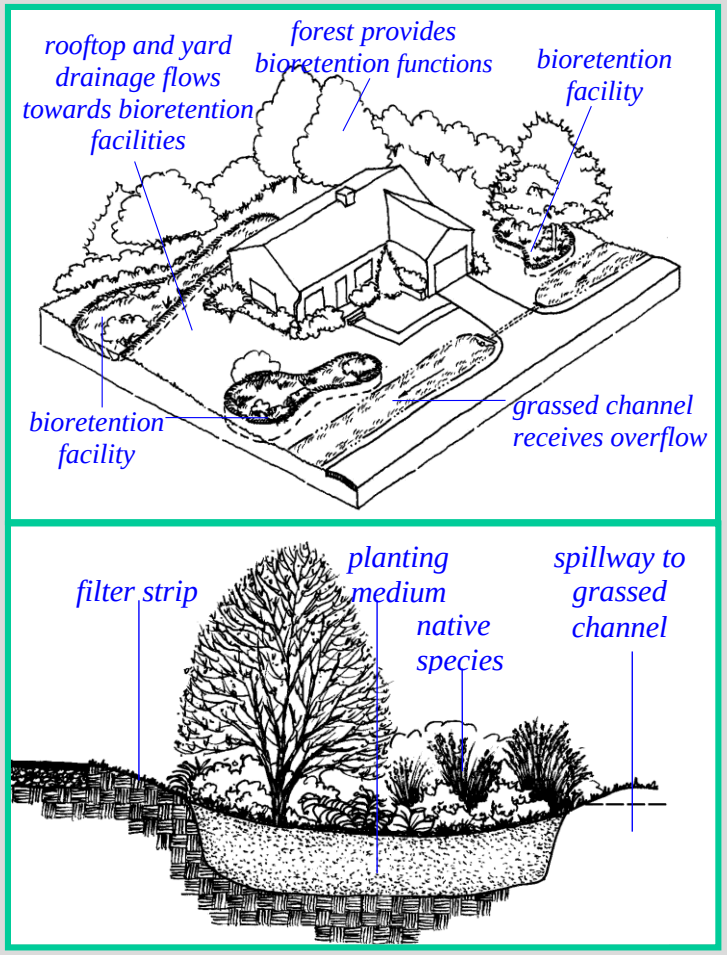
- Shallow, landscaped areas
- Improve water quality through filtration, sedimentation and biological processes
- Off-line systems capture flow from small storms and initial flow from larger storms

Design Characteristics

- Flow deflectors divert runoff
- Landscaped with native water-tolerant plants
- Space limitations may limit use of grass filters or dispersion trenches to slow and distribute flows

Applicability

- Can be used in almost any type of land use or in-situ soil
- Off-line bioretention is good for retrofitting in areas with limited space and difficult grade adjustments
- Low maintenance landscaping makes system good choice for parking lots



Bioretention Islands

Description

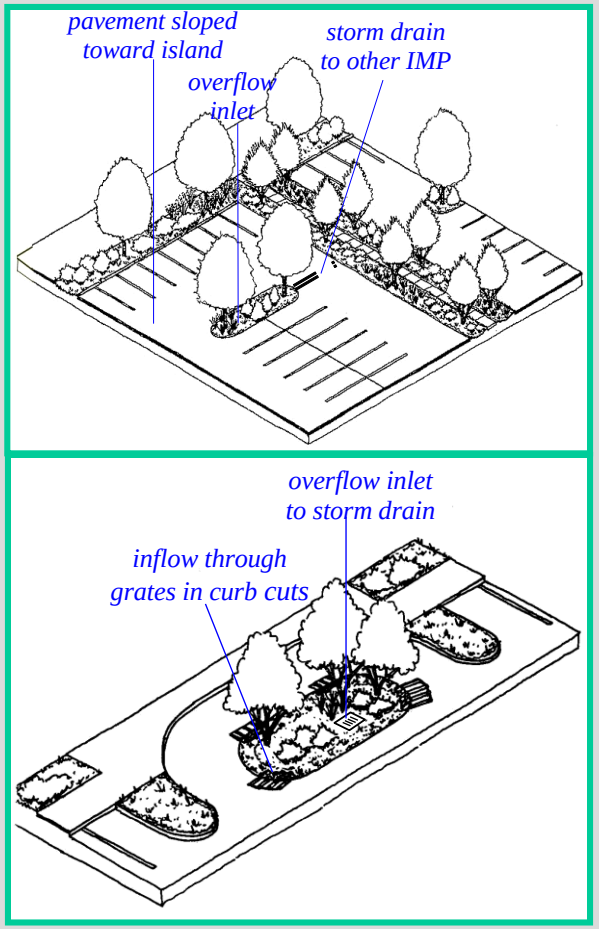
- Shallow, landscaped areas
- Improve water quality from paved areas through filtration, sedimentation and biological processes
- Capture runoff from small storms and initial runoff from larger storms

