



Watershed Design Guide

**Best Practices for
the Hudson Valley**

2014 | Final

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Introduction and Overview

We have always settled along the edges of streams, rivers and oceans. Water is life.

Yet, as we urbanize more and more of the landscape, our relationship to these water resources becomes more and more problematic: Wetlands and shorelines were filled; developed lands increased the amount of polluted stormwater runoff that made its way to the estuary; industry added pollutants; sewage treatment infrastructure failed to keep pace with development. All of these practices disrupted natural hydrologic patterns and diminished groundwater recharged. Now, in the face of climate change and sea level rise, our approach to our water resources is more critical than ever.

At stake is not just our scenic views and recreational opportunities, but our economic health and our way of life in the Hudson Valley.

Recognizing this, the New York State Department of Environmental Conservation (NYSDEC) established the Hudson River Estuary Program. Since 1996, this program has been devoted to supporting both the natural and human ecology of the Hudson Valley. The first Action Agenda was released in 1998, and has been up-dated at regular intervals since. In 2010, the Hudson River Estuary Action Agenda: 2010-2014 was released. It explains how the priorities for the Action Agenda will be implemented over a five year period by DEC in partnership with other state agencies and the federal government, as well as local municipalities, non-profits, academic and scientific institutions, businesses, trade organizations, conservation groups, landowners and dedicated volunteers.

The Hudson River Estuary Action Agenda: 2010-2014 has five key objectives:

- Ensure clean water
- Protect and restore habitat
- Provide water recreation and river access
- Adapt to climate change
- Conserve scenery

Embedded explicitly in the Agenda is the mandate to build local capacity and provide tools for local stewardship of the estuary. It is in support of that objective that Orange County has created this Watershed Design Guide.



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Who is this Design Guide For?

This document is a resource for the many municipal officials, members of local planning boards and commissions, citizen planners and advocates throughout the Hudson Valley as well as responsible developers who realize that the environmental health and economic prosperity of their communities depends on implementing the best practices for watershed management. It is meant to be accessible to people who are not necessarily design or engineering professionals and so it is not excessively technical. Rather, it presents the strategies and details and the contexts where they can be used at a level where constituents can decide for themselves what is most appropriate in their community. The manual has several charts that can help communities make this evaluation.

At the local level, this Guide can be used as a reference during municipal planning processes such as site plan and subdivision to help applicants and local officials communicate about and enhance proposed design elements. The Guide can also be used as guidance during the comprehensive planning process and while developing municipal land use regulations.

The content in this Manual is supported by substantial technical research, some of which is referenced in the Appendix at the back of the document that includes links to web sites and other technical documents.

Acknowledgements

This document was prepared by the Orange County Water Authority (OCWA) for the Hudson River Estuary Program (HREP), New York State Department of Environmental Conservation (NYSDEC), with support from the NYS Environmental Protection Fund, in cooperation with the New England Interstate Water Pollution Control Commission (NEIWPCC). The viewpoints expressed here do not necessarily represent those of NEIWPCC or NYSDEC, nor does mention of trade names, commercial products or causes constitute endorsement or recommendation for use.

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Best Design Practices for Watershed Management

Watershed management is a complex enterprise with many dimensions:

- Conducting a detailed assessment of existing and future conditions.
- Creating and implementing a comprehensive watershed plan.
- Monitoring, over time, conformance with the goals and objectives of the watershed plan.
- Building capacity among the constituents who are the stewards of the plan.

Because watershed management is a priority for the New York State Department of Environmental Conservation, the Hudson River Estuary program, NEIWPCC, and for other environmental organizations, these organizations offer a large variety of resources for watershed management and planning. (see Appendix for a partial list of sources these resources).

This Watershed Management Design Guide is a complement to those other management and planning documents: It focuses on the kinds of land use and development practices that local governments and advocates can influence in the shorter term, even as they work within the context of a larger and longer-term watershed management initiative. This guide is predicated on the notion that multiple interventions at a variety of scales, can have a huge incremental impact on the success of a watershed management plan.

Some of the details and strategies in this guide focus on best practices for storm water management (sometimes called “Best Management Practices” or BMPs), practices that can help reduce the volume and improve the quality of storm water at the scale of individual sites. But the guide also offers strategies at the larger scale of development patterns in the landscape and the scale of neighborhood form which can have a huge impact on the integrity of natural systems.

Finally, the last section of the Guide offers a check list of best practices, not only for design, but for land use regulation, administration of those regulations, and other municipal actions, such as waste management and road maintenance that can have a large impact on watershed resources.

The Potential for “Green Infrastructure”

New York State Department of Environmental Conservation defines Green Infrastructure as an approach to managing stormwater runoff while maintaining or restoring green features such as stream buffers, floodplains, rain gardens, porous pavements, and many more. Green Infrastructure solutions are often less expensive and offer many other collateral benefits around energy, visual resources and habitat. The result is better air quality, enhanced fish and wildlife habitat and new and improved green

spaces for communities, building owners and their tenants. But there are challenges:

Securing the space for building these systems at the site, street and municipal scales.

The success of green infrastructure systems depends on siting and managing a large number of properties and small-engineered systems, often on private property or in streets, parks, or other public facilities that serve other purposes. Planners can help green infrastructure succeed by incorporating this technology into zoning ordinances, site reviews, building codes and redevelopment decisions that protect and enhance existing watershed functions and encourage retrofits of already developed areas and buildings.

Finding the funding to pay for the construction and management of green infrastructure facilities.

Current allocations from federal and state programs are well below forecasts. Municipalities can issue bonds backed by the ratepayers using water or discharging their sewage. As a result local governments are looking for alternative means of finding the funding needed to build green infrastructure systems. These methods include revising their fee structures so storm water generators pay their fair share of treatment costs, establishing effective mitigation and credit strategies to compensate for development impacts and substituting lower-cost passive strategies for traditional infrastructure. Green infrastructure and related capital improvements that benefit multiple sites can be potentially financed and managed by through the formation of special improvement districts. Similar to the common examples of water supply, sewer, or library districts, a neighborhood or landscape improvement district is a tool to consider that can incorporate watershed goals and design elements discussed in this Guide. The success of these strategies depends on close coordination between agencies, municipalities and private property owners.

Rethinking management to ensure systems are built and operated effectively.

Most water and other capital funding decisions are made by individual, single-purpose agencies following traditional cost-sharing requirements and project-focused planning guidance. Stove-piped regulatory and management authorities make it difficult even within agencies to encourage innovative solutions. For instance, there are distinct rules that govern the management of storm-water, waste water and drinking water. Most water resource agencies are not equipped to take on the care of plants and soils that are the heart of green infrastructure systems. Understandably, these agencies are loath to take on added operational responsibilities and liabilities. Institutionalizing the green infrastructure approach requires decision makers to operate outside of their traditional silos and lines of responsibility.

How this guide is organized

This organization parallels the structure of the **Orange County Design Manual** (http://www.orangecountygov.com/filestorage/124/1362/4663/Orange_County_Design_Manual.pdf) which should be used as a companion document because it contains many additional strategies that support the kind of best practices featured here.

Three Scales

The best practices for development and design in watersheds are presented at three scales. This is because the management of watersheds and the implementation of watershed plans takes place at multiple scales.

Landscape and Neighborhood Form

This includes strategies such as conservation subdivision, buffering of development away from stream corridors and maintaining the integrity of steep slopes and ridgelines. Comprehensive watershed plans are typically done at the Landscape scale, while on-the-ground management actions are often addressed at the Neighborhood scale. Implementation will often rely on inter-municipal cooperation and address a complex suite of issues, resources, and stakeholders.

Public Spaces

This includes using best practice details to manage storm water from green streets, parking lots and public spaces. Implementation here relies on actions of individual municipalities as well as County, State, and Federal agencies. Public spaces can offer opportunities for creating parks or green spaces where the public can access or view a wetland, stream, or lake and can increase public appreciation for the waterbody. These spaces are also ideal for showcasing demonstration projects of the Best Management Practices (BMPs) described in this Guide; such projects are very effective at increasing understanding, acceptance, and support of BMPs. The daylighting of the Saw Mill River is a successful example of a river restoration project that helped revitalize a section of Yonkers in addition to re-establishing a more natural riparian corridor.

Buildings

This includes green infrastructure details that are for managing stormwater at the scale of individual development sites, such as on-site rainwater harvesting and bio-swales. Implementation here relies on the actions of individual property owners and developers.

The three scales are color-coded on the outer margins of the pages.



This guide is organized in to three sections: Places, Details and Actions.

Section 1:

PLACES

In this section, you will see where watershed management details and strategies can be implemented in each of six different community types, or “place types” found throughout the Hudson Valley:

-  **Downtowns**
-  **Edges**
-  **Corridors**
-  **Crossroads**
-  **New Neighborhoods**
-  **Rural**

For each of these place types, the details and strategies are presented at the three scales, from largest to smallest.

See pages 14 and 15 for the descriptions of these Places types.

Section 2:

DETAILS

In this section, are the construction details and other best practices for managing water quality in watersheds. These are also organized into three scales: Landscape and Neighborhood Form, Public Spaces and Buildings. Most of the best practices presented here are construction details. But some of the best practices that are not so much details as land use planning strategies which are equally important in managing water quality.

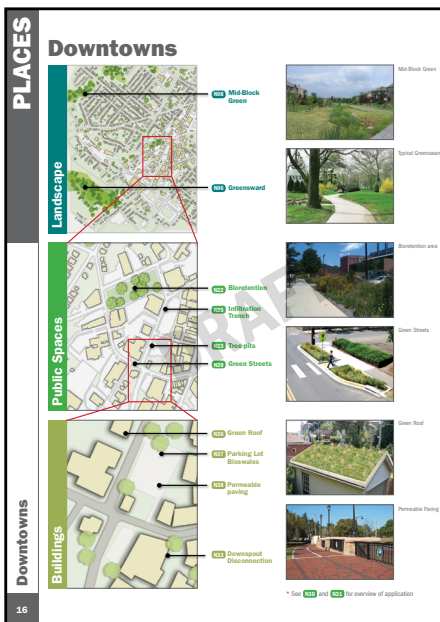
In general, each detail is presented using one or more drawings, some representative photos, a brief explanation and a case study for what that detail has been used.

At the back of this section are charts that summarize where the different details are best used, and evaluates how they are most effective as well as the space, cost and maintenance implications of each.

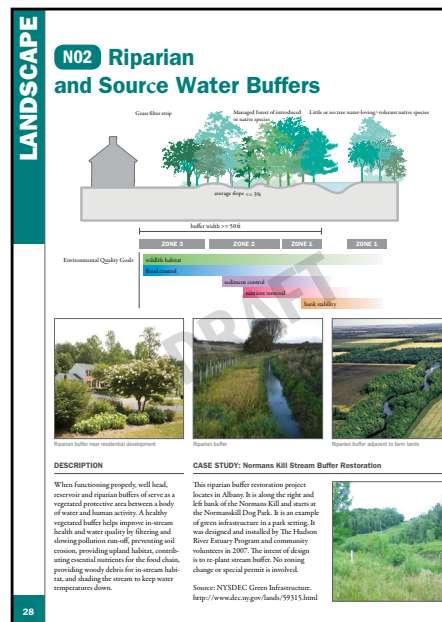
Section 3:

TOOLS & ACTIONS

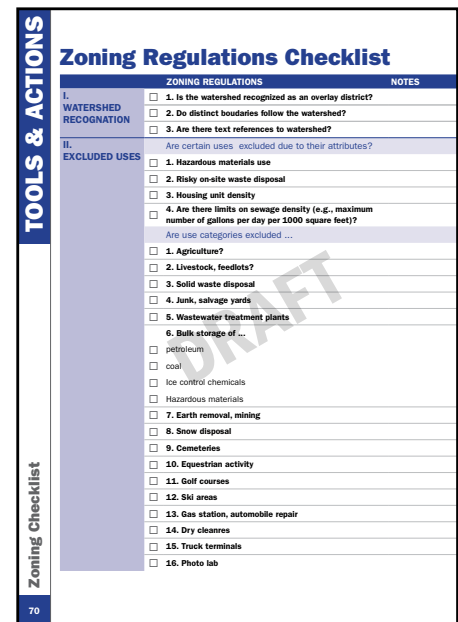
The last section contains a series of best-practice checklists for Zoning Regulations, Subdivision Controls and Land Use Management. Municipalities should use these check lists to audit their own current practices as they advance watershed planning in their communities



Places page

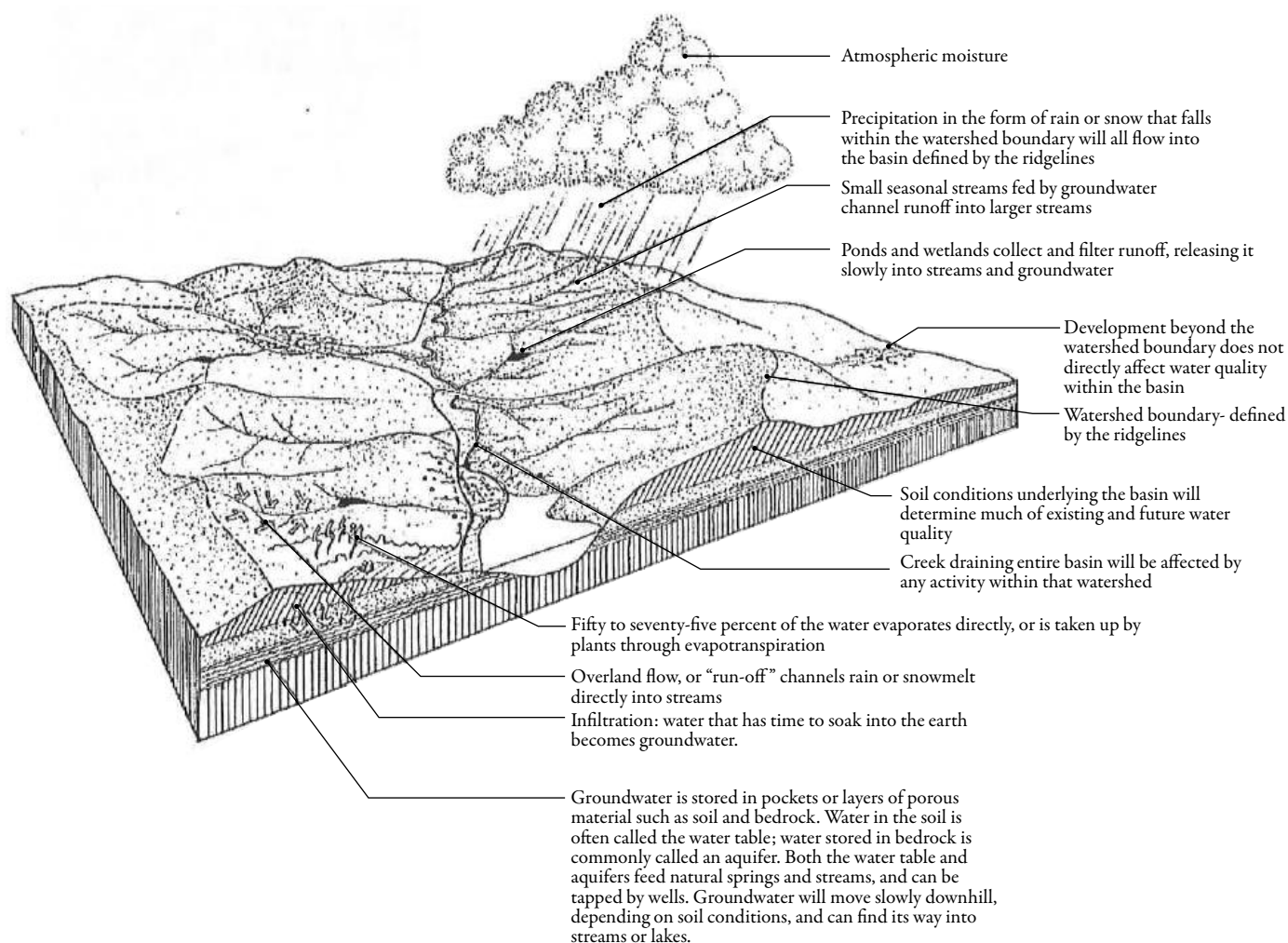


Details page



Tools & Actions page

Watersheds and the Hydrological Cycle



The Benefits of Watershed Management

Watershed Management presents a real opportunity for communities in the Hudson Valley to both protect the environment and stimulate local economies. More than other planning projects, watershed management results in a series of collateral benefits.

The benefits begin with the planning process itself. Land use techniques such as zoning and land protection are just as important as the specific design elements highlighted in this Guide. A watershed management plan can explain what current trends will create and can say what needs to be done going forward.

Comprehensive watershed management addresses a wide range of issues. While this Guide focuses primarily on measures that help protect water quality, water quantity is also important to address in many watersheds. This can range from implementing measures that absorb, retain or divert stormwater so as to reduce flooding and erosion, to removal of a dam in order to supply adequate downstream flows for aquatic life.

