LOW IMPACT DEVELOPMENT / GREEN INFRASTRUCTURE / BEST MANAGEMENT PRACTICES
For Sustainable Stormwater Management
Hudson County Planning Board

The following list of Low Impact Development (LID) and Green Infrastructure techniques are examples of strategies that can be employed to control stormwater runoff in Hudson County. In practice, these techniques utilize engineered or natural systems to mimic natural processes and pre-development conditions. Many strategies (such as green roofs, permeable paving, rain gardens, infiltration trenches, etc…) use soils and vegetation to infiltrate, evapo-transpirate and/or recycle runoff. Other strategies focus on site design (i.e., reducing connected impervious surfaces, reducing the number of parking spaces, adding bike lanes or green roofs atop parking decks, etc.) to produce a variety of environmental benefits.

Green Infrastructure

The suitability of a strategy or combination of strategies for each project will depend on the physical opportunities and constraints of a site, as well as the intended environmental benefits of the strategy. Physical factors to consider include the amount of space available, soil permeability, slopes, distance to water table/bedrock, proximity to building foundations, depth requirements and maintenance needs. The environmental benefits of a strategy vary with respect to runoff rate control, volume reduction, water quality benefits, heat island effect reduction, resource protection, air quality improvement, etc.

In all new development and redevelopment projects, the use of green Infrastructure/LID strategies should be considered a priority tool for stormwater management, before resorting to conventional end-of-pipe approaches.

LOW IMPACT DEVELOPMENT / GREEN INFRASTRUCTURE / BEST MANAGEMENT PRACTICES
For Sustainable Stormwater Management
Hudson County Planning Board

The table below provides general descriptions for some LID/Green BMP strategies. For each method selected, the developer shall provide detailed construction specifications, and shall comply with all requirements for stormwater management, in accordance with the provisions of the Hudson County Land Development Regulations.

	Strategy	Type	Description	Implementation	Maintenance
1	**Conservation Easements**	Site Design	Conservation easements are voluntary agreements that allow individuals or groups to limit the type or amount of development on all, or just a portion of their property. By agreeing to give up or restrict the development rights for a parcel of land, landowners can guarantee that their property will remain in a prescribed state for perpetuity while receiving tax benefits.	Easements should include (1) a description of the resource they are designed to protect (e.g., agricultural, forest, historic, water quality or open space easements), (2) restrictions on the uses and development (3) who is responsible (land trust, government agency, etc.) for maintenance, (4) language that is clear and enforceable, (5) maps, descriptions and baseline documentation of the property's characteristics, and (6) explanation of how the use of the land will be monitored on a regular basis.	The responsibility for maintenance of property in a conservation easement depends on the individual agreement with a land trust or agency. While many organizations assume the responsibility for managing and monitoring a property, some land trusts leave maintenance responsibilities to the landowner and act only to monitor that the terms of the easement are met.
2	**Land Compatible Design**	Site Design	Natural drainage patterns, native vegetation, and stabilization of soil during construction are important factors in the prevention of flooding and degradation of water quality. Priority shall be placed on site design that maintains natural drainage patterns and watercourses. Alterations to natural drainage patterns shall not create flooding or degradation in water quality for adjacent downstream property. Site design shall minimize the disturbance and loss of vegetation	Site development should be fitted to the topography and soil so as to create the least potential for vegetation loss and site disturbance; Vegetation removal should be limited to that amount necessary for the development of the site; Vegetation native to the site or plant community should be restored in areas affected by construction activities.	New planting shall be given sufficient water, fertilizer if necessary, and protein to ensure reestablishment.
3	**Native Landscaping**	Site Design	Natural landscaping refers to the use of native vegetation (particularly prairie, wetland and wooded species) on a development or redevelopment site. The preservation and restoration of natural plant communities is important for the protection of natural resources and habitat, prevention of flooding and erosion, and the enhancement of the quality and quantity of water resources, and therefore encourages their protection and enhancement.	New development should incorporate plant species native to New Jersey and tolerant to urban environments. Native vegetation should factor in topography, soils, drainage patterns and sun exposure, and should be considered for use for: green roofs, parks, detention basins and drainage features, edges of streams, lakes and wetlands, residential areas and gardens, commercial, industrial and institutional developments, common areas and parking lots.	Native vegetation typically requires less routine maintenance than conventional landscaping.
4	**Redevelopment**	Site Design	Redevelopment is development that occurs on previously developed land. Redevelopment of already-impervious surfaces can be a key strategy for reducing net increases in impervious surfaces and associated degradation to receiving waters.	Redevelopment include adding green roofs; micro-detention techniques; alternative pavers and porous pavement; infrastructure upgrades to repair deteriorating pipes contributing to water quality impairments; in-pipe and small structural devices	NA