Design Characteristics

- Flexible shape and size
- Runoff may need to be directed to islands
- Dispersion trench can slow and disperse concentrated flows

Applicability

- Can be used in almost any type of land use or in-situ soil
- Retrofitting in areas where space is limited and grade adjustments are difficult
- Good for parking lots, intersections and paved areas adjacent to roads
- Short groundcover can be used where sight lines are important



Linear Bioretention

Description

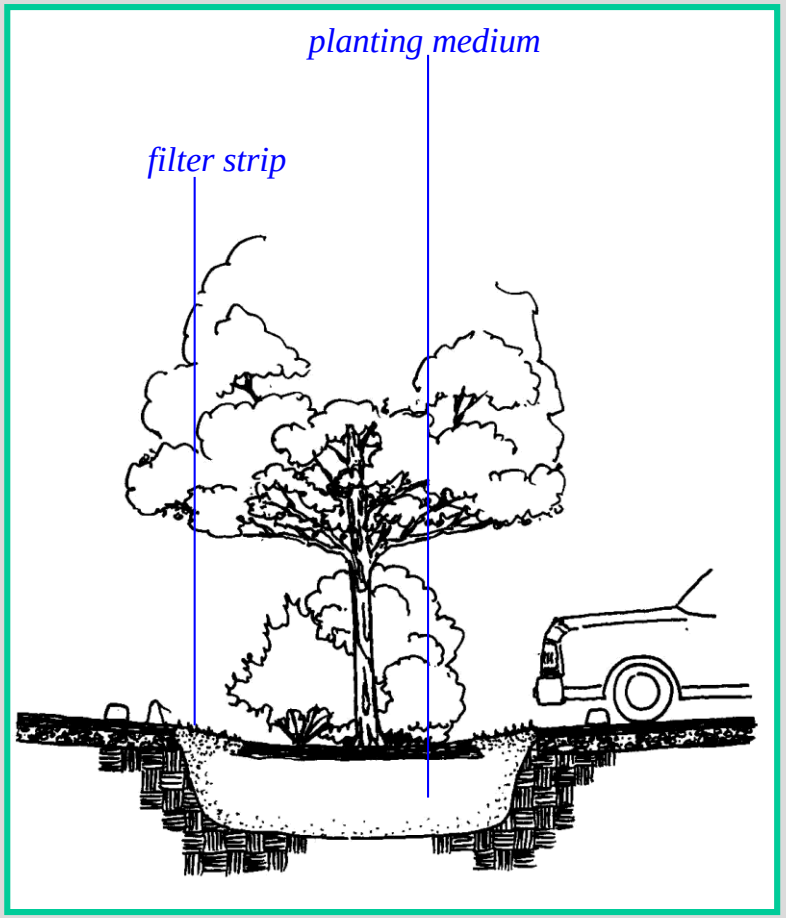
- Shallow, landscaped areas
- Off-line systems capture flow from small storms and initial flow from larger storms
- Captures and treats runoff from roads and parking lots to improve storm water quality

Design Characteristics

- Runoff reduces need for additional watering of landscaping
- Grass filter strip can be used to prevent clogging

Applicability

- Can be used in almost any type of land use or in-situ soil
- Well-suited for retrofitting streets in existing developments as long as sidewalk removal leaves enough space
- Good for areas near roads due to plant's need for less water
- Short ground cover can be used to minimize obstruction of site lines