Watershed management is typically guided by these overarching objectives:

- Protect water quality and quantity
- Provide source water supply protection
- Support excellence in community design
- Promote sustainable economic development

The first objective - protecting water quality and quantity - is accomplished by use of a variety of best practices many of which are introduced in this manual. Taken together, these can accomplish the following:

- Minimize pollutant loading of sediments, nutrients and pathogens from point and non-point sources
- Minimize the volume, velocity and pollutant concentration of stormwater flow
- Minimize physical, chemical and biological damage to streams, wetlands and other water resources

Many of these objectives can be accomplished by implementing best practice storm water management details at the scale of large and small development sites as well as at the scale of streets and public spaces. But equally important will be the overall community development patterns because these can disturb the natural drainage patterns in the watershed and allow development to encroach in wetlands stream corridors and other water resources. That is why a portion of this manual is devoted to interventions at the larger scales of landscape neighborhood design. It is also important to understand that water quality depends both on stormwater quality and wastewater management.

Intermunicipal Watershed Partnerships

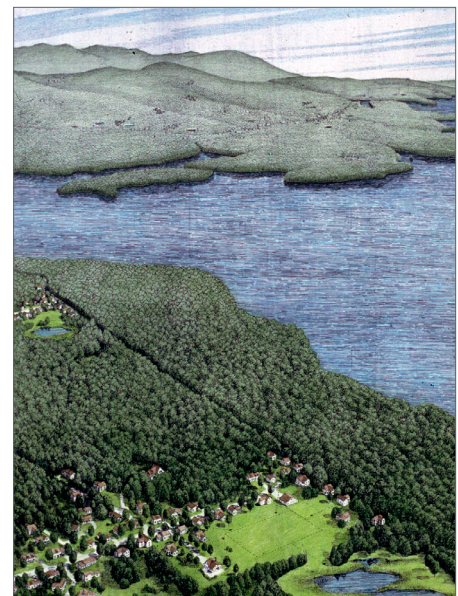
Effective watershed management almost always requires collaboration and cooperation across jurisdictional boundaries. Because watersheds often extend beyond the boundaries of individual municipalities, watershed planning enables communities to cooperate around a set of shared objectives without compromising their “home rule” principles. Many times, cooperation which is initially focused on water quality, results in a larger conversation about other issues where there is shared concern, such as traffic or over-development; as well as



Existing condition



Conventional development: excessive clear-cutting, natural drainage patterns ignored



Watershed-sensitive development: site plan responds to vegetation, water bodies and natural drainage patterns

other opportunities such as shared promotion of tourism opportunities or recreational resources. The use of BMPs that protect or improve water quality is especially important in watersheds of drinking water supplies (reservoirs) and in areas that drain into polluted or otherwise degraded waterbodies.

Intermunicipal partnerships can take a variety of forms: from simply cooperating around a set of shared goals for a basin, to creating local councils of government or cooperatives.

In the Hudson Valley, there are examples of several types of organizational structures for watershed groups. An example of a formal style of organization is the Moodna Creek Watershed Intermunicipal Council, which formed in 2010 to implement the Moodna Creek Watershed Conservation and Management Plan. This group was created by a memorandum of agreement between 15 municipalities who pledged to work together to address intermunicipal water and natural resource issues. Since the Council's formation, 15 non-municipal members, comprised of individuals and conservation groups, have joined the group. This watershed effort was led by the Orange County Water Authority, which is also a Council member. Among other accomplishments, the Council has organized outreach and educational events to make the public more aware of natural resource issues and has crafted a model local law for stream corridor management that it hopes will be adopted watershed-wide.

But intermunicipal watershed efforts do not need to have a formal structure in order to be effective, as proven by the Quassaick Creek Watershed Alliance. The Quassaick Watershed spans portions of both Ulster and Orange Counties and, unlike the Council mentioned above, the Alliance does not require official membership, but rather encourages broad citizen participation by residents, government staff and officials, business owners, and other stakeholders. The Alliance has helped to lead the development of the Quassaick Creek Watershed Management Plan, secured grant funds for watershed enhancement projects, performed stream monitoring, and mobilized volunteers to plant trees and clean up garbage. The Alliance also works with the municipalities in the Watershed to identify sources of water pollution and to advance watershed-friendly development practices.

Municipal Role in Watershed Management Zoning and Subdivision Regulations

As shown in the checklists in the Actions section of this manual, basic zoning practices can have a huge impact on water quality. This includes limiting uses that may contribute to pollutants reaching water resources and providing performance requirements for others. Zoning regulations can easily incorporate requirements for adequate buffers between uses and water bodies

Subdivision regulations codes and ordinances can have a large effect on water quality by controlling things like the amount of impervious surfaces and the distance between the development and water resources. The road pattern can be designed to work with natural drainage patterns and can capture or slow down run-off to support evapotranspiration.

Conservation Subdivision (also sometimes referred to as clustering) can be used to protect on-site open space.

Another technique for municipal watershed management is to map Critical Environmental Areas. This is a specific geographic area, designated by a state or local agency that is deemed to have exceptional or unique environmental characteristics. It can protect a natural area by requiring subsequent site-specific projects and other actions in the area to be reviewed more carefully for potential impacts. Controls can be broadly considered to include issues like views from scenic corridors.

Capital Investments

While there are many best practices that can be implemented with little or no cost, some important investments are inevitable or desirable. These can include:

- Septic system remediation and upgrade
- Centralized facility upgrades or expansion to meet predictable needs
- Facility modernizations and efficiencies
- System leak detection and repairs

Strategic smart capital investments remain a necessary complement to the watershed guidance found here. Capital and infrastructure planning and budgeting must happen coordinated with the use of quality design once tangible land or water use change is proposed. For those projects that cannot be fully funded through a municipal budget, grants from the state or federal government can provide at least partial funding or low- or no-interest loans. In New York, there are several agencies that offer grants, including the Department of State, Department of Environmental Conservation, Department of Health, and the Environmental Facilities Corporation; the latter agency also offers low-interest financing to municipalities for water and sewer infrastructure improvements, among other projects. At the federal level, there is an even wider variety of agencies that offer grants, ranging from the Department of Commerce's Economic Development Grant program that funds public works projects, to the Environmental Protection Agency's Urban Water Small Grants program that advances water quality improvement projects. See Appendix for an inventory of grant and loan programs that fund watershed-related projects.

Administrative Actions

As important as the planning and design interventions are, municipalities and counties can also impact water quality through a variety of administrative actions. Many of these are non-structural and involve little or no capital expenditure:

Evaluate existing regulations and infrastructure

Using checklists like those provided in this manual, counties and municipalities could make sure that their existing regulations do not allow practices that compromise water quality. Bring municipal land use practices into conformance with best practices and consider adopting these guidelines into local and county comprehensive plans.

Septic System Maintenance

In much of the watershed, waste is managed using septic systems. Because this has been standard practice for a long time, these systems are taken for granted and as a result, nutrient loading of water resources is a significant but neglected problem. To address this, municipalities can launch efforts to build awareness and capacity for local officials and developers. They can also support engineering studies to evaluate cost-effective and environmentally sound solutions to area-wide septic system failure.

Site Plan and Subdivision Review

Municipalities have wide discretion in what they consider when reviewing applications for site plan review and for subdivisions. This creates the opportunity to consider road design and drainage regulations; to create an overlay with storm water BMPs within buffer zones around water bodies; to protect wetlands; and limit development on steep slopes and ridge lines, etc.

Roadway maintenance practices

Local DPWs can maintain roads in ways that support water quality such as street sweeping, managing use of salts and other winter highway maintenance materials and maintaining vegetative buffers along rural roads.

Management of Municipally Owned Land

As with streets, municipalities can control what happens on their own property. In addition to the direct benefits of managing their lands according to best practices, there is an opportunity to use these sites as demonstration sites. This can have education and communication benefits and can signal to developers and others the municipality's commitment to these practices.

Other Policies & Tools for Protecting Water Quality

In addition to zoning, subdivision controls, and other traditional land use planning practices, there are additional tools and practices which can be targeted directly to water quality:

Wetland protection

Wetlands are a critical part of the hydrological cycle, as well as providing valuable habitat and vegetation. New York State regulates certain activities involving wetlands larger than 12.49 acre but municipalities can enact wetland laws to regulate activities affecting wetlands that are unregulated by the state. Towns can include wetland protections in their local zoning ordinances including permitted activities and the size of buffers.

Stream corridor protection

Stream banks and stream- or riparian-corridors are extremely fragile systems. Erosion can be aggravated by construction, logging, recreation and cattle. Educating users and riparian landowners is essential. Fishing clubs and the users of these resources can be good sources for information about the health of stream and can be valuable partners in protecting them. As with wetlands, zoning regulations can be hugely beneficial in limiting the kinds and proximity of activities near streams.

Vegetated buffer zones

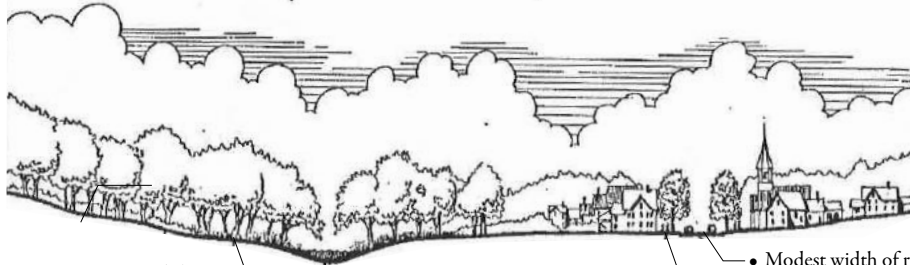
Stream buffers are extremely important for minimizing disturbance to water resources. Buffers reduce stormwater velocity, volume and pollutant concentrations. They stabilize stream banks, provide habitat and are also a visual benefit. Buffers are usually set at an absolute distance. But calculation of buffer widths should be based on a variety of factors including slope, soil type and native cover. Performance standards can enable this more refined approach. Buffers must also be maintained in order to be effective over the long term and their effectiveness is maximized when they are combined with other best practices beyond the buffer zone.

Land Conservation: Purchase and Transfer of Development Rights (TDR); Direct Full Fee Acquisition

Conserving land can be an important component of a water quality program. Acquisitions can be made by public agencies such as municipal and county park departments, local land trusts and national conservation organizations. But often, strategic land is too important and needs direct acquisition and protection. Through the use of conservation easements, a land owner can sell or donate certain property rights while retaining rights to use the land for certain purposes such as farming or forestry. Easements can be very flexible and can be designed to meet the landowners' needs and still accomplish significant water quality objectives. Transfer of Development Rights (TDR) programs allow someone who wants to build in a place that is suitable for development, to purchase additional development capacity from a landowner in a conservation area. The appeal of these programs is that if the market values are calibrated properly, land can be conserved at no cost. The challenge is that most successful TDR programs rely on some kind of "bank" to hold the development credits and to facilitate the transaction. Also, most programs need to be attractive enough to work on a voluntary basis because mandatory TDR programs can be unpopular.

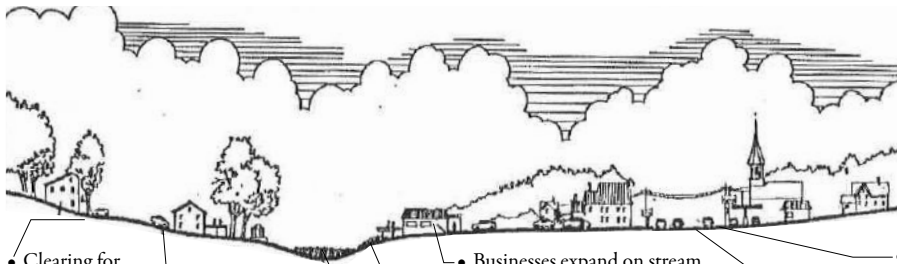
Stream Corridor Sections with Different Watershed Management Strategies

Section through existing corridor



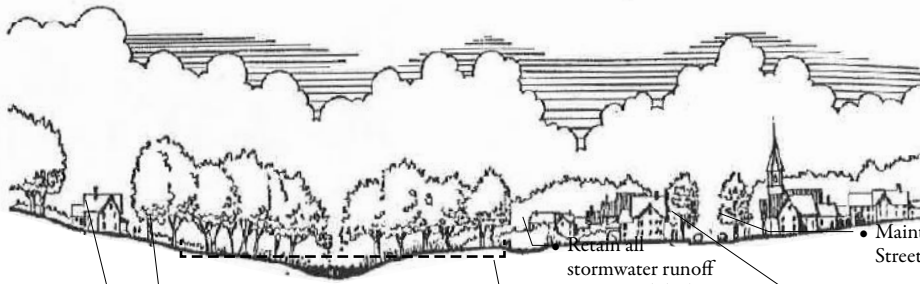
- Vegetated slopes absorb and filter runoff and release it slowly to groundwater
- Tree- shaded stream with gravel bottom; cold water at a consistent level makes ideal trout habitat
- Underdeveloped floodplain stores runoff; wetland vegetation filters silt and nutrients, protects banks from erosion
- Modest width of road limits volume of runoff
- Lawns and tree belts absorb and filter runoff

Section through stream corridor - typical zoning



- Clearing for new home sites; boosts runoff as lawns replace forests; sedimentation and pollution persist
- Surface runoff from roads and driveways carries oily pollutants and heavy metals into stream. Underground, septic system load groundwater with nutrients.
- Businesses expand on stream side, clearing for views and parking
- Land filling and loss of vegetation increase size and frequency of floods. Increase in flow requires rip-rapping of stream banks to prevent erosion
- Tree cutting increases water temperature. Nutrients from fertilizer and septic effluent use up available oxygen. Water levels fluctuate as groundwater subsides and flooding increases. Trout habitat vanishes.
- Underground gas tanks pose potential danger for leaks
- Highway widening and new parking lots and driveways eliminate trees and lawns; volume and velocity of runoff increases

Section through stream corridor - buffer zone protection



- Septic system placed beyond buffer zone to allow for minimum possible treatment of wastewater before contact with surface water sources
- Allow new homes at low densities outside of village. Site plan controls keep clearing and grading to a minimum. Collect runoff from site
- Retain all stormwater runoff on site and deal using constructed pond/ wet-land systems
- Create buffer zones along stream banks within which any development is strictly regulated. Potential use as greenway park for recreation as well as wildlife habitat.
- Maintain historic width of Main Streets and enhance pedestrian areas
- Accommodate growth of village through infill careful expansion at like densities. Compact development patterns allow efficient community wastewater treatment to replace individual septic systems

Downtowns



Edges



Corridors



Crossroads



New Neighborhoods



Rural Areas



PLACES
WHERE to consider



Downtowns

Downtowns are places that already contain a mix of activities associated with a complete community:

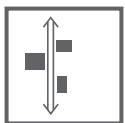
places to shop, to work, civic and public spaces and a wide variety of housing types. Municipal services (water, sewer) are in place and it is capable of accommodating some forms of transportation. A downtown is also the center for many of the important civic and commercial activities for the surrounding community. Downtowns can be of any size from rural village centers to large cities, but regardless they are all distinct and clearly identifiable as “places”. New development within downtowns—so-called “infill” development—is an opportunity to make efficient use of existing infrastructure. New infill development in downtowns should reinforce the unique character of the place.



Edges

Edges are places into which the street-and-block network and land use patterns of a downtown can be extended.

It may be completely undeveloped land, but it is more likely that it will be a place that already has some development and infrastructure but at a greatly reduced density so that there is an opportunity for a significant increase in development. New development at the edge should as much as possible feel like a seamless extension of the existing urbanized areas and so the mix of land uses may be similar but less intensive.

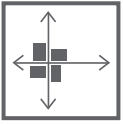


Corridors

A commercial corridor is a road that is lined with auto-oriented commercial uses.

While there may be other kinds of activities within the surrounding area, the commercial corridor is almost entirely single use. With a few exceptions in small areas, the environment is built around the automobile, so much so that auto access is excessive in scale and creates a hostile environment for pedestrians. New development along the corridor is an opportunity to balance the needs of the car with those of pedestrians and to create new connections to surrounding areas.





Crossroads

Crossroads are places that already have some of the ingredients of a new center but at lower densities:

perhaps there are some auto-oriented commercial uses; often there may be a fire station, town hall or other civic use; it is surrounded by developable lands that are suitable for future walkable neighborhoods. This area is already a destination for the local community. New development at the crossroads has the potential to complete the mix of land uses to create a new compact, mixed-use place with a distinct identity for the community.



New Neighborhoods

New neighborhoods are places that are largely undeveloped,

but are still appropriate for new development. These are mainly residential places in a wide variety of housing types. But to be “complete communities” these include some amount of neighborhood retail and services, opportunities for live-work space, and civic uses. Although these are primarily residential areas, the objective is to create a complete community that includes a variety of housing types and some mix of commercial and institutional uses. New development here can capture development that would otherwise go to higher value landscapes such as productive farmlands and critical watersheds.