	Strategy	Type	Description	Implementation	Maintenance
5	**Green Parking**	Site Design	Green parking refers to several techniques that applied together reduce the contribution of parking lots to total impervious cover, and consequently, reduce the amount of stormwater runoff. Green parking lot techniques include: minimizing the dimensions of parking lot spaces; utilizing alternative pavers in overflow parking areas; providing "compact vehicle" only parking spaces; providing bicycle parking; using bioretention areas to treat stormwater; encouraging shared parking; and structured parking with green roofs.	New parking lots and structures should include a percentage of designated spaces for compact cars, motorcycles, and bicycles. Compact car spaces shall be smaller than typical spaces. Motorcycle spaces shall be smaller still, and racks or other facilities shall be provided for bicycles. Shared parking is encouraged where adjacent businesses or other uses can reasonably share parking spaces, such as when businesses have staggered needs according to peak times. Alternative paving materials are recommended for overflow parking and other low volume parking areas where groundwater will not be impacted by such materials. Bio-infiltration, filter strips, and other practices should be included in all off-street parking facilities for 20 or more vehicles. Interior landscaping of parking lots should be maximized.	Limitations to green parking techniques include applicability, cost, and maintenance. Shared parking is practical in mixed use areas; structured parking may be limited by the cost of construction; alternative pavers are typically recommended only for overflow parking because of their expensive maintenance costs. Bioretention areas also increase construction costs.
6	**Riparian Buffers/ Forested Buffers**	Site Design	A riparian or forested buffer is an area along a shoreline, wetland, or stream where development is restricted or prohibited to physically protect and separate a stream, lake, or wetland from future disturbance or encroachment. If properly designed, a buffer can provide stormwater management, and can act as a right-of-way during floods, sustaining the integrity of stream ecosystems and habitats.	The following criteria should be considered when establishing a stream buffer: Minimum total buffer width; Mature forest as a vegetative target; Conditions for buffer expansion or contraction; Conditions where buffer can be crossed; Integrating stormwater and stormwater management within the buffer; Buffer education, inspection, and enforcement; Buffer flexibility.	An effective buffer management plan includes establishment, management, and distinctions of allowable and prohibited uses in the buffer zones. Buffer boundaries should be well defined and visible before, during, and after construction. Buffers designed to capture urban stormwater runoff will require more maintenance if designated as a bioretention or other engineered depression area.
7	**Innovative Street Design**	Site Design	Two aspects of street design relate to stormwater and its impacts: the pattern of the street and how the street is constructed (width, materials, etc.) The design of "green streets" for smart growth involves creating network of well-connected streets that support multiple transportation modes, and which also improve drainage.	Some smart growth approaches to street design include decreasing street widths, adjusting the vehicular level of service (LOS), adding bike lanes or bus lanes; incorporate features such as boulevard islands, rotary islands, parking lot islands, swales, sidewalk tree and groundcover planters designed to capture, filter, and infiltrate runoff (as well as traffic calming); Street retrofits can improve the drainage system or add structural and non-structural BMPs to lessen the flow of stormwater volumes or filter pollutants.	All types of systems should have regular maintenance to ensure they are functioning properly. Typical maintenance considerations for curb and gutter designs include street sweeping, catch basin cleaning, clearing blocked sewer lines, repairing and replacing failed pipes, and other aspects of maintaining buried, hard infrastructure. See other bio-retention/-infiltration maintenance sections.