Bioretention Bench

Description

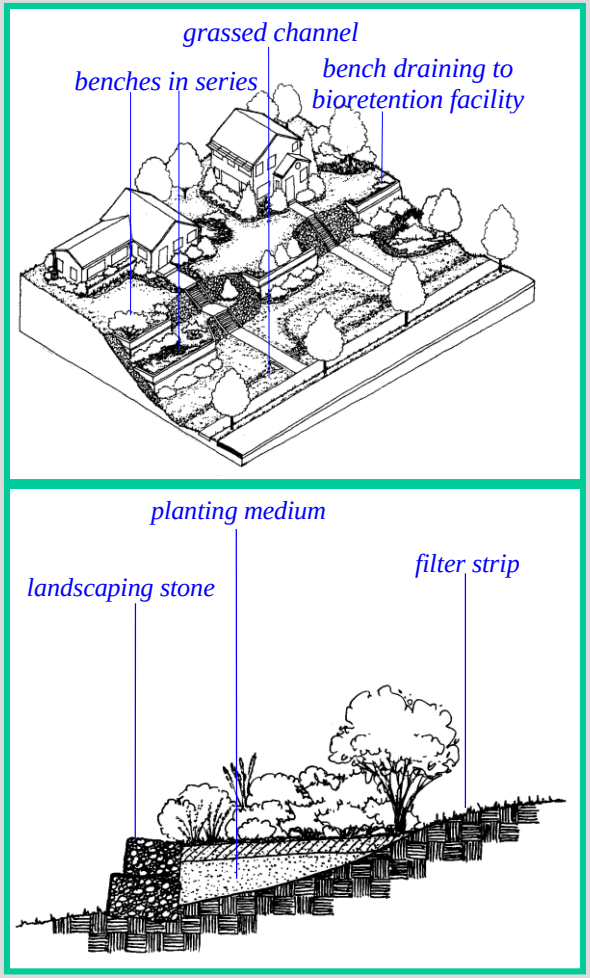
- Shallow, landscaped areas on slopes
- Treats runoff while allowing it to pond
- Improves quality through infiltration, sedimentation and biological processes
- Treated water discharges as runoff

Design Characteristics

- Located on slope with “weeping wall”
- Retaining walls made of lumber, stone or gabions

Applicability

- Limited to open spaces with moderate slopes
- Applicable in high-density residential or institutional land uses



Underdrained Bioretention

Description

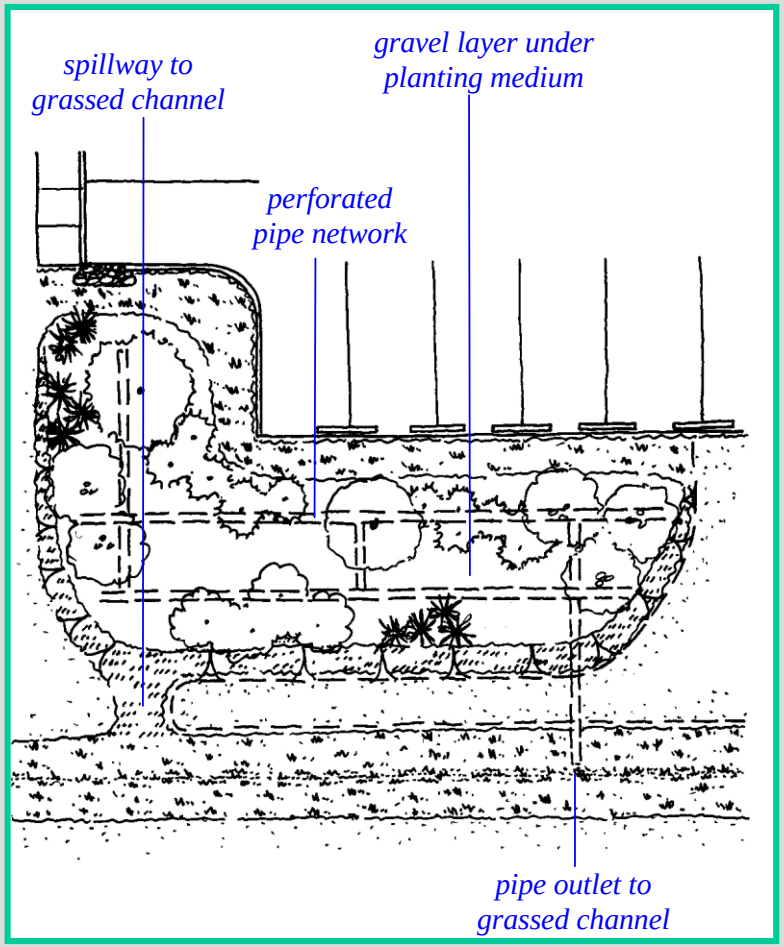
- Similar to conventional bioretention systems
- Used where building proximity or poor draining in-situ soils require underdrain systems

Design Characteristics

- Underdrain system can include pipes, gravel layers and collector pipes
- Can handle larger flows than typical bioretention areas
- Excess flows may be bypassed or discharged through spillway
- Landscaping must be drought tolerant