Rural Areas

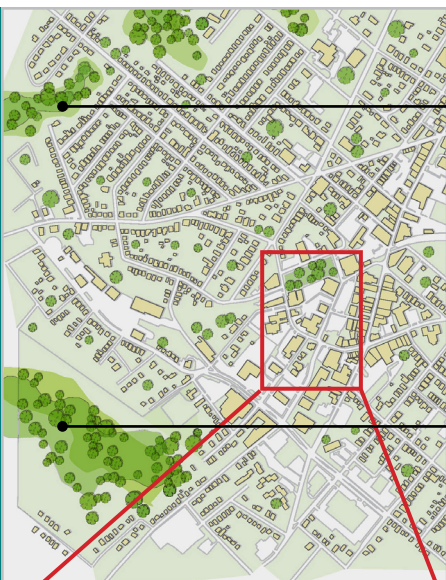
Landscapes are places where the historic character of the land is still intact.

Because human habitation is sparse, natural features such as forests, rolling hills, lakes and streams predominate. What little development has taken place is at very low densities and is primarily in the form of farms and historic homesteads. Rural roads and scenic byways are an essential part of the experience of these places. Development in these areas is extremely limited and any new development needs to be exceptionally sensitive to the character of the landscape and the integrity of natural systems.



Downtowns

Landscape

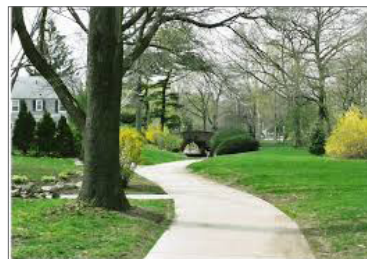


N08 Mid-Block Green



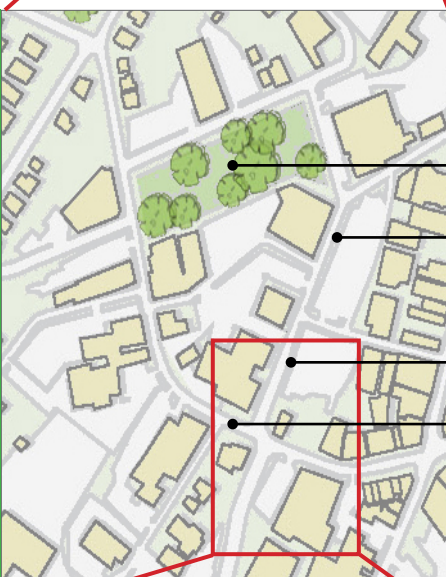
Mid-Block Green

N06 Greensward



Typical Greensward

Public Spaces



N22 Bioretention



Bioretention area

N25 Infiltration Trench

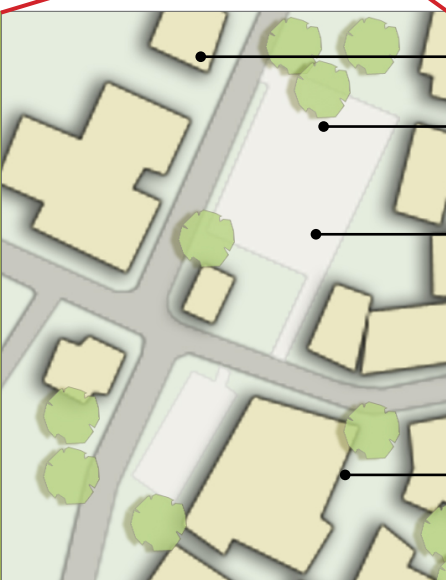
N23 Tree pits

N20 Green Streets



Green Streets

Buildings



N36 Green Roof

N37 Parking Lot Bioswales

N38 Permeable paving

N33 Downspout Disconnection



Green Roof



Permeable Paving

* See **N30** and **N31** for overview of application

Edges

Landscape



- N02 Riparian Buffer
- N10 Constructed Wetlands
- N08 Mid-block green
- N09 Link Resources on and between Parcels
- N07 Stream Daylighting



Riparian Buffer



Mid-block green

Public Spaces



- N21 Vegetated Swale
- N20 Green Street
- N25 Infiltration Trench
- N23 Tree Pits
- N22 Bioretention



Vegetated swale



Green Street

Buildings



- N33 Downspout Disconnect
- N38 Permeable paving
- N37 Parking Lot Bioswales
- N36 Green Roof
- N34 Rain Water Harvesting



Downspout Disconnect

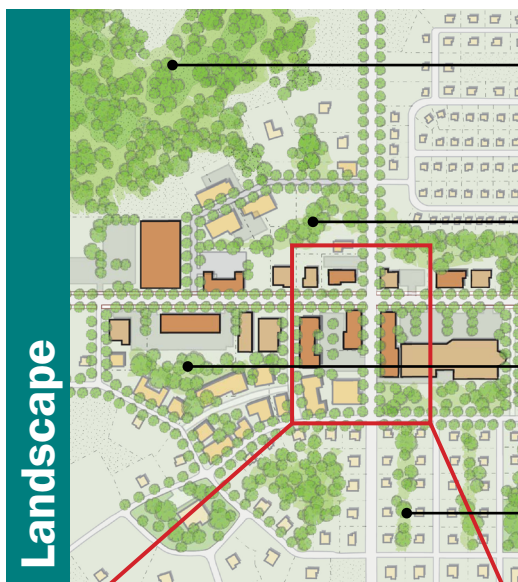


Permeable paving

* See N30 and N31 for overview of application

Corridors

Landscape



N06 Greensward

N11 Retention Basin

N09 Link resources on and between parcels

N08 Mid-Block Green

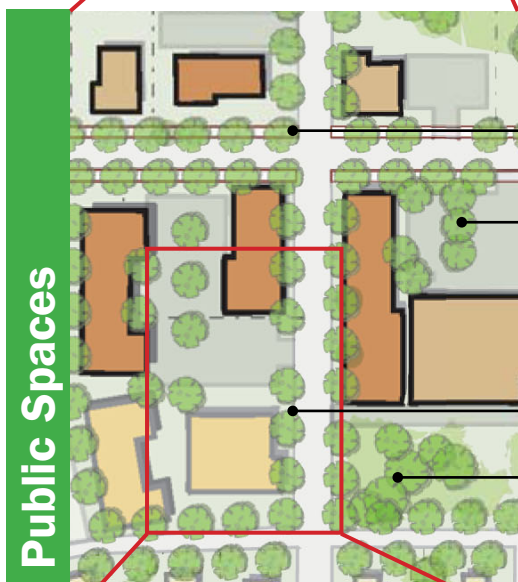


Retention Basin



Link resources on and between parcels

Public Spaces



N20 Green Street

N24 Planter box

N23 Tree Pits

N22 Bioretention

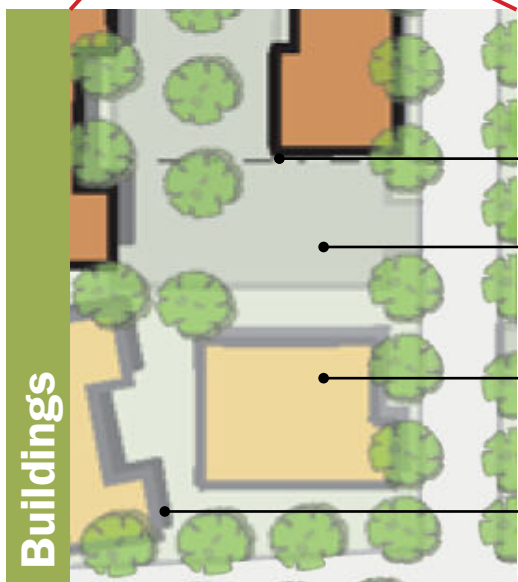


Bioretention



Green Streets

Buildings

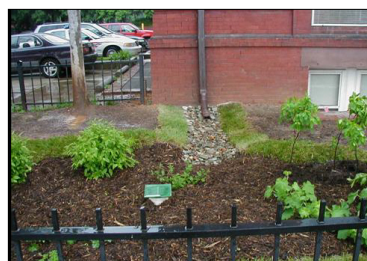


N37 Parking Lot Bioswales

N38 Permeable paving

N36 Green Roof

N33 Downspout Disconnection



Downspout Disconnect



Permeable paving

* See **N30** and **N31** for overview of application

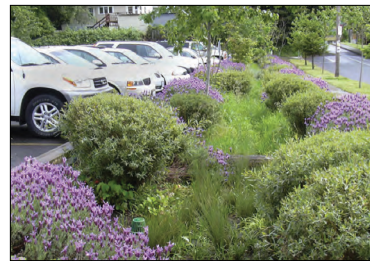
Crossroads



Retention Basin



Conservation Subdivision



Vegetated Swale



Rain Garden



Downspout Disconnect

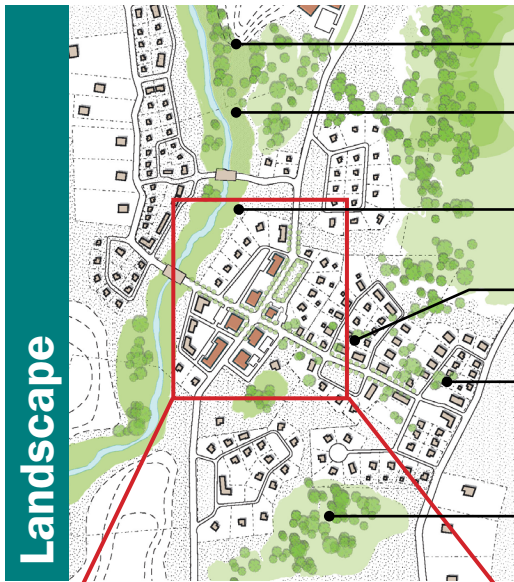


Permeable Paving

* See N30 and N31 for overview of application

New Neighborhoods

Landscape



- N10** Constructed Wetlands
- N06** Greensward
- N02** Riparian Buffer
- N08** Mid-Block Green
- N03** More density on gradual slopes
- N11** Retention basin

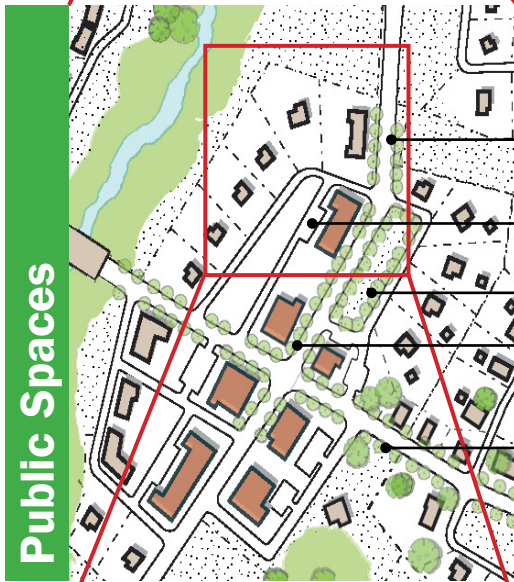


Greensward

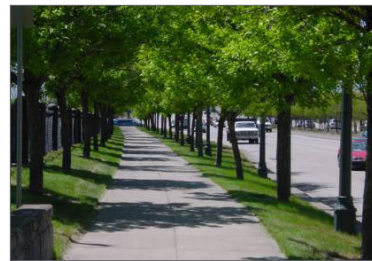


More density on gradual slopes

Public Spaces



- N20** Green Street
- N25** Infiltration Trench
- N22** Bioretention
- N21** Vegetated Swale
- N23** Tree Pits

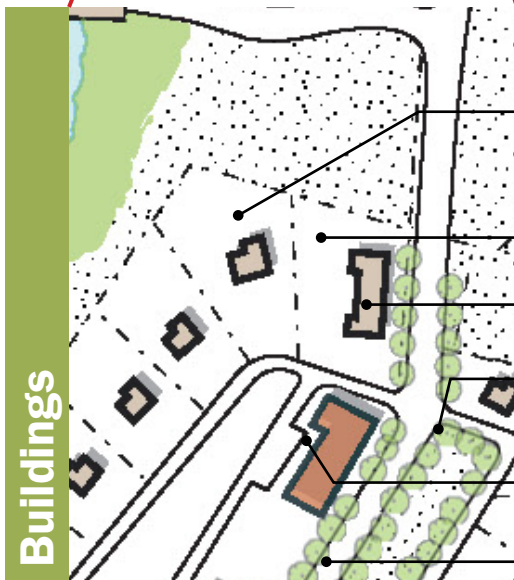


Green Street



Infiltration Trench

Buildings



- N34** Rainwater harvesting
- N38** Permeable paving
- N36** Green Roof
- N37** Parking Lot Bioswales
- N33** Downspout disconnect
- N35** Rain Garden



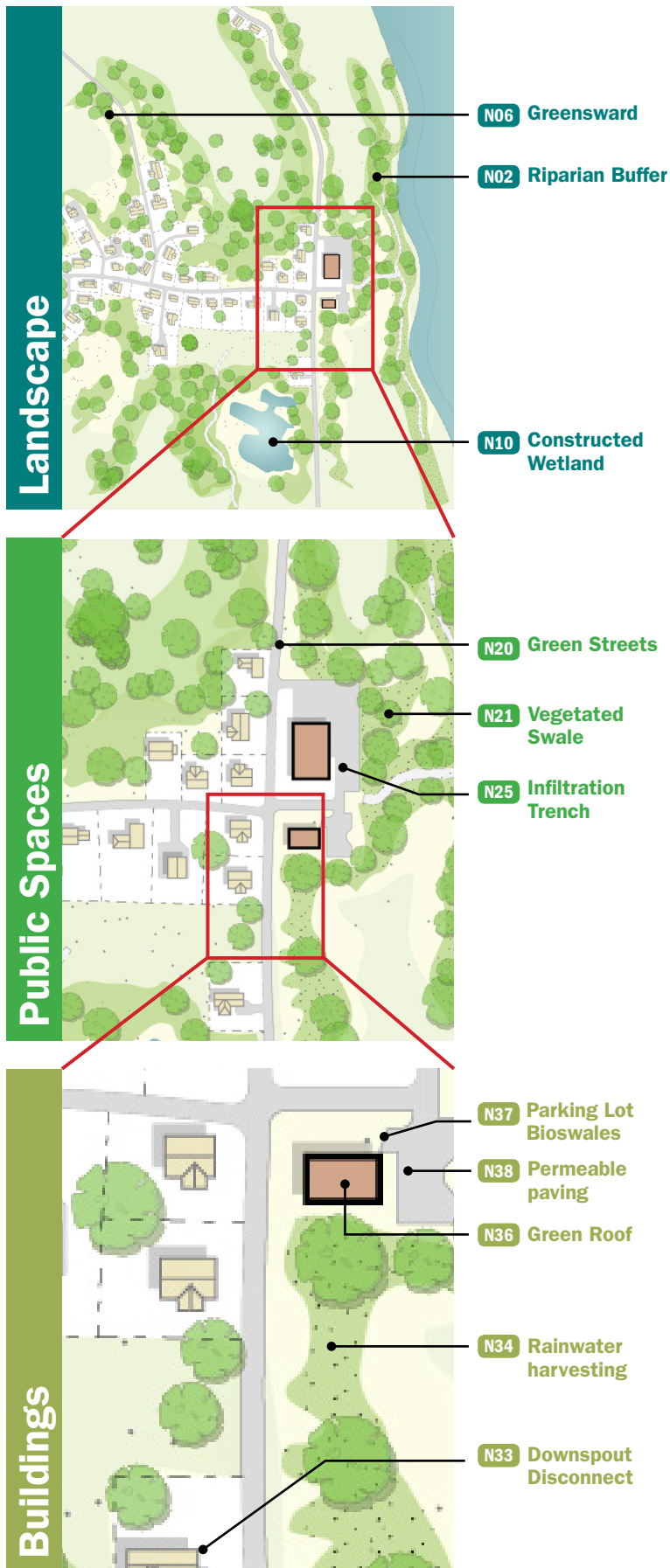
Rainwater Harvesting



Green Roof

* See **N30** and **N31** for overview of application

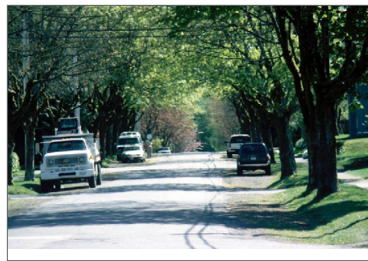
Rural Areas



Constructed Wetland



Riparian Buffer



Green Streets



Vegetated swale



Permeable Paving



Downspout Disconnect

* See **N30** and **N31** for overview of application

Landscapes

Public Spaces

Buildings

DETAILS

WHAT you need to do

LANDSCAPES

Working With Landscapes / Townscapes

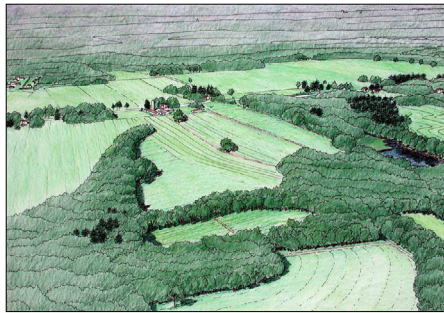
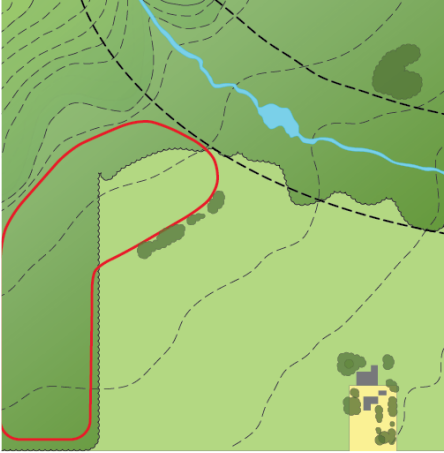
Public and private investments in conservation, master plans, zoning ordinances, environmental review processes and land management can promote green infrastructure at the municipal or landscape scale.