	Strategy	Type	Description	Implementation	Maintenance
8	**Protection of Natural Features**	Site Design	Natural features that provide environmental, aesthetic, and recreational benefits, if preserved and protected from the impacts of construction and development, can include wetlands, riparian areas, floodplains, aquifer recharge areas, mature trees, woodlands, and other wildlife habitat. Restricted areas such as floodplains and steep slopes should also be protected from possible impacts from construction activities. Properties that are being redeveloped might have attractive open space, well-drained soils, or riparian areas that should be identified and considered for preservation early in the planning process.	Protect mature trees or woodlands, and steep slopes. Check erosion controls on upslope areas that will be cleared and graded and ensure that runoff from these areas is diverted away from or around the slope. Areas with well-drained soils and those that feed aquifers should be protected from compaction. Maintain existing vegetation wherever possible. Before planting permanent vegetation, aerate the soil to ensure that runoff infiltrates. Establish a buffer around marshes, swamps, or other wetlands and along stream corridors in which no construction activity occurs. Avoid stream crossings wherever possible. Contact a local wildlife authority if you find nests, dens, or other animal habitat on the property. Establish perimeter controls in floodplain areas.	Landscaping maintenance can be reduced because natural areas do not require the same level of maintenance as turf grass; Preservation of natural areas also eliminates the need to mow, fertilize, and perform other lawn maintenance activities.
9	**Green Roofs**	Site Design	Green roofs can be effectively used to reduce stormwater runoff from commercial, industrial, and residential buildings. They absorb, store, and later evapo-transpire initial precipitation, thereby acting as a stormwater management system and reducing overall peak flow discharge to a storm sewer system. They have the potential to reduce discharge of pollutants such as nitrogen and phosphorous due to soil microbial processes and plant uptake. Green roofs offer additional benefits including the reduction of the urban heat island effect, increased thermal insulation and enhanced energy efficiency.	Green roofs can be installed during initial construction or as part of a retrofit. The amount of stormwater that a green roof mitigates is directly proportional to the area it covers, the depth and type of the growing medium, slope, and the type of plants selected. A building must be able to support the loading of green roof materials under fully saturated conditions. These materials include a waterproofing layer, a soil or substrate layer, and a plant layer. Plants selected need to be suited for local climatic conditions and can range from sedums, grasses, and wildflowers on extensive roofs to shrubs and small trees on intensive roofs. It is the responsibility of the applicant to review the latest green roof technology when submitting applications for their use.	Green roofs need to be monitored regularly to ensure the vegetation thrives. During the first season, green roofs may need to be watered periodically if there is not sufficient precipitation. After the first season, extensive green roofs may only need to be inspected and lightly fertilized approximately once per year. The roofs may need occasional weeding and may require some watering during exceptionally dry periods.
10	**Urban Forestry (Trees and Tree Boxes)**	Site Design	Urban forestry is the presence of trees and forests located in and around the city. Since trees absorb water, patches of forest and the trees that line streets can help provide some of the stormwater management required in an urban setting. Urban forests help break up a landscape of impervious cover, provide small but essential green spaces, and link walkways and trails.	Tree preservation areas should be clearly marked. Delineating lines along a critical root zone (CRZ) rather than a straight line is essential to preserving trees. Trees should be planted in accordance with the Hudson County Urban Forestry Plan.	See the *Hudson County Community Forestry Plan*

	Strategy	Type	Description	Implementation	Maintenance
11	**Stormwater Wetlands**	Detention	Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.	Wetlands need sufficient drainage area to maintain the permanent pool, typically about 25 acres; Wetlands can be used on sites with an upstream slope of up to about 15 percent and a relatively shallow local slope; Wetlands can be used in almost all soils and geology, with minor design adjustments for regions of karst (i.e. limestone) topography; Design should incorporate pretreatment, treatment, conveyance, maintenance reduction, and landscaping	Wetlands should be designed with non-clogging features to reduce maintenance. Regular maintenance and inspection practices are needed, including clean and removal of debris from inlet and outlet structures; mowing side slopes; removal of invasive vegetation; repairing undercut or eroded areas; and sedimentation control.
12	**Bioretention / Rain Gardens**	Filtration	Bioretention areas are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions designed to incorporate natural pollutant removal mechanisms. During storms, runoff collects above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system.	Some considerations for selecting a stormwater management practice are the drainage area the practice will need to treat, the slopes both at the location of the practice and the drainage area, soil and subsurface conditions, and the depth of the seasonably high ground water table. Bioretention facilities are best applied to relatively shallow slopes of five percent (5%) and must be separated somewhat from the ground water to prevent groundwater contamination. The use of native, deep-rooted perennial plantings instead of sod is recommended wherever possible. Bioretention area design features should incorporate five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.	Bioretention requires landscaping maintenance including the need to: Water plants daily for 2 weeks (at project completion); Re-mulch void areas, treat diseased trees and shrubs, and Mow turf areas (as needed); Inspect soil and repair eroded areas and remove litter and debris (monthly); remove and replace dead and diseased vegetation (twice/year); add mulch and replace tree stakes and wires (once/year).
13	**Filter Strips**	Filtration	Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow.	Filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. Typically, filter strips are used to treat very small drainage areas, i.e., one acre of impervious surface per 580-foot length. Filter strips should be designed on slopes between 2 and 6 percent. Filter strips should not be used on soils with a high clay content; Filter strips should be separated from the ground water by between 2 and 4 ft.	Maintenance is very important for filter strips, particularly in terms of ensuring that flow does not short circuit the practice. Typical maintenance includes regular removal of sediment build-up within the bottom; and annual inspection of pea gravel diaphragm for clogging, vegetation for rills and gullies, and to ensure that grass has established (if not, replace with an alternative specie); Seed or sod bare areas.