Applicability

- Almost any type of land use and suitable for retrofitting
- Good in areas with limited space and an existing storm drain system



Slope Reduction Bench

Description

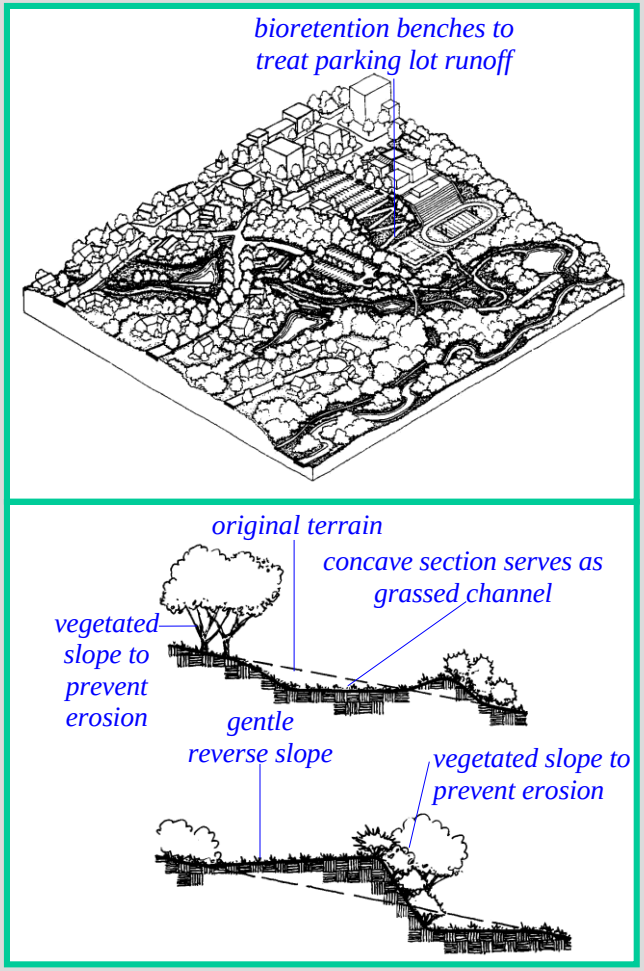
- Ground surfaces are sloped as benches or flat channels
- Terraces redirect water to flow along contours
- Decreases runoff velocity
- Facilitates settling of solids and provides storage

Design Characteristics

- Terrace width varies with slope and soil stability conditions
- Vegetation must be used to stabilize terrace slopes

Applicability

- Suitable for large, sloped areas
- May be used along road, rail or utility right-of-ways



Filter Strips

Description

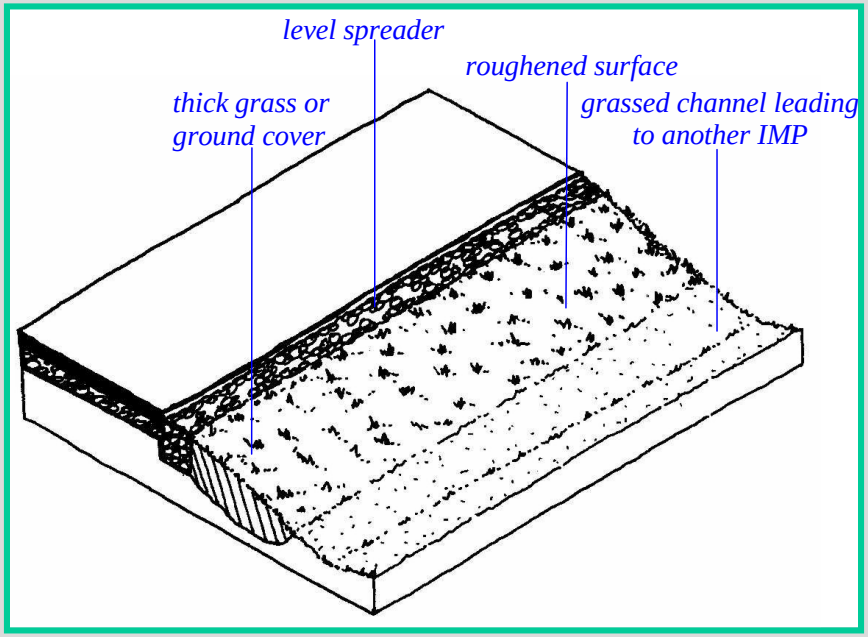
- Vegetated buffers used to slow down and filter runoff
- Provides limited infiltration
- Dense vegetation, long flow path and low gradient are most effective