List of Included Details

- N01** Conservation Subdivision
- N02** Riparian and Source Water Buffers
- N03** More Density On Gradual Slopes
- N04** Use High Points Carefully
- N05** Direct The Flow
- N06** Greensward
- N07** Stream Daylighting
- N08** Mid-Block Green
- N09** Link Resources On And Between Parcels
- N10** Constructed Wetlands
- N11** Retention Basin
- N12** Detention Basin

N01

Conservation Subdivision

**Existing landscape**

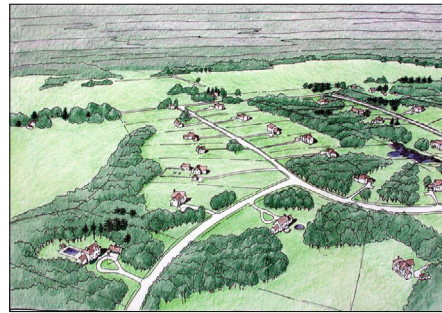
A few houses, many on existing or former farms, but an otherwise unspoiled/intact rural landscape.

Step 1

Require a map of the open space system for the parcel and surrounding area.

A. Locate Appropriate Places for Development

A sketch analysis of the area provides all the basic information to calculate how a development can fit into the landscape – what land should be protected and potential development pockets.

**Subdivision sprawl**

Individual parcels are developed for stand-alone, large lot houses which spread out across the landscape degrading visual and environmental resources.

Step 2

Conventional sketch layout determines maximum lot count under existing three-acre zoning.

B. Typical Superimposed Subdivision

- Productive farmland lost forever
- Pleasant view from road ruined.
- Stream corridor cut off by backyards.
- Large lots divide up and dominate the landscape.
- Individual roads for each subdivision.
- No chance for residents to enjoy special site features.

**Conservation neighborhood**

Development is concentrated in more compact neighborhoods, preserving the visual and environmental integrity of most of the landscape.

Step 3

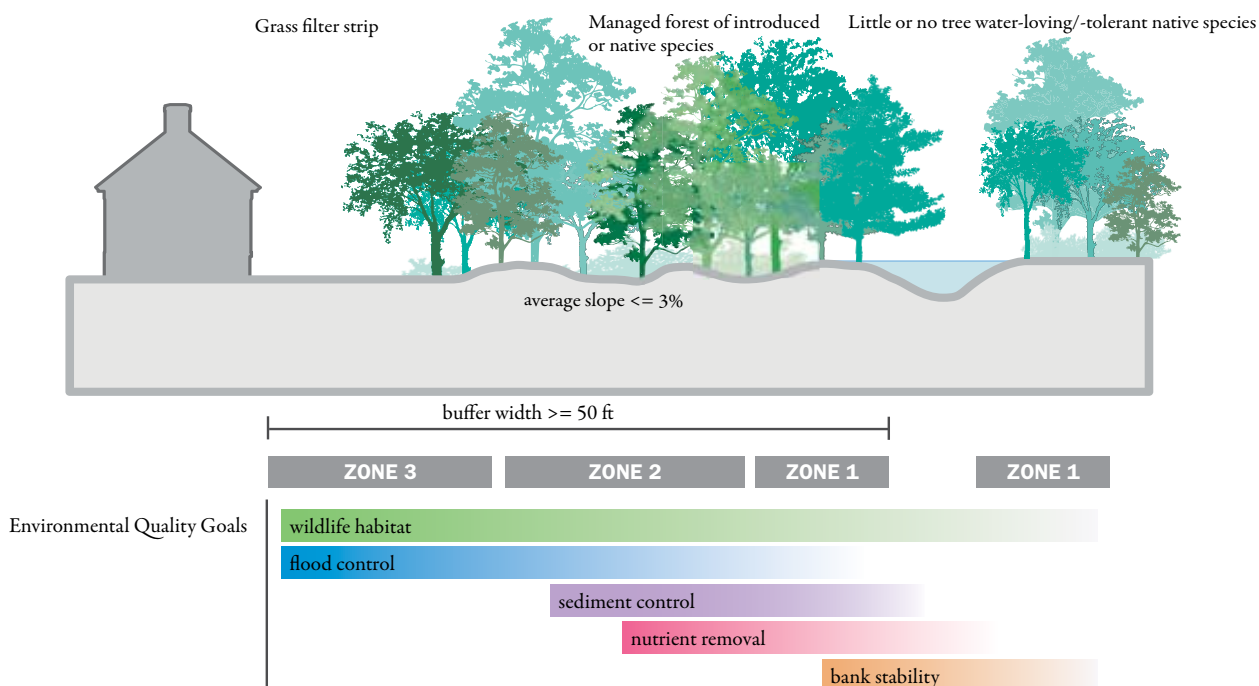
The same number of houses can fit into the landscape while preserving 80 percent of the open space.

C. Conservation Subdivision

- Large farm fields protected.
- Rural view from road retained.
- Trail system allows access to stream.
- Smaller, but substantial individual lot sizes with central green.
- Potential connection to adjacent parcel.
- Less expensive construction costs.
- Residents have views of open field and direct access to woods.
- Less clearing and grading.

N02

Riparian and Source Water Buffers



Riparian buffer near residential development



Riparian buffer



Riparian buffer adjacent to farm lands

DESCRIPTION

When functioning properly, well head, reservoir and riparian buffers of serve as a vegetated protective area between a body of water and human activity. A healthy vegetated buffer helps improve in-stream health and water quality by filtering and slowing pollution run-off, preventing soil erosion, providing upland habitat, contributing essential nutrients for the food chain, providing woody debris for in-stream habitat, and shading the stream to keep water temperatures down.

CASE STUDY: Normans Kill Stream Buffer Restoration

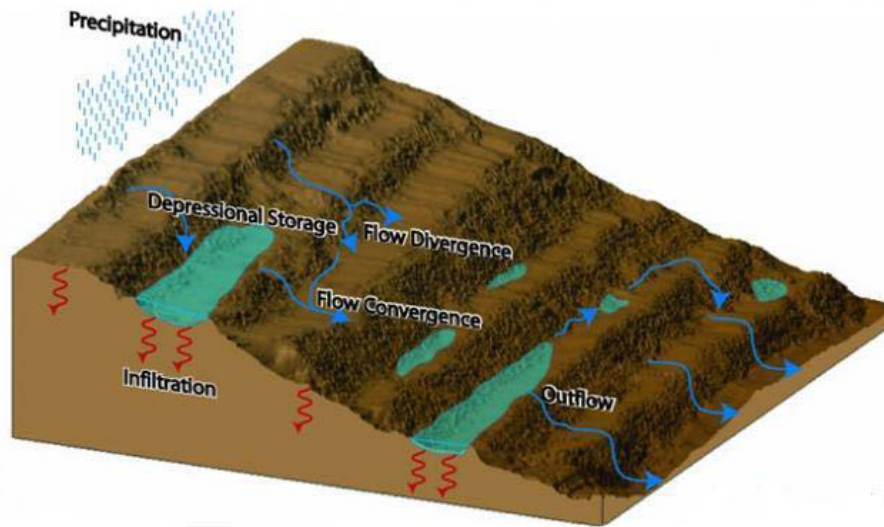
This riparian buffer restoration project locates in Albany. It is along the right and left bank of the Normans Kill and starts at the Normanskill Dog Park. It is an example of green infrastructure in a park setting. It was designed and installed by The Hudson River Estuary Program and community volunteers in 2007. The intent of design is to re-plant stream buffer. No zoning change or special permit is involved.

Source: NYSDEC Green Infrastructure.
<http://www.dec.ny.gov/lands/59315.html>



N03

More Density on gradual slopes



Steep slope protection

DESCRIPTION

Steer intense development to gradual slopes (1% to 15%) as “table-flat” lands are often either best suited to agriculture or are environmentally sensitive. Reduce requirements for flat land in each lot to maximize land efficiency and to minimize earthworks. Connect developed terraces with streets that either follow the contours or that climb steeply over short distances.

CASE STUDY: Town of Somers Steep Slopes Protection

Town of Somers, NY uses Steep Slopes Protection Ordinance to mitigate the damage to steep slopes that have been or are in jeopardy of being destroyed by unregulated regrading, filling, excavating, building, clearing, and other such acts which are inconsistent with the natural condition or acceptable uses of steep slopes.

The Ordinance recognizes the rights of owners of property exhibiting steep slopes to use their property for reasonable purposes consistent with other regulations and controls, provided that such use, in the judgment of the appropriate agencies or officials of the Town of Somers, does not result in a significant loss or degradation of steep slopes or the benefits which they have been found to fulfill in the Town of Somers.

Source: <http://landuse.law.pace.edu>

N04 Use High Points Carefully



DESCRIPTION

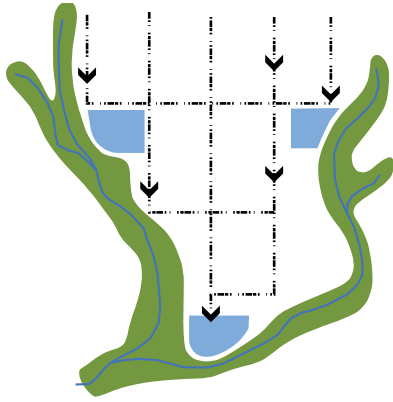
High points are very visible and desirable locations. When development leaves them unbuilt, environmental impacts are reduced while access to these points can be available to all. Capitalize on the district’s high points in a district by preserving them for the whole community.

CASE STUDY: North Carolina Mountain Ridge Protection Act

The 1983 Mountain Ridge Protection Act, also called the “North Carolina Ridge Law,” was enacted by the NC General Assembly in 1983 in response to a high-rise resort that was built on Sugar Top Mountain in Avery County. This huge blight on the ridge of sugar top mountain led to public outrage. The public outrage led to a law being written and passed that would protect the highest ridges from ever having that happen again. The law protects ridges at or above 3,000 feet elevation or which are 500 feet or more above an adjacent valley floor, limiting building heights to 40 feet on protected ridges.

Source: <http://webpages.charter.net/acdp/page6.html>

N05 Direct the Flow



Flow direction



Flow direction and the receiving stream

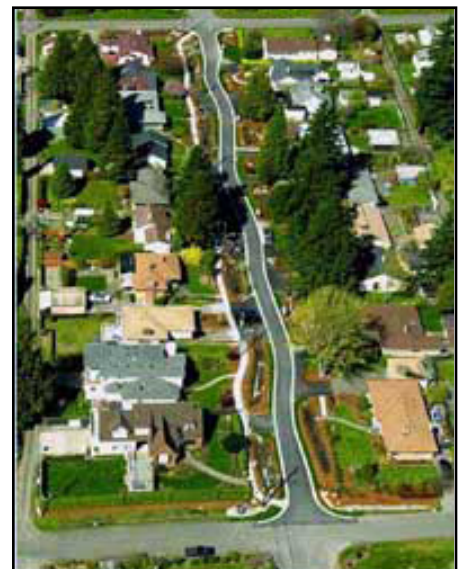
DESCRIPTION

Streets provide an ideal vehicle for integrating local watersheds to the larger hydrological system. The street network should work with, not against, the natural drainage patterns of a site. Small storms should all be absorbed by streetside and yard soils. Within the connected ecological network, large natural areas such as schools and parks are ideal places for diverting runoff from very large storms and for integrating biological treatment/wetland areas into the district. School and park sites also offer the best opportunity for increasing the biotic diversity of the site and for managing the headwaters of receiving streams.

CASE STUDY: Seattle Flow Direction



Before: Convention street design.



After: Green street with swales and other green infrastructure techniques to collect storm water runoff.

N06 Greensward



Greensward

A network of connected open spaces of different kinds and which may be surrounded by development, but which never the less that maintains the continuity and integrity of natural systems.



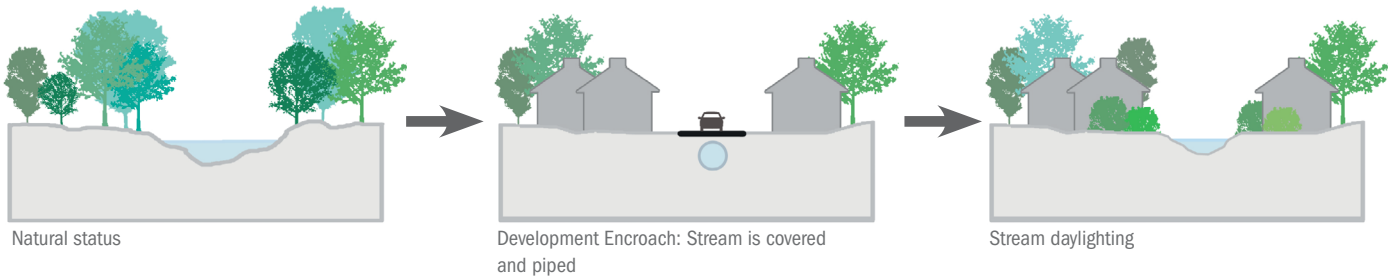
DESCRIPTION

A green network is an amalgam of various contiguous and connected open space and natural resources. These resources include but are not limited to buffered streams, reservoirs and well heads, active and passive parks, stands of mature trees, and natural turf playing fields associated with schools or other institutions. It is both an amenity for the community and an active part of a passive storm water management strategy. Connections may be large open spaces or more constrained green treatments such as green streets (see details N70 and N71) and mid-block lawns (see detail N47).

CASE STUDY: Radburn Neighborhood Greensward



N07 Stream Daylighting



DESCRIPTION

Stream daylighting includes the removal of natural streams from artificial pipes and culverts to restore a natural stream morphology that is capable accommodating a range of hydrologic conditions while also providing biological integrity.

Stream daylighting restores habitat, promotes infiltration, helps reduce pollutant loads and can provide better runoff attenuation because it increases the storage size of the natural system. Stream daylighting is not only an important water quality practice, but it is also a powerful economic development and community revitalization tool.

CASE STUDY: Daylighting the Saw Mill River in Yonkers

Saw Mill River located in downtown Yonkers, NY. In the 1920s, the river was buried and turned into Larkin Plaza in order to manage sanitation and floods. Afterward the river was banished underground for 90 years, devastating local plants and wildlife while robbing the community of public park space and a flowing river.

After years of efforts of local groups and communities, multiple grants from the Hudson River Foundation were received and helped bring water back to flow aboveground. The project also created 13,775 square feet of aquatic habitat, which supports existing species including the American eel.



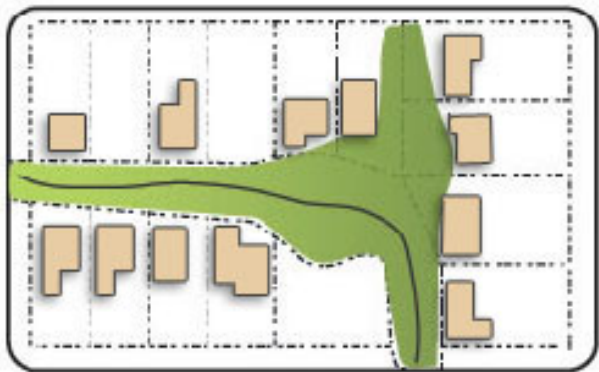
Saw Mill River being covered

Source: <http://daylightyonkers.com>



Saw Mill River after daylighting

N08 Mid-block Green



Mid-block green



Mid-block green



Mid-block green

DESCRIPTION

An individual block may wrap itself around a natural feature. The residents whose properties contain the natural feature may hold it either in common or individually (with restrictive covenants on use).