	Strategy	Type	Description	Implementation	Maintenance
14	**Porous Pavements**	Infiltration	Porous pavement is a permeable pavement surface, often built with an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil. Porous pavement replaces traditional pavement, allowing parking lot stormwater to infiltrate directly and receive water quality treatment. There are various types of porous surfaces, including porous asphalt, pervious concrete, and grass or permeable pavers. Porous pavement should be sited on low to medium traffic areas, such as residential roads, overflow and special event parking, driveways, utility and access roads, emergency access roads, fire lanes and alleys.	While porous pavement can be a highly effective treatment practice, maintenance and proper installation are necessary to ensure its long-term effectiveness. Soils permeability should be at least 0.5 inches per hour; The bottom of the stone reservoir should be flat, so that runoff can infiltrate through the entire surface; Pavement should be sited at least 2 to 5 feet above the seasonally high ground water table; the base of the stone reservoir should be below the frost line; Design characteristics should include: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.	Using contractors skilled in techniques of installation of pervious concrete, permeable pavers, or porous asphalt will increase performance and longevity of the system. Monthly inspection is needed to ensure that paving area is clean of debris, the paving dewaters between storms, and the area is clean of sediments. As needed (3-4 time's/year), it is necessary to mow upland and adjacent areas, seed bare areas, vacuum sweep frequently to keep the surface free of sediment, and inspect the area for deterioration.
15	**Infiltration Trenches**	Infiltration	An infiltration trench (a.k.a. infiltration galley) is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.	Use is restricted due to potential ground water contamination, soils, and clogging. They shall not be used where there is potential for infiltrated water to interfere with existing infrastructure, and if the site soils have poor infiltration capacity. Considerations for their applicability are the size of the drainage area, slopes, soil infiltration rates and textural class, and distance from ground water sources and wells. Infiltration trench designs shall include features for pretreatment, treatment, conveyance, maintenance reduction, and landscaping.	Infiltration trenches should have an access path for maintenance activities such as an observation well (PVC pipe) that can enable inspectors to monitor the drawdown rate. Trenches should have a means to drain the practice if it becomes clogged, such as an underdrain. Standard maintenance includes remove sediment and oil/grease from pretreatment devices and overflow structures.
16	**Grassed Swales**	Infiltration	Swales (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) are vegetated, open-channel management practices designed to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows along these channels, vegetation slows the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs.	Grassed swales are well suited for treating highway or residential road runoff because they are linear practices that require large areas. Grassed swales should generally treat runoff from small drainage areas (less than 5 acres); should be used on sites with relatively flat slopes of less than 4 percent slope; in areas with larger slopes, check dams can be used to reduce the influence of the slope; the bottom of the swale should be constructed at least 2 ft above the ground water table to prevent a moist swale bottom or contamination of the ground water.	Maintenance of grassed swales mostly involves litter control and maintaining the grass or wetland plant cover.