Design Characteristics

- Commonly used as pre-treatment
- Without other IMPs, it effectively treats runoff from only low intensity rainfall
- Does not reduce peak discharges to pre-development levels
- Must be used with flow spreaders to disperse concentrated flows

Applicability

- Limited use in urban areas due to flow length and gradient requirement
- Used primarily along roadways



Rain Gardens

Description

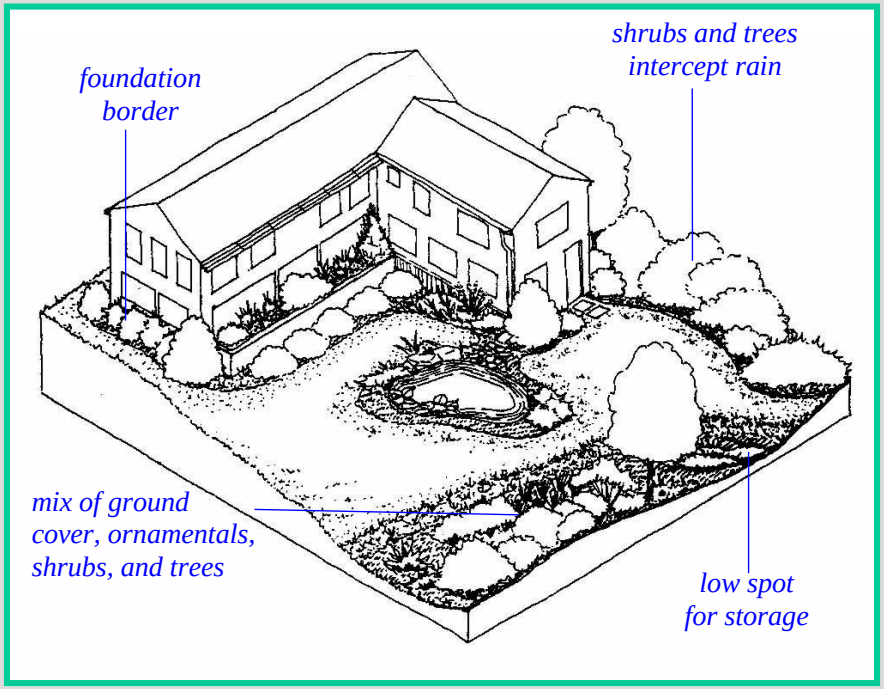
- Low-lying areas away from homes where water collects during heavy rains
- Naturally slows down flow into drainage systems and streams

Design Characteristics

- Use water-tolerant plants
- Plants increase infiltration and evapotranspiration rates

Applicability

- Can be used in new development
- Especially useful for retrofitting large yards



Fish Pond

Description

Ponds receive runoff, provide storage and help remove solids

Rainwater preferred over chlorinated water

Design Characteristics

Design should allow for additional storage above normal level

Outlet releases excess volume and spillway handles overflows

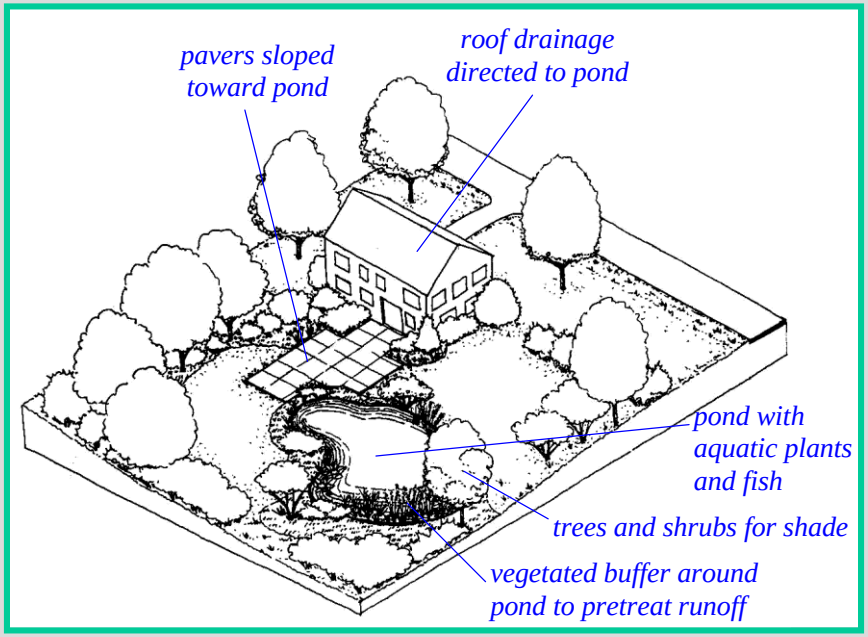
Fish should be pollution-tolerant (e.g., gold fish)