Mid-block green

N09 Link Resources on and between Parcels



Existing



Uncoordinated Conservation



Coordinated Conservation

DESCRIPTION

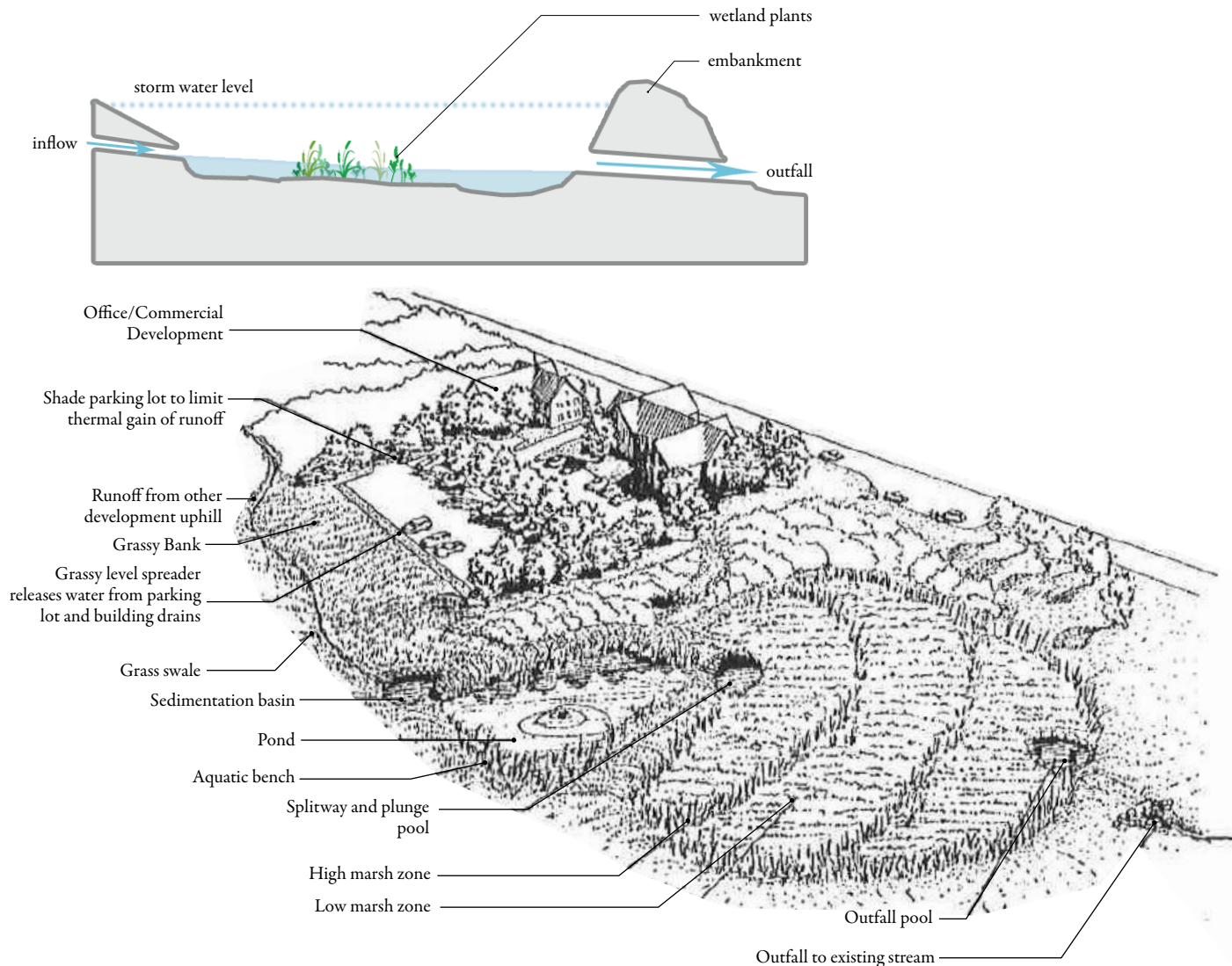
Preserving natural resources on individual parcels does not insure the continuity of larger natural systems. Resources must be linked to insure the effectiveness of natural systems such as stormwater and habitat, in addition to visual value. The location and configuration of open spaces on adjacent conservation subdivisions should be coordinated to create a green network of continuous natural corridors.

CASE STUDY: Town of Warwick, NY



N10

Constructed Wetlands



DESCRIPTION

Constructed stormwater wetlands are practices that create shallow marsh areas to treat stormwater and often incorporate small permanent pools and/or extended detention storage. The wetland plants are planted at the wetland bottom. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Advantages of constructed wetland include low cost, simplicity of operation and flexibility in rate of pollutant loading. Disadvantages are large land requirements and lack of proven design and operation criteria.

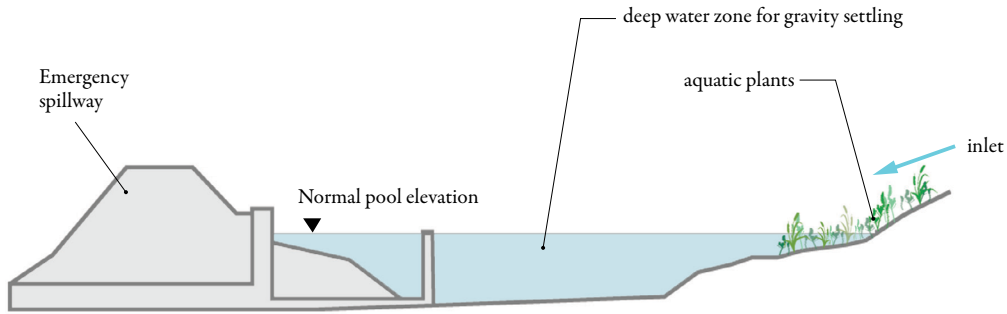
CASE STUDY: Wetland Improvement for the Village of Wappinger Falls

Wappingers Falls is a village located just east of the Hudson River between the Newburgh-Beacon and the Mid- Hudson Bridges. Wappingers Lake provides ground-water recharge to wells that provide the Village’s potable water supply. This project’s green infrastructure practice, a constructed “gravel wetland,” helps protect that supply by reducing sediment deposition in the lake. Runoff is directed into a forebay pond, then pass through a gravel filter zone and a shallow wetland area before leaving the system from an outlet pool. Stormwater that flows through this constructed wetland will enter the Wappingers Creek watershed with a significantly reduced sediment and pollutant load.



Source: <http://www.efc.ny.gov/Default.aspx?tabid=522>

N11 Retention Basin



Retention basin for residential development



Retention basin for residential development



Retention basin for parking lot and residential development

DESCRIPTION

A retention basin is a small artificial lake with emergent wetland vegetation around the perimeter, designed to remove pollutants from stormwater. It is different from conventional detention basin as it has a permanent water level. Therefore it is also grouped as wet basin/wet pond/wet detention basin. The larger permanent pool of retention basins allows water to reside in the interval between storms, when further treatment occurs. Advantages include low maintenance costs, and higher pollutant removal rate compared with detention basin. Disadvantage is that it requires larger space and higher construction costs than detention basin.

CASE STUDY: Teaberry Run. Moorestown, NJ



Existing Condition



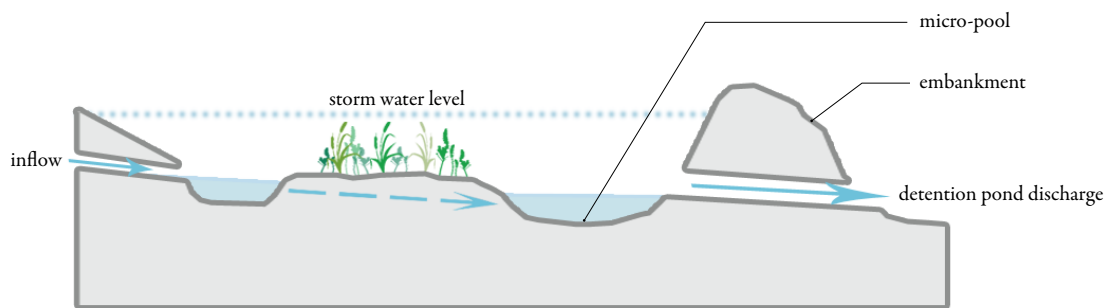
After Installation



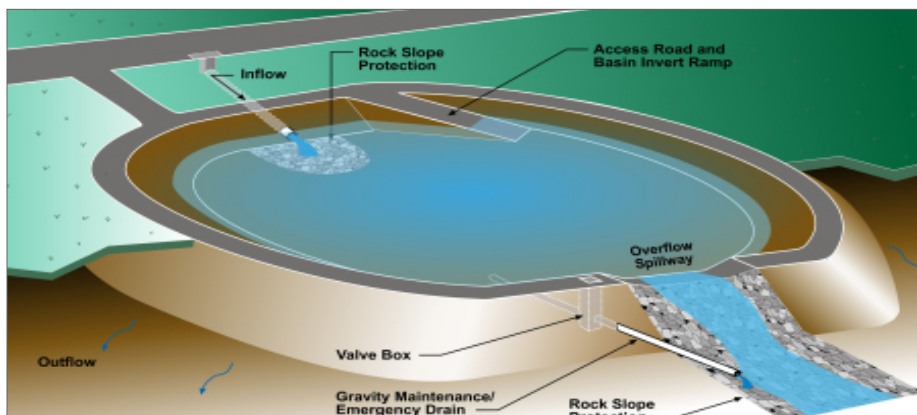
One Year Later

Source:
<http://www.richlandtownship.org/storm-water/RutgersPowerPoint.pdf>

N12 Detention Basin



Detention Basin



DESCRIPTION

A detention basin or pond detains water temporarily, releasing water through a pipe or channel by means of a weir, orifice, or pump. Because of its ability to release flow during inflow, the overall volume of storage required for a given storm event is reduced. Another advantage of the detention basin is the positive means of outflow, resulting in fewer problems with long-term ponding. Detention basin can be classified as extension detention basin or dry detention basin.

CASE STUDY: Staten Island Bluebelt Stormwater Management

The Staten Island Bluebelt is an award winning, ecologically sound and cost-effective stormwater management for approximately one third of Staten Island's land area. The current Bluebelt system drains 15 watersheds clustered at the southern end of the Island with total drainage areas of approximately 10,000 acres. To control stormwater discharges, NYCDEP has undertaken a major capital program to build special Bluebelt facilities where the storm sewers end and the natural areas begin. These facilities include constructed wetlands, stormwater detention ponds, and stream restoration projects.



Source: NYCDEP Project. http://www.nyc.gov/html/dep/html/dep_projects/bluebelt.shtml



PUBLIC SPACES

Working With Neighborhoods/Public Spaces

Municipalities can lead by example by showcasing the range of green infrastructure techniques that justify incentives and mandates. These investments can familiarize planning, zoning and public works staff and their private sector colleagues with the maintenance, installation and best practices technique.

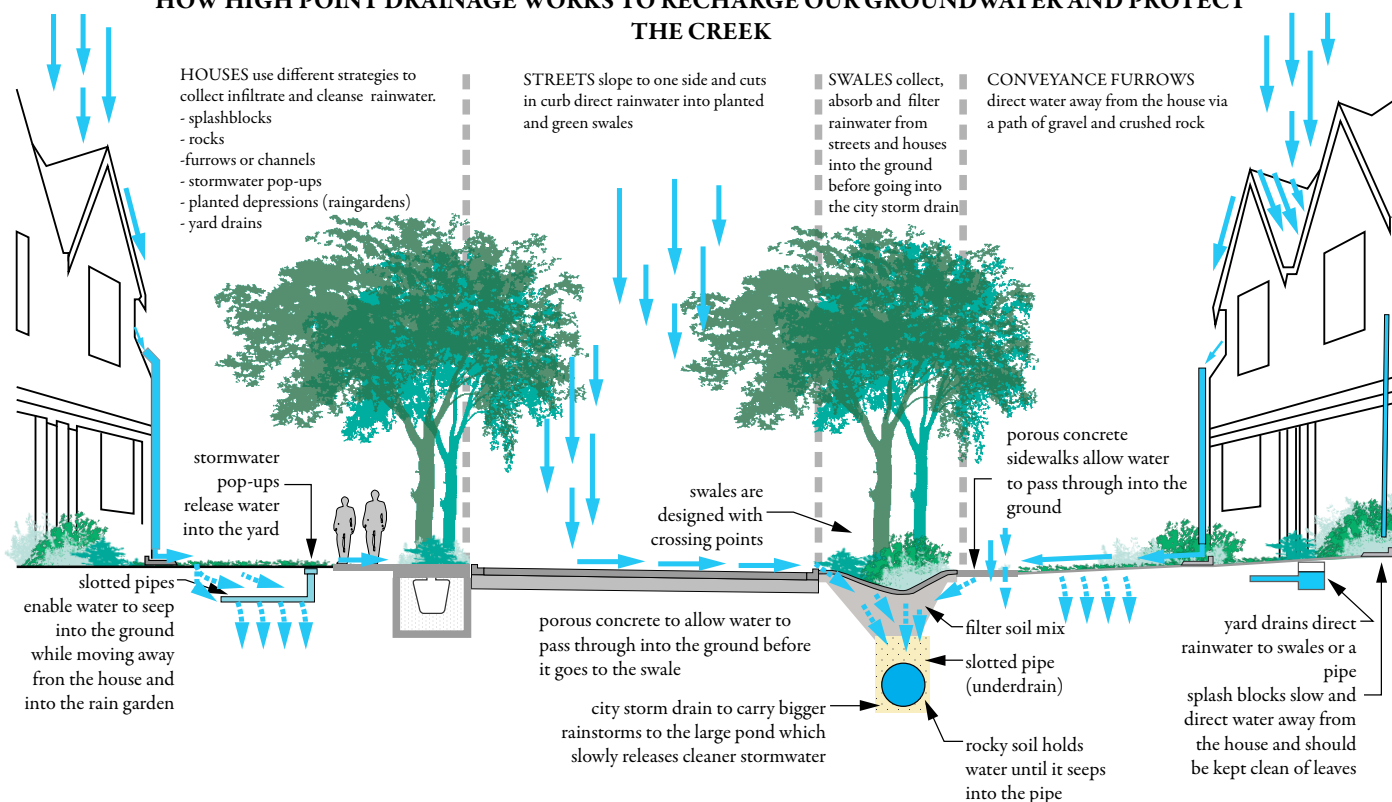
List of Included Details

- N20** Green Streets
- N21** Bioswales/Vegetated Swale
- N22** Bioretention
- N23** Tree Pits
- N24** Planter Boxes
- N25** Infiltration Trench

See also **N37** Parking Lot Bioswales and **N38** Permeable Paving in the **Buildings** section.

N20 Green Street

HOW HIGH POINT DRAINAGE WORKS TO RECHARGE OUR GROUNDWATER AND PROTECT THE CREEK



We are starting to recognize the huge role that streets play in creating community: The Completet Streets movement recognizes that streets are public spaces and that they need to accommodate mobility of all kinds (walking, biking). Streets also make up a huge proportion of the built landscape and therefore can have a huge impact on the environment. It is possible to reduce a total impervious area of 50% to an effective impervious area of 10% or less through these means.

This is especially true for storm water management and quality: In aggregate, streets create huge expanses of impermeable surface which collect and direct huge volumes of untreated storm water. The streets are huge collectors of so-called non-point source

pollutants, especially particulates from automobile exhaust and materials for winter road maintenance. For these reasons it is essential to put streets at the center of the green infrastructure strategy.

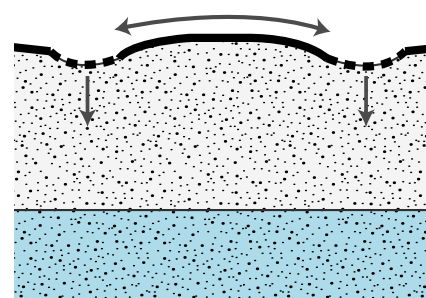
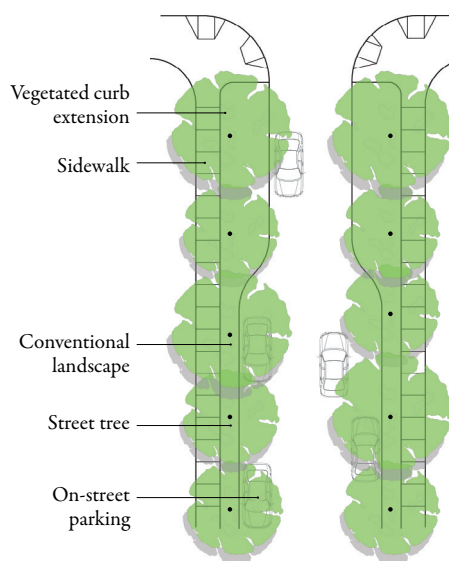
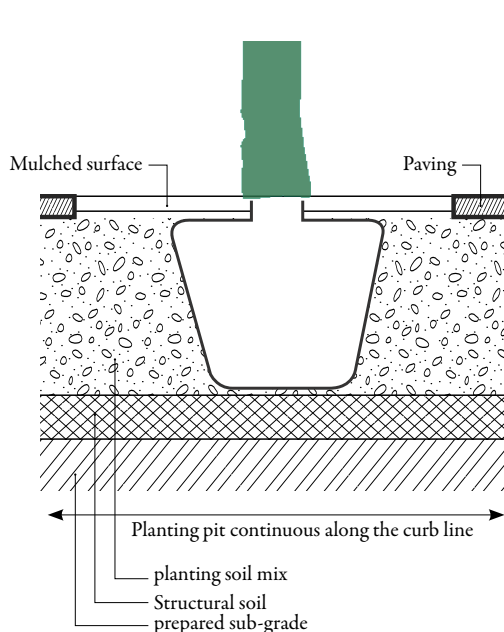
These strategies include, among others:

- N21** Bioswales
- N23** Tree pits street greening
- N24** Planter boxes
- N25** Infiltration trenches
- N38** Permeable Paving
- N34** Rainwater Harvesting

Collectively, these green street strategies can have a huge impact on storm water run-off quality and quality.