	Strategy	Type	Description	Implementation	Maintenance
17	**On-Lot Treatment (Storing runoff)**	Retention/ Detention	The primary purpose of most on-lot practices is to manage runoff from rooftops, driveways and sidewalks. Rooftop runoff generally has low pollutant concentrations compared to other urban sources. Practices that store rooftop runoff, such as cisterns and rain barrels, are the simplest of all of the on-lot treatment systems. Cisterns and rain barrels can be particularly valuable where rainfall is infrequent, and reuse for irrigation can save homeowners money. Down spouts can be disconnected from the storm drain system and rainfall can instead be collected and stored on site.	Basic design components include the barrel (typically plastic, min. 60 gallons), a sealed yet removal child resistant top to keep potential pests out, but still allow easy access for cleaning, screens at the barrel entrance to reduce particulate matter and the potential for mosquitoes and connections to the downspout, runoff pipe, and spigot. In order for the practice to be effective homeowners or businesses need to have a use for the water collected. These practices are best suited to an individual who has some active interest in gardening or landscaping, since the stored water may be used for irrigation. Some sort of pretreatment, such as a mesh filter, is often also found at the top of rain barrels and cisterns. A hose mounted at the bottom of the barrel or cistern is typically used for irrigating gardens or for landscaping. The design must also accommodate overflow and winter freezing conditions.	Rain barrels and cisterns require minimal maintenance, but the homeowner needs to ensure that the hose remains elevated during the winter to prevent freezing and cracking. In addition, the tank needs to be cleaned out about once per year. Rain barrels and cisterns should be checked periodically to ensure that they are properly sealed to prevent mosquito breeding.
18	**On-Lot Treatment for Residences (Infiltration)**	Retention/ Detention	The primary purpose of most on-lot practices is to manage runoff from rooftops, driveways and sidewalks. Rooftop runoff generally has low pollutant concentrations compared to other urban sources. The practice most often used to infiltrate rooftop runoff is the drywell. In this design, the storm drain is directed to an underground rock-filled trench that is similar in design to an infiltration trench. French drains or Dutch drains can also be used for this purpose.	In these designs, the relatively deep dry well is replaced with a long trench equipped with a perforated pipe buried within the gravel bed to distribute flow throughout the length of the trench. Pretreatment is important to ensure they do not clog with leaf debris. A settling tank or, at a minimum, a debris-trapping grate or filter in the downspout, may precede infiltration practices. An above-ground opening in the downspout can serve as the bypass. The infiltration area should be at least 10 feet away from the house to prevent the undermining of the foundation or basement seepage.	Infiltration practices require regular removal of sediment and debris settled in the pretreatment area, and the media might need to be replaced if it becomes clogged.
19	**On-Lot Treatment for Residences (Run-off diversion)**	Retention/ Detention	The primary purpose of most on-lot practices is to manage runoff from rooftops, driveways and sidewalks. Rooftop runoff generally has low pollutant concentrations compared to other urban sources. Runoff can be diverted to a pervious area or a treatment area using site grading, or channels and berms.	Treatment options can include grassed swales, bioretention, or filter strips. The bioretention design can be simplified for an on-lot application by limiting the pre-treatment filter and, in some cases, eliminating the underdrain. Alternatively, rooftop runoff can simply be diverted to pervious lawns, as opposed to flowing directly onto the street and then to the storm drain system.	Bioretention areas, filter strips, and grassed swales require regular maintenance to ensure that the vegetation remains in good condition.

Infiltration beds in a parking lot

Bioretention swale in a parking area

Urban bioswale

Rain garden in parking lot

Rain garden on a residential property

Bioswale along a residential street

Bioretention swale retro-fit to roadway

Street Tree stormwater treatment retrofit

Native landscaping at a Chicago School

Permeable paving options

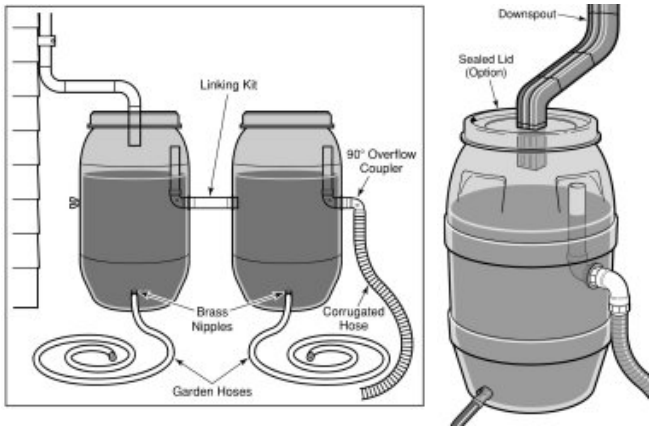
Permeable paver retrofit for a residential street

Permeable parking lot and bioretention system for commercial building

Green Roof

Green roof in a dense urban setting

Rainwater harvested in a cistern



Typical manufactured urban rain barrel design

Parking space for compact vehicles

Bicycle parking and shelter