Provide a minimum depth of 15 inches to maintain fish habitat during winter

Impermeable liner and other equipment help maintain proper conditions

Applicability

Backyards, schools, office buildings, shopping malls



Dripline Planter Box

Description

Water dripping from roof used to water plants

Configurations include foundation plantings below roof edge or box planters along side of building

Design Characteristics

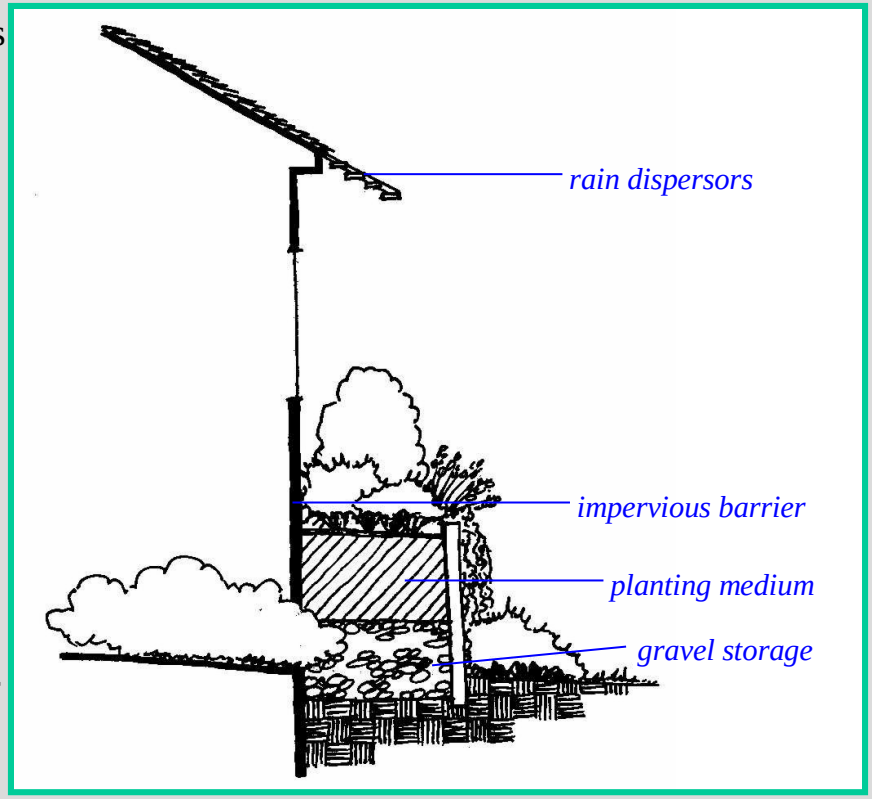
Runoff can be sent from down-spouts or as spray from rain dispersers

Planter volume based on area of roof

Planting bed slope should be away from foundation to prevent basement leakage

Applicability

New and existing development in any type of building



Native Groundcover Landscaping

Description

Portions of lawn planted with native ground covers, shrubs and trees

Replicates infiltration in forested areas

Design Characteristics

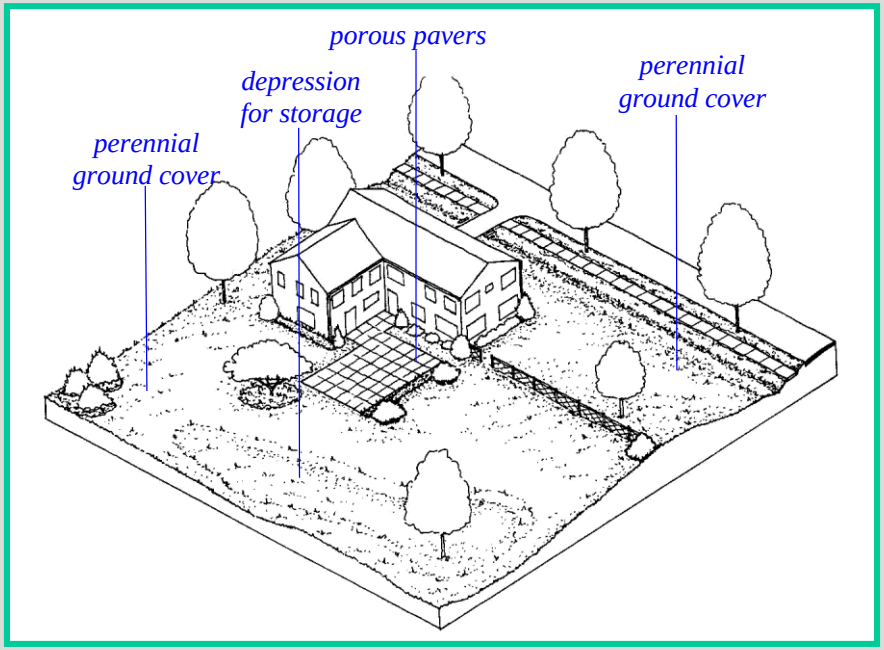
Consider maintenance in selection of plants