Finally, new road networks in subdivisions or in larger properties can be designed to work with natural drainage patterns and can direct the flow towards passive storm water management facilities where the water can be cleaned and slowed down before being released into a water resource.

N05 Direct the Flow



Tree pits



Suburban green street



Bio-swale street edge

N23 Tree Pit

A tree pit diverts runoff from the street into the curb. Therefore, it can collect rainwater. It is usually constructed with soils and native plants to infiltrate runoff and remove the pollutants.

In some tree pits that are specially enhanced, storage chambers are added to hold additional runoff, available for plant uptake or ground water recharge.

To be most effective, an enhanced tree pit will include an underground storage tank to increase the amount of stormwater retained.

Suburban green street

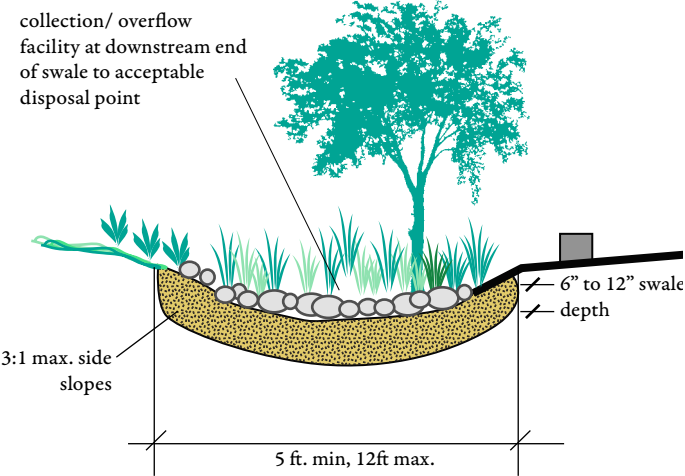
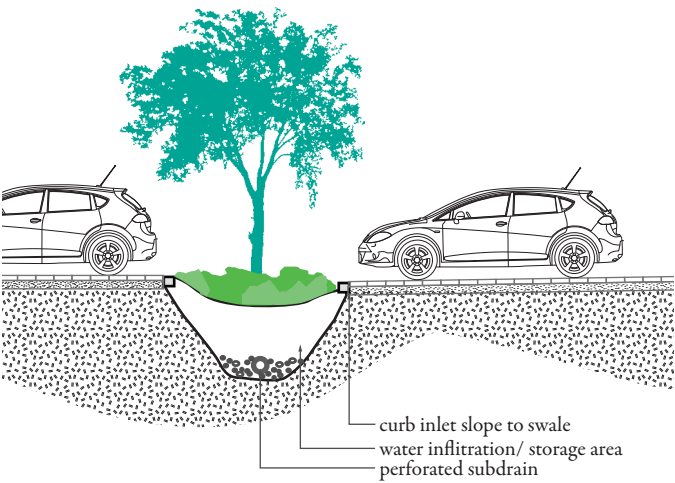
If properly designed, streets can be an integral part of a best-practice storm water management strategy: width of pavement should be minimized and a continuous planting zone on either side of the street will maximize infiltration and reduce heating of the paved surfaces.

In the overall passive storm water management plan, some streets may be used to collect storm water in an infiltration swale and direct the water towards water resources (streams, wetlands) where the cleaned water is collected.

Bio-swale street edge

Research suggests that the health of watersheds is compromised when the effective impervious area (comprised mostly of streets and rooftops) exceeds 10% of an entire watershed. Reducing the width of streets will reduce the amount of impervious surface area, while using the roadside area to clean and absorb rainwater will minimize the impact of remaining impervious surfaces.

N21 Bioswales/ vegetated swales



Bioswale along streets



Bioswale landscape



Bioswale along sidewalks

DESCRIPTION

Bioswales are vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another. Vegetated swales slow, infiltrate, and filter stormwater flows.

As linear features, vegetated swales are particularly suitable along streets and parking lots. Swales typically have several advantages over conventional stormwater management practice, such as storm sewer systems, including the reduction of peak flows; the removal of pollutants, the promotion of runoff infiltration, and lower capital costs.

However, bioswales are typically ineffective in, and vulnerable to, large storms, because high-velocity flows can erode the vegetated cover.

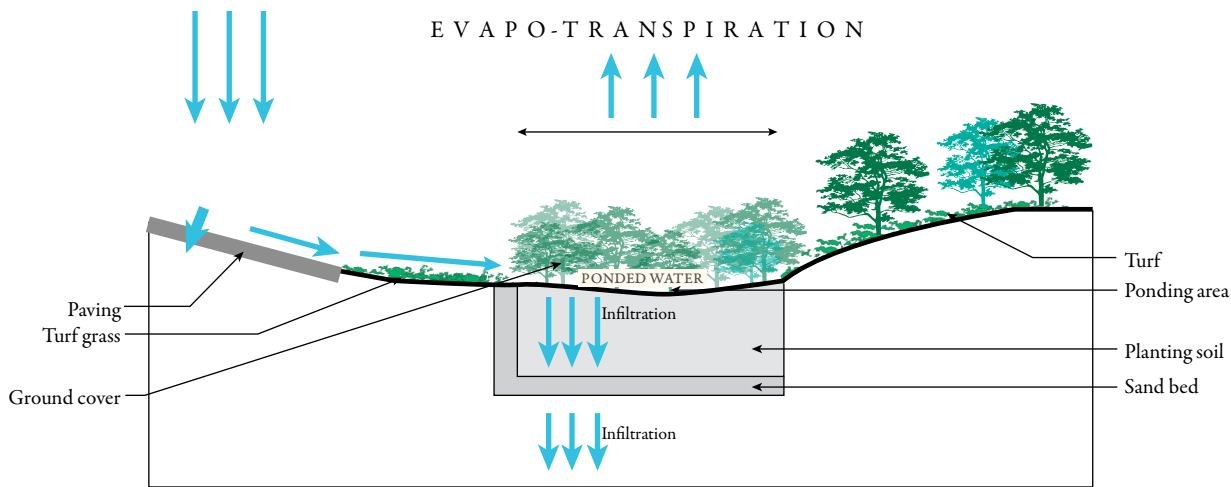
CASE STUDY: Orangeburg Bioswale

This bioswale project locates North East side of County Rte 15, Orangeburg, NY. It is an example of green infrastructure in an institutional setting. It intends to perform stormwater quality treatment through filtration and quantity control through detention. The stormwater management capacity is 1251 cubic feet. It uses mosquito control design, no permanent pools (standing water), per Rockland County Regulations.

Source: NYSDEC Projects. <http://www.dec.ny.gov/lands/59332.html>



N22 Bioretention



Bioretention

DESCRIPTION

Bioretention provides stormwater treatment that enhances the quality of downstream water bodies. Runoff is temporarily stored and released over a period of four days to the receiving water. It is also able to provide shade and wind breaks, absorb noise, and improve an area's landscape.

However, bioretention is not an appropriate practice at locations where the water table is within 1.8 meters (6 feet) of the ground surface and where the surrounding soil stratum is unstable. Clogging may be a problem, particularly if the receives runoff with high sediment loads.

CASE STUDY: Beacon Institute Bioretention Basin

This bioretention basin is an example of green infrastructure in an institutional setting. It protects the water quality of the Hudson River by capturing and filtering stormwater runoff from the building and site.

The retained runoff allows heavier sediments to fall to the bottom of the basin where it is filtered by plants, natural decomposition, and evapotranspiration. Further filtering takes place as the runoff slowly seeps through the underlying soils before reaching groundwater.

The location chosen was a naturally occurring basin in the existing landscape, maintaining the project's low-impact footprint. In addition, the plants in and around the basin are native to this area, have excellent filtering capabilities, and attract birds, butterflies and wildlife.



Source: NYSDEC projects. <http://www.dec.ny.gov/lands/63455.html>

N24 Planter Boxes



Planter boxes with benches



Planter boxes beside sidewalks



Planter boxes in plaza

DESCRIPTION

Planter boxes are urban rain gardens with vertical walls and open or closed bottoms that collect and absorb runoff from sidewalks, parking lots, and streets. The ones with open bottoms are also referred as infiltration planters, which are not recommended for soils that don't drain well. Planter boxes are ideal for space-limited sites in dense urban areas and as a streetscaping element.

CASE STUDY: Ardsley Bus Shelter Stormwater Planter

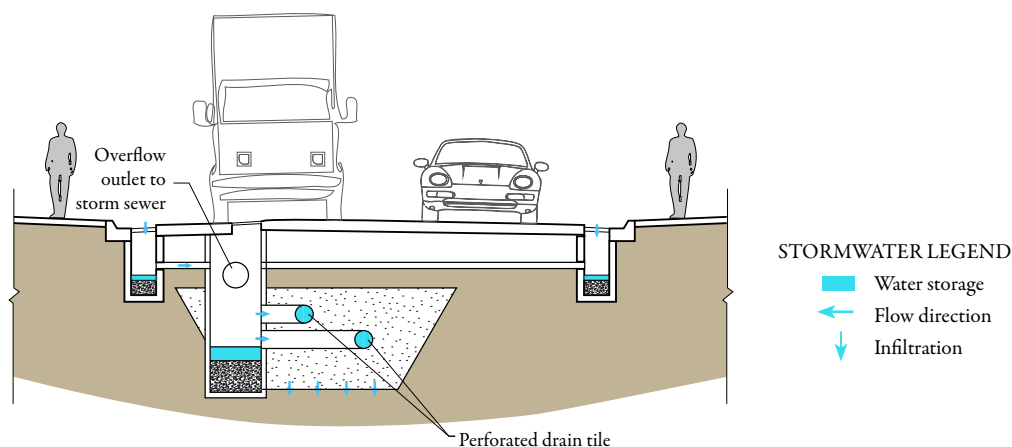
This project locates at Route 9A/Saw Mill River Road and Ashford Avenue, Ardsley, NY. The stormwater planter captures roof runoff from an adjacent public bus shelter, which helps improve the quality and reduce the flow of stormwater in the Saw Mill River watershed.

The planters redirect roof runoff, encourage infiltration and serve as a model for homeowners with limited space. The structure is 10 square feet in size and has drainage area of 55 square feet. Educational signage is also installed.



Source: NYSDEC projects. <http://www.dec.ny.gov/lands/74996.html>

N25 Infiltration Trench



Infiltration trench along sidewalks



Infiltration trench adjacent to buildings



Infiltration trench in parking lots

DESCRIPTION

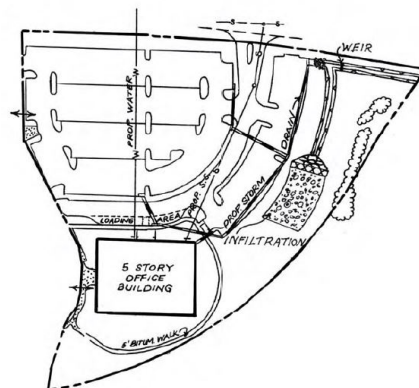
An infiltration trench, or infiltration galley, is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between 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. Infiltration trench's application is limited due to concerns over ground water contamination and other soils requirements. In addition, maintenance can be burdensome, and infiltration practices have a relatively high rate of failure.

CASE STUDY: Albany Lake Center Infiltration Trench

This design example focuses on the design of an infiltration trench for a 4.5-acre catchment of the Lake Center, a hypothetical commercial site located in Albany, NY. A five-story office building and associated parking are proposed within this catchment. The catchment has 3.05 acres of impervious cover, resulting in a site impervious cover of 68%. The pre-developed site is a mixture of forest and meadow.

Source: The New York State Stormwater Management Design Manual <http://www.dec.ny.gov/chemical/29072.html>



BUILDINGS

Working With Buildings/Sites

Landowner incentives provide the necessary motivation at the building and site level, in particular for existing properties. Guidelines and changes in building code can require or simply enable implementation during new construction. For larger developments, site plan review standards and negotiations can be used to encourage landowners to consider green infrastructure.

List of included details

Overall LID Applications – Residential

Overall LID Applications – Commercial

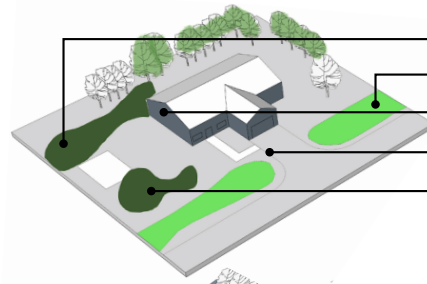
- N32** Water Flow On Small Sites
- N33** Downspout Disconnection
- N34** Rain Water Harvesting: Tanks, Cisterns, Barrels
- N35** Rain Gardens
- N36** Green Roofs
- N37** Parking Lot Bioswales
- N38** Permeable Paving

See also **N25** Infiltration Trench in the **Public Space** section.

Integrated Best Management Practices Application

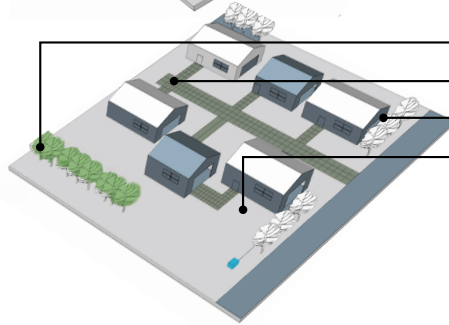
OVERALL LID APPLICATIONS – RESIDENTIAL

Low Density Residential



- N22 Bioretention
- N21 Bioswale/Vegetated Swale
- N33 Downspout Disconnection
- N38 Permeable Paving
- N35 Rain Garden

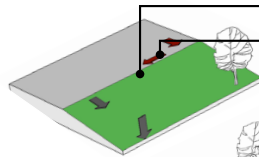
High Density Residential



- N21 Bioswale/Vegetated Swale
- N38 Permeable Paving
- N33 Downspout Disconnection
- N34 Rainwater Harvesting

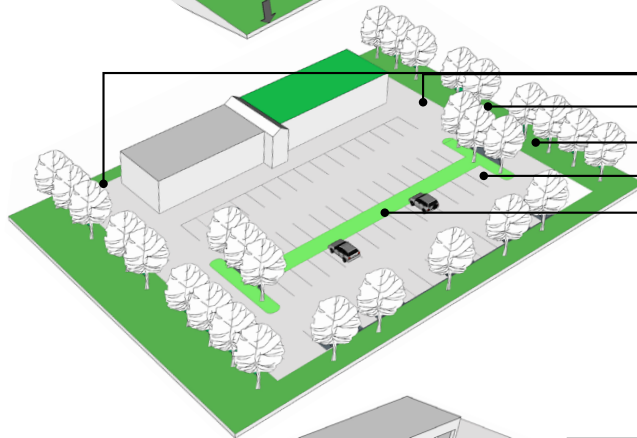
OVERALL LID APPLICATIONS – COMMERCIAL

Small Commercial Site



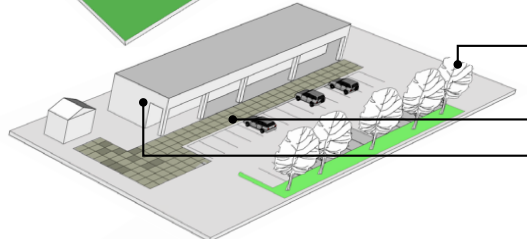
- N21 Bioswale/Vegetated Swale
- N38 Permeable Paving

Shopping Center



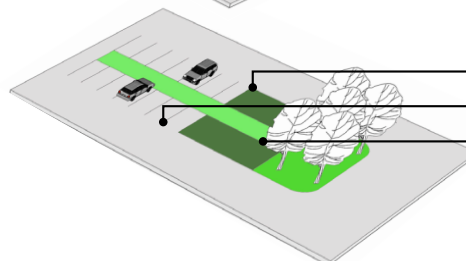
- N05 Direct the Flow
- N21 Bioswale/Vegetated Swale
- N23 Tree Pit
- N38 Permeable Paving
- N37 Parking Lot Bioswale

Small Shopping Center



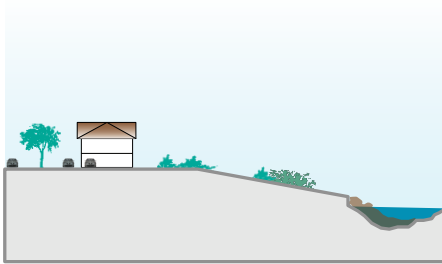
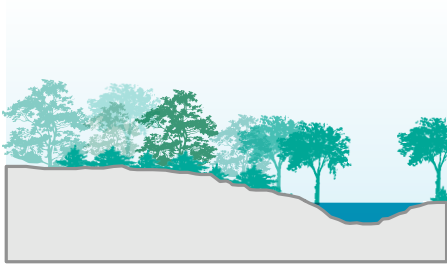
- N21 Bioswale/Vegetated Swale
- N38 Permeable Paving
- N33 Downspout Disconnection

Commercial parking Lot



- N21 Bioswale/Vegetated Swale
- N38 Permeable Paving
- N37 Parking Lot Bioswale

N32 Waterflow on Small Sites



Runoff destination under natural condition



Runoff after conventional development



Runoff after low Impact development

Runoff destination Natural condition

In the natural landscape, very little water runs off directly into streams and other water resources. Most water either goes back into the atmosphere through evaporation and transpiration or through the ground into the aquifer where it slowly makes its way to the stream as clean water.

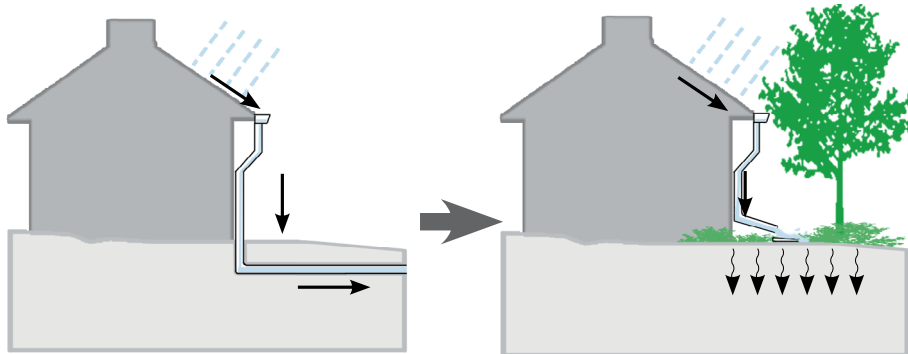
Runoff after conventional development

After conventional development, site clearing and impervious surfaces cause most rainfall to speed to the water resource as runoff that is both the wrong temperature and polluted with non-point source pollutants such as fertilizers and car exhaust particulates.

Runoff after low Impact development Small-lot residential

Direct run-off of polluted water into streams and water bodies is minimized by protecting trees and pervious surfaces and by proper grading.

N33 Downspout Disconnection



Downspout Disconnection



Downspout Disconnection



Downspout Disconnection

DESCRIPTION

Downspout disconnection refers to the rerouting of rooftop drainage pipes to drain rainwater to rain barrels, cisterns, or permeable areas instead of the storm sewer. Downspout disconnection stores stormwater and/or allows stormwater to infiltrate into the soil. This simple practice may have particularly great benefits in cities with combined sewer systems.

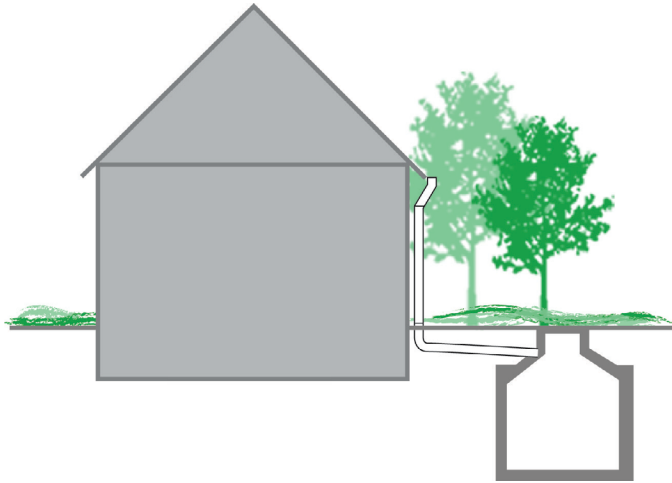
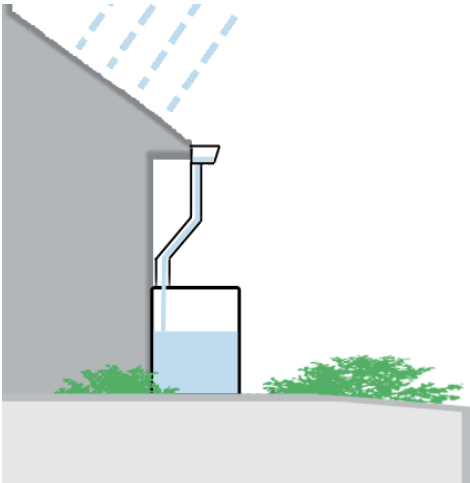
CASE STUDY: Tillson Stormwater Management

This commercial site located at 826 Route 32, Tillson, NY. The intention is to capture and possibly reuse the stormwater runoff. 1,200 square feet roof line installed downspout disconnection. 60% of roof runoff is piped underground to a separate filtering chamber, which also overflows into the well. The hope is to reuse the stored water in the future for irrigation and truck washing. In addition, driveway was constructed from permeable pavers to allow for stormwater infiltration.

Source: NYSEDC Projects. <http://www.dec.ny.gov/lands/74993.html>



N34 Rainwater Harvesting



Rain barrels for residential buildings



Rain barrels for residential buildings



Rainwater harvesting system

DESCRIPTION

Rainwater harvesting systems collect and store rainfall for later use. When designed appropriately, rainwater harvesting systems slow and reduce runoff and provide a source of water. These systems may be particularly attractive in arid regions, where they can reduce demands on increasingly limited water supplies.

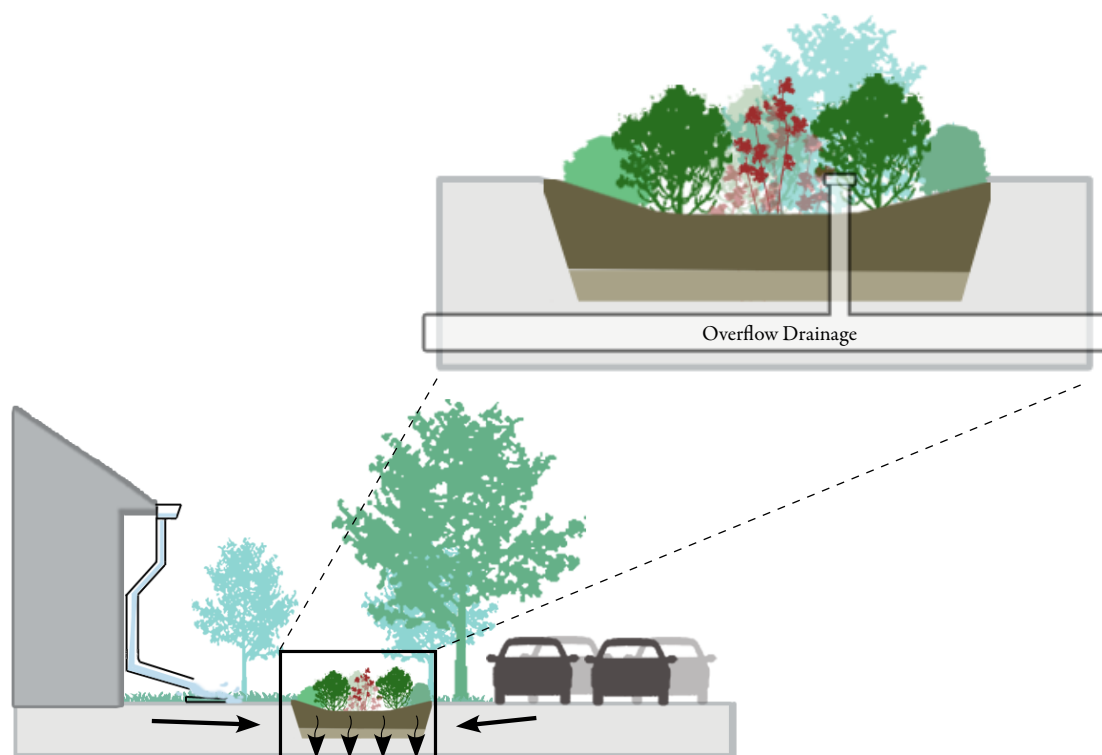
CASE STUDY: Vassar College Farm and Ecological Preserve Rain Barrels

During the spring of 2009, an Environmental Studies class from Vassar College, Poughkeepsie NY, built these rain barrels to serve as a demonstration site. Gutters were installed on part of the old cow barns to collect the water. Two 55-gallon barrels with 110 gallons total volume were installed for drainage area of 400 square feet.

Source: NYSEDC Projects. <http://www.dec.ny.gov/lands/74999.html>



N35 Rain Garden / Bioswale



Rain garden beside streets



Rain garden for residential buildings



Rain garden for parking lot

DESCRIPTION

Rain gardens, as a simplified version of bioretention, are shallow and vegetated basins that collect and absorb runoff from rooftops, sidewalks, and streets. Rain gardens mimic natural hydrology by infiltrating and evapotranspiring runoff. They can manage and treat small volumes of stormwater through soil and vegetation within a shallow depression. Rain gardens are versatile features that can be installed in almost any unpaved space.

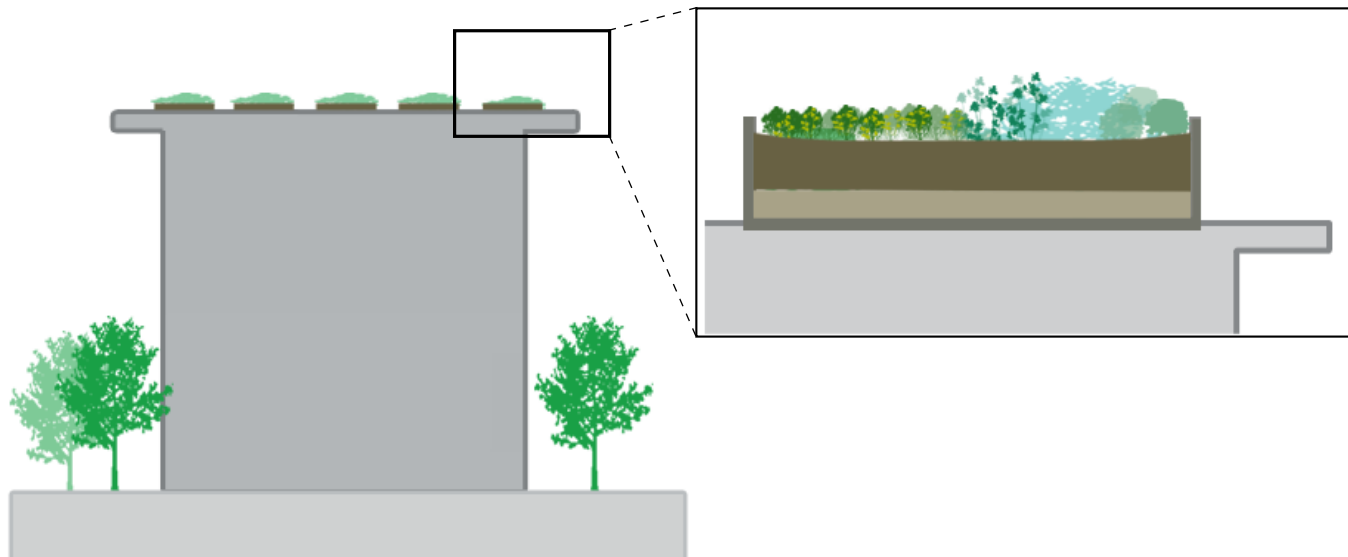
CASE STUDY: Cornell Cooperative Extension Greene County Rain Garden

This rain garden is located adjacent to the Agroforestry Resource Center, Acre NY, and was installed as a demonstration for homeowners. The garden receives water from two gutter downspouts, and is functioning quite well. The size of the structure is about 8 feet by 4 feet. It serves drainage area of $\frac{1}{2}$ acre. Native plants transplanted from volunteers' gardens.

Source: NYSDEC Project. <http://www.dec.ny.gov/lands/72990.html>



N36 Green Roof



Green roof detail



Green roof outlet



Green roof with slope

DESCRIPTION

Green roofs are covered with growing media and vegetation that enable rainfall infiltration and evapotranspiration of stored water. Green roofs are particularly cost effective in dense urban areas where land values are high and on large industrial or office buildings where stormwater management costs may be high.

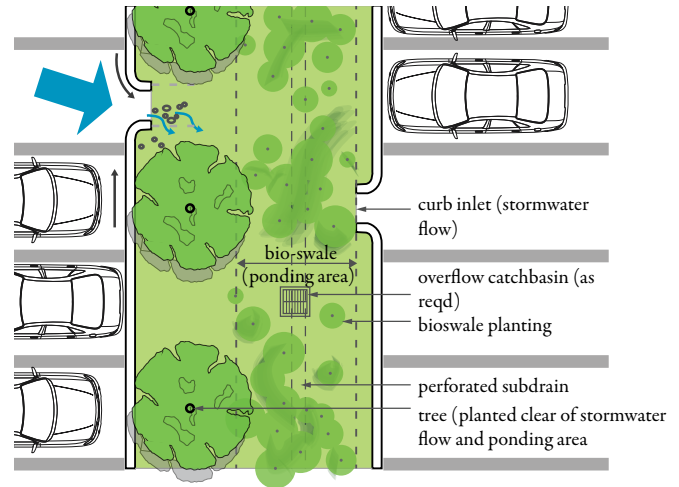
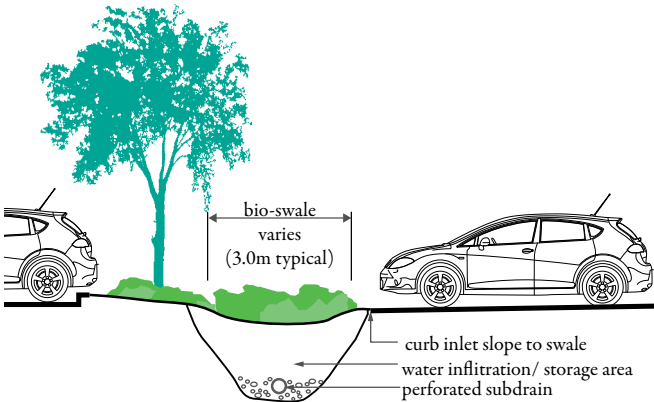
CASE STUDY: Beacon Institute Green Roof

This green roof is an example of green infrastructure in an institutional setting. Renovations called for adding a new 1000' annex to the existing historic brick building. This was an opportunity to create a green roof, mitigating runoff by absorbing rainwater, providing insulation to the building, helping to lower urban air temperatures by combating heat island effect, and creating a habitat for wildlife.

Source: NYSDEC Project. <http://www.dec.ny.gov/lands/63456.html>



N37 Parking lot bioswales



Parking lot bioswales



Parking lot bioswales



Parking lot bioswales

DESCRIPTION

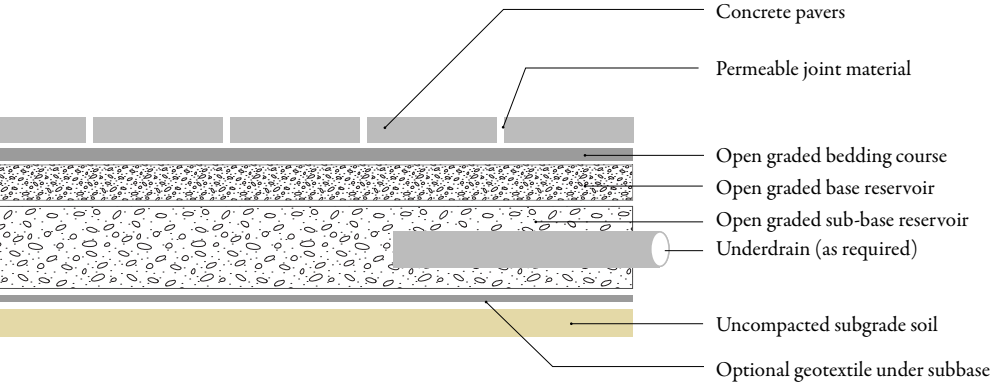
Large volumes of polluted water run off of commercial parking lots. To the greatest extent possible this water should be captured and cleaned in bio swales with plants before being released into the ground.

CASE STUDY: Roeliff Jansen Community Library. Hillsdale, NY

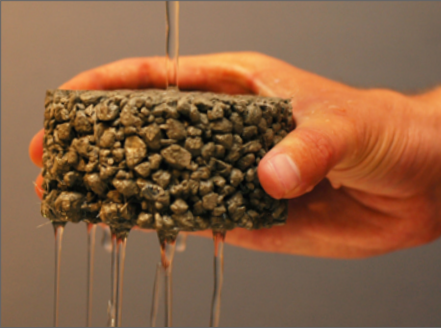


N38

Permeable Pavements



Permeable interlocking concrete pavers



Permeable asphalt



Grass pavements

DESCRIPTION

Permeable pavements are paved surfaces that infiltrate, treat, and/or store rainwater where it falls. Permeable pavements may be constructed from pervious concrete, porous asphalt, permeable interlocking pavers, and several other materials. These pavements are particularly cost effective where land values are high and where flooding or icing is a problem.