Can be used to provide screening, privacy, shade and year-round natural aesthetics

Applicability

Feasible for any land-use type

Slopes require special consideration to prevent erosion



Green Alleys

Description

Linear network of bioretention basins, infiltration trenches, and channels

Create landscaped features along the edge of developments, fence lines or roads

Provide redundant storm water quality management and conveyance functions

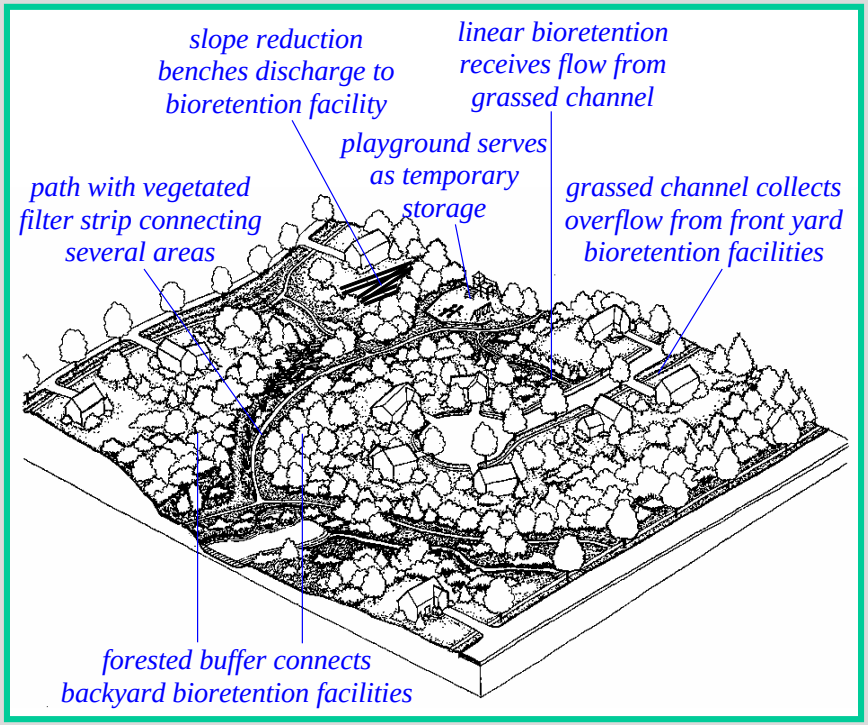
Design Features

Components of each IMP are incorporated into alley design

Individual IMPs can be connected via perforated or solid pipe, infiltration trenches, or sand filters

Applicability

Use where linear pervious areas permit the installation of a linear network of IMPs



Infiltration Trench

Description

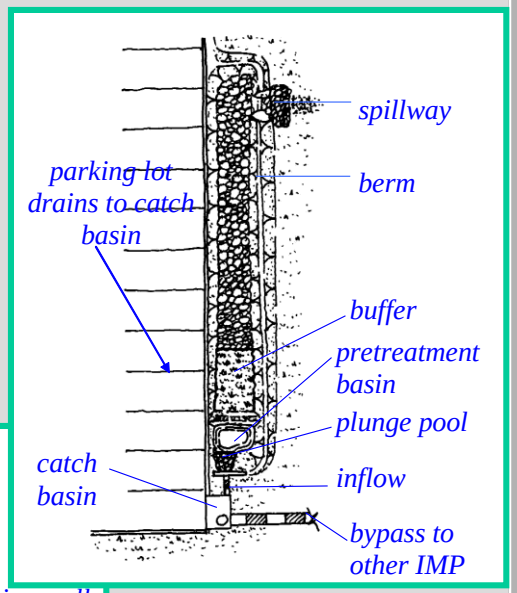
- Linear trenches used in areas where space for storm water management is long and narrow
- Can be used with berms

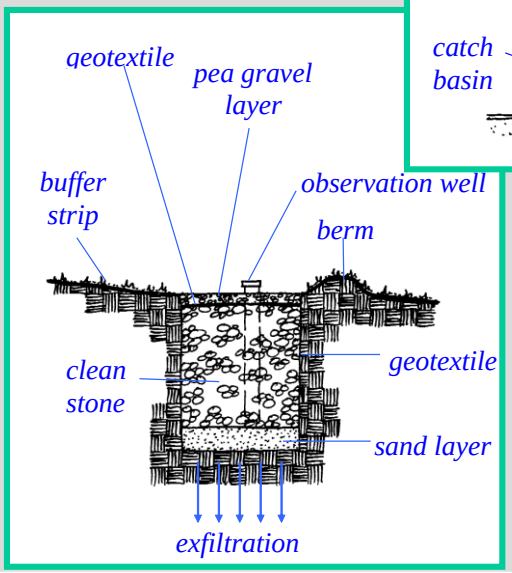
Design Characteristics

- Minimum of 3’ wide with washed rock wrapped in filter fabric and overlain with permeable backfill
- Berm allows ponding and can be landscaped
- Plunge pool, pre-treatment basin and grass channel at inlet reduce sediment build-up in trench
- Curb cuts serve as flow spreaders
- Bypass at inlet or spillway manages overflows

Applicability

- Well-suited for use as road medians, shoulders and along edge of parking lots
- Test in-situ soils to ensure that minimum infiltration requirements





Below-Pavement Infiltration Basins

Description

Runoff that drains through porous pavement, is stored in layer of coarse material and infiltrates into soil

Design Characteristics

In-situ soil below pavement needs adequate drainage and needs to be uncompacted

Storage layer thickness determined by volume of water to be stored

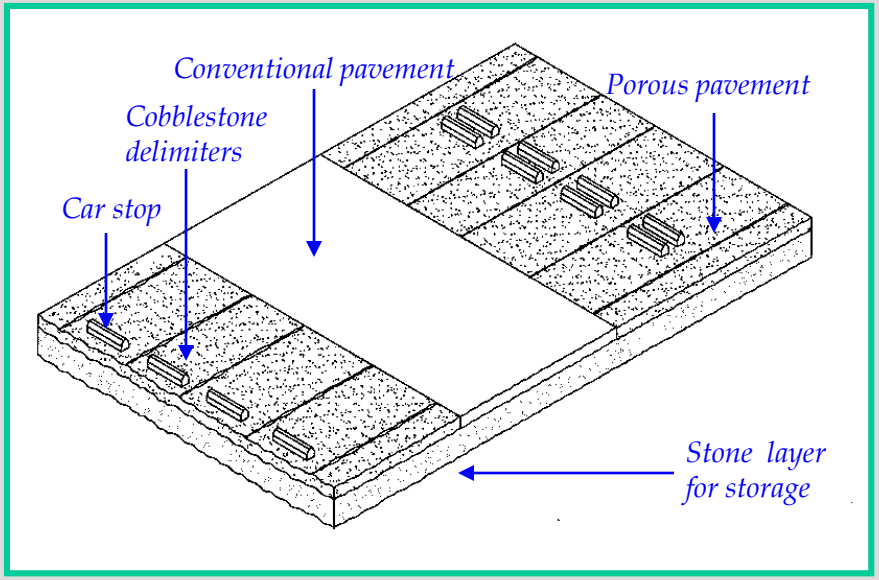
Asphalt thickness determined by bearing capacity needs

Applicability

Adequate for flat, low-volume traffic areas

In high traffic areas, porous pavement under parking bays needs to be used with strips of conventional pavement

Can be used in parking lots, highway shoulders, pullover zones and in parking zones along residential streets



Exfiltration Devices

Description

- Consist of variety of below grade infiltration devices to treat runoff from localized drainage area
- Devices include bottomless metal or precast concrete inlets, or stone fill surrounded by filter fabric

Design Characteristics

- Design varies with maintenance needs and site conditions
- Metal or precast concrete allow for more storage and can be fitted with lid for maintenance access
- Stone fill is less expensive but may clog

Applicability

- Useful for "spot-treating" small areas where runoff cannot be easily diverted to another IMP
- Require moderate to well-drained in-situ soils