CASE STUDY: Albany Pine Bush Discovery Center Porous Pavement

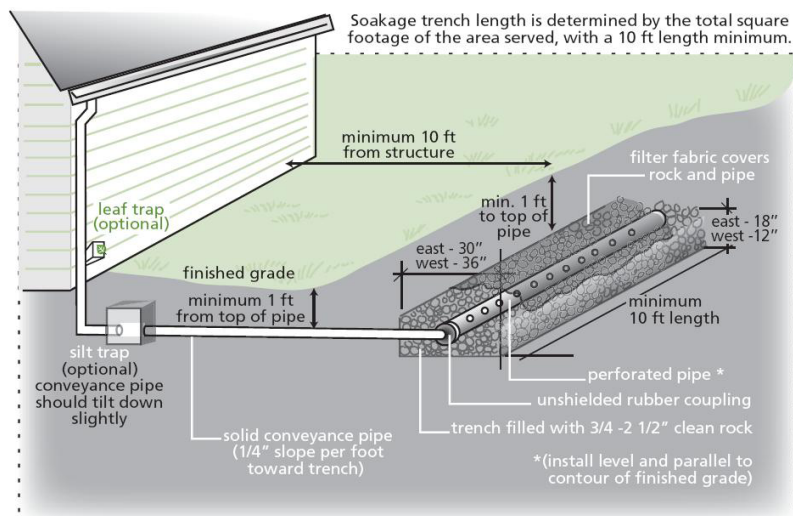
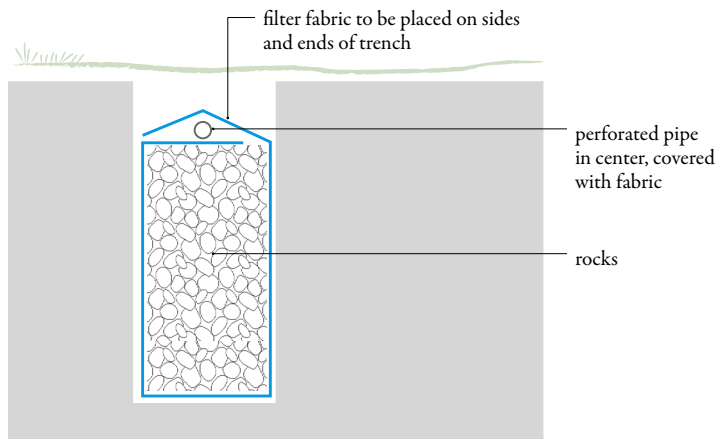
The Discovery Center installed Flexi-Pave, a porous pavement material made from recycled tires, as a trail surface along the Metamorphosis Maze exhibit and the Native Plant Walkway. The installation involved applying Flexi-Pave over two different sub-base materials: a sand base and a crusher run base. The total size of structure is 1,500 square feet, serving 1,500 square feet drainage area.

Source: NYSDEC Project. <http://www.dec.ny.gov/lands/76843.html>



N25

Infiltration Trench



DESCRIPTION

Infiltration Trench is also referred as Soakage Trench, which can be applied for residential buildings. An infiltration system is similar to the septic tanks and drain fields that are used to dispose of wastewater from the house. The system is composed of several elements that convey runoff (gutters and downspouts) to a sediment control structure (similar to a septic tank, but much smaller) which filters out debris and finally to a gravel-filled trench where the runoff percolates into the soil.

CASE STUDY: Infiltration trench Chester County, PA



BMPs Master List: Landscapes

		SCALES			FUNCTION	DESIGN CONSIDERATIONS
BMP		Landscape	Public Spaces	Building		
N02	Riparian Buffers	●	◐	○	separate shoreline from polluted runoff; slow down, filter and infiltrate runoff, thus increasing water quality and protecting habitat	must be engineered to satisfy demanding hydrologic conditions
N07	Stream Daylighting	◐	●	●	expose some or all of a previously covered river, stream, or stormwater drainage; control flooding and reduce erosion	design morphologies and the openness of stream depends on space, land use and available water source
N10	Constructed Wetland	●	○	○	create shallow marsh areas to treat urban stormwater and incorporate permanent pools and/or detention storage	no more than 8% slope; microtopography is encouraged to enhance wetland diversity
N11	Retention Basin	●	○	○	provide long-term storage of stormwater runoff in order to treat stormwater before being discharged by displacement	more appropriate in residential and commercial areas where nutrient loadings are expected to be high
N12	Detention Basin	●	○	○	providing both retention and treatment of contaminated storm water runoff	no more than 15% slope

Legend



Suitable



Less Suitable



Unsuitable

	SPACE	COST	MANAGEMENTS / MAINTENANCE	EFFECTIVENESS
N02	minimum width: 50 ft for slopes of 0% to 8%, 75 ft for 8% to 12% and 100 ft for 12 % to 15 %	cost \$200-700 per acre to plant and maintain	for existing developed areas, an easement may be needed from adjoining landowners	serve as right-of-way during floods; need to be combined with other filter structure for pretreatment
N07	for streams buried beneath concrete, day-lighting requires major excavation	\$1,000 per linear ft. of stream day-lighted	regular monitor for water quality; vegetation maintenance and sedimentation clearing	significantly improving nutrient uptake and stream metabolism compared to buried channels
N10	the wetland depth ranges from 6 to 12 inches	approximately \$0.25~1 per sf.	if coverage of 50% is not achieved in the planted wetland, a reinforcement planting is required	wetlands can control flood by providing flood storage; has high pollutant removal rate for P, N
N11	usually limited to use with moderate to large drainage areas, often greater than 20 acres	approximately \$1.0~2.0 per cubic foot of storage	permanent maintenance access must be provided to the forebay, outlet, and embankment areas	reduce runoff through infiltration and evapotranspiration; high pollutant removal rate
N12	suitable for capturing runoff from a drainage area of at least five acres	range from \$1.0~1.5 per cf. of detention	routine maintenance, like mowing and debris removal, is vital to the proper operation	dry detention basin has larger capacity than wet basin; removal of pollutants is less efficient

BMPs Master List: Public Spaces

		SCALES			FUNCTION	DESIGN CONSIDERATIONS
BMP		Landscape	Public Spaces	Building		
N21	Bioswales/ Vegetated swale	●	●	●	convey stormwater at a low velocity, promoting natural treatment and infiltration	have a slope between 0.5% and 4% (between 1.5- 2.5 percent recommended)
N22	Bioretention	●	●	●	capture and treat stormwater, allowing the water to filter through soil and vegetation	not recommended for areas with slopes greater than 20%, or where mature tree removal would be required
N23	Tree Pits	●	●	●	reduce stormwater runoff, increase nutrient uptake, provide shading and thermal reductions, and encourage wildlife habitat	the average slope for the contributing area must not be greater than 5%.
N24	Planter Boxes	●	●	●	are usually larger than rain gardens and designed with an underdrain to connect to the storm drain system	infiltration depth should be at least 3 ft.; infiltration planters should be designed with no slope
N25	Filter Strips	○	●	●	treat sheet flow from adjacent surfaces and remove pollutants through filtration and infiltration	max slope less than 2%; inappropriate for higher pollutant loading due to direct infiltration
N26	Infiltration Trench	●	●	●	stores the water quality volume in the void spaces of a gravel trench before it is infiltrated into the ground	no more than 15% slope; at least 3 ft. above water table, or 4 ft. if sole source aquifer

Legend

●

Suitable

●

Less Suitable

○

Unsuitable

	SPACE	COST	MANAGEMENTS / MAINTENANCE	EFFECTIVENESS
N21	can be used where the contributing drainage area is less than 5 acres	approximately \$0.5 per sf.	require more maintenance than curb or closed drainage; fertilize and lime are needed	be effective for road and parking lots runoffs reduction; high removal rates for some pollutants
N22	maximum recommended ponding depth of the bioretention area is 6 inches	approximately \$10~20 per sf.	areas devoid of mulch shall be re-mulched on an annual basis; dead plant shall be replaced	reduce runoff and maintain peak discharge rate; able to achieve excellent removal of heavy metals
N23	individually planted trees in contained areas such as sidewalk cut-outs or curbed islands	\$1500~6000 for installation per tree	the first three years, mulching, watering and protection of young trees may be necessary	can remove trace amounts of harmful chemicals including metals, organic compounds and solvents
N24	a few sf. of surface area and can be adjacent to buildings, on terraces or rooftops	approximately \$8 per sf.	maintenance of vegetation and structural components following bigrain events	not designed to provide flood control; can treat initial runoff flow in small quantity
N25	treat small areas of impervious cover (e.g., 5,000 sf) close to source	\$ 13000 ~30,000 per acre	inexpensive maintenance with cost of \$350 per acre per year	do not have the capacity to detain relatively large storm events; low pollutant removal rate
N26	maximum drainage area is 5 acres	construction costs \$5~10/cf. of stormwater	remove sediment and oil/grease from pretreatment devices and overflow structures	recharge the ground water because runoff is treated; have very high pollutant removal

BMPs Master List: Buildings

	BMP	SCALES			FUNCTION	DESIGN CONSIDERATIONS
		Landscape	Public Spaces	Building		
N33	Downspout Disconnection	○	●	●	redirect water to permeable surface including yards and gardens; reduce demand on sewer system	avoid disconnecting downspouts across a walk/driveway because of tripping hazards
N34	Rainwater Harvesting	◐	●	●	capture and store stormwater runoff to be used later for irrigation, etc.	install rain barrels on a firm level surface and locate at the base of the downspouts gutter
N35	Rain Gardens	○	○	●	combines physical filtering and adsorption with bio-geochemical processes to remove pollutants	require relatively flat slopes to be able to accommodate runoff filtering through the system
N36	Green Roofs	○	●	●	absorb, store, and later evapotranspire initial precipitation	installed during initial construction or retrofit; constructed on roofs with up to a 20% slope
N38	Permeable Pavements	○	●	●	reduce runoff by allowing water to soak through the paved surface into the ground beneath	inlets can be placed in the porous asphalt to accommodate overflows from extreme storms

Legend



Suitable



Less Suitable



Unsuitable

	SPACE	COST	MANAGEMENTS / MAINTENANCE	EFFECTIVENESS
N33	the contributing area of rooftop to each discharge is 500 sf. or less	for residential housing, costs \$40 per house	clean gutters twice a year; check downspouts regularly to avoid clogging	only treat a relatively small portion of the watershed imperviousness
N34	the cistern/rain barrel sizing is based on the water demand for the intended use	costs \$100 for 60 gallon scale rain barrels	periodic cleaning to ensure effective storage while reducing mosquito breeding	focus on water quantity collection and don't have treatment process for water quality
N35	usually be applied in small sites; ponding depth be less than 6 inches	residential \$3~5 per sf, commercial \$50per sf.	initially require intense maintenance, but less maintenance is needed over time	can divert initial flow; relatively high removal rate
N36	appropriate for industrial and commercial facilities and large resid. buildings	approximately \$5~80 per sf.	less prone to leaking than conventional roofs; need occasional weeding and watering	if implemented on a wide scale, will reduce runoff and metal pollutant entering waterway
N38	can be installed across an entire street width or an entire parking area;	ranges from \$0.50~1.0 per sf.	periodic maintenance to remove fine sediments from paver surface will optimize permeability	porous asphalt, pervious concrete, and permeable pavers all have the same underlying stormwater storage

BMPs Benefits and Practices

Benefit		Practice	Green Roofs	Tree Planting*	Bioretention & Infiltration *	Permeable Pavement	Water Harvesting
Reduces Stormwater Runoff	Reduces Water treatment needs		●	●	●	●	●
	Improves water quality		●	●	●	●	●
	Reduces grey infrastructure needs		●	●	●	●	●
	Reduces flooding		●	●	●	●	●
Increases available water supply			○	○	◐	○	●
Increases groundwater recharge			○	◐	◐	◐	◐
Reduces salt use			○	○	○	●	○
Reduces Energy use			●	●	○	◐	◐
Improves Air Quality			●	●	●	●	◐
Reduces Atmospheric CO2			●	●	●	●	◐
Reduces urban heat island			●	●	●	●	○
Improves Community Livability	Improves aesthetics		●	●	●	○	○
	Increases recreational opportunity		◐	●	●	○	○
	Reduces noise pollution		●	●	◐	●	○
	Improves Community Cohesion		◐	●	◐	○	○
	Urban Agriculture		◐	◐	○	○	○
Improves habitat			●	●	●	○	○
Cultivates public education opportunities			●	●	●	●	●

Legend

● YES

◐ MAYBE

○ NO

Notes:

* Bioretention & Infiltration include: Bioswales/Vegetated Swales, Bioretention, Planter Boxes, Infiltration Trench, Parking Lot Bioswales, Rain Gardens.

* Tree Planting includes: Mid-Block Green, Green Streets, Tree Pits.

Adapted from Center for Neighborhood Technology "The Value of Green Infrastructure - A Guide to Recognizing Its Economic, Environmental and Social Benefits".
<http://www.cnt.org/repository/gi-values-guide.pdf>

TOOLS & ACTIONS

HOW you need to do it

Zoning Regulations Checklist

	ZONING REGULATIONS	NOTES
I. WATERSHED RECOGNATION	<input type="checkbox"/> 1. Is the watershed recognized as an overlay district?	
	<input type="checkbox"/> 2. Do distinct boudaries follow the watershed?	
	<input type="checkbox"/> 3. Are there text references to watershed?	
II. EXCLUDED USES	Are certain uses excluded due to their attributes?	
	<input type="checkbox"/> 1. Hazardous materials use	
	<input type="checkbox"/> 2. Risky on-site waste disposal	
	<input type="checkbox"/> 3. Housing unit density	
	<input type="checkbox"/> 4. Are there limits on sewage density (e.g., maximum number of gallons per day per 1000 square feet)?	
	Are use categories excluded ...	
	<input type="checkbox"/> 1. Agriculture?	
	<input type="checkbox"/> 2. Livestock, feedlots?	
	<input type="checkbox"/> 3. Solid waste disposal	
	<input type="checkbox"/> 4. Junk, salvage yards	
	<input type="checkbox"/> 5. Wastewater treatment plants	
	6. Bulk storage of ...	
	<input type="checkbox"/> petroleum	
	<input type="checkbox"/> coal	
	<input type="checkbox"/> Ice control chemicals	
	<input type="checkbox"/> Hazardous materials	
	<input type="checkbox"/> 7. Earth removal, mining	
	<input type="checkbox"/> 8. Snow disposal	
	<input type="checkbox"/> 9. Cemeteries	
	<input type="checkbox"/> 10. Equestrian activity	
	<input type="checkbox"/> 11. Golf courses	
	<input type="checkbox"/> 12. Ski areas	
	<input type="checkbox"/> 13. Gas station, automobile repair	
	<input type="checkbox"/> 14. Dry cleanres	
	<input type="checkbox"/> 15. Truck terminals	
	<input type="checkbox"/> 16. Photo lab	

Zoning Regulations Checklist (continued)

	ZONING REGULATIONS	NOTES
III. PERFORMANCE CONTROLS	Are allowed uses based on ... or not?	
	<input type="checkbox"/> 1. Soils	
	<input type="checkbox"/> 2. Slope	
	<input type="checkbox"/> 3. Sewarage	
	<input type="checkbox"/> 4. Public water	
	Is density based on .. ?	
	<input type="checkbox"/> 1. Soils	
	<input type="checkbox"/> 2. Slope	
	<input type="checkbox"/> 3. Sewarage	
	<input type="checkbox"/> 4. Watershed	
	<input type="checkbox"/> 5. Public water	
	6. Site carrying capacity	
	<input type="checkbox"/> Based on nitrate loading	
	<input type="checkbox"/> Based on phosphorus loading	
	Are impervious surfacecs limited by ... ?	
	<input type="checkbox"/> 1. Soils	
	<input type="checkbox"/> 2. Slope	
	<input type="checkbox"/> 3. Watershed	
	<input type="checkbox"/> 4. Within waterbody proximity (buffer)	
	Are there waterbody buffers?	
	<input type="checkbox"/> 1. No buildings allowed within buffer areas	
	2. Explicit rules about uses within buffers:	
	<input type="checkbox"/> Use limitation	
	<input type="checkbox"/> Density limits	
	<input type="checkbox"/> Vegetation requirements	
	<input type="checkbox"/> Hazard limits	
	<input type="checkbox"/> Road, rail setbacks	
	<input type="checkbox"/> Maintenance rules	
	<input type="checkbox"/> 3. Is discretionary/site plan review required?	

Zoning Regulations Checklist (continued)

ZONING REGULATIONS		NOTES
VI. OTHER ENVI- RONMENTAL CONTROLS	<input type="checkbox"/> 1. Flood plain control	
	<input type="checkbox"/> 2. Pesticide/herbicide rules	
	3. Agricultural practices	
	<input type="checkbox"/> Manure controls	
	<input type="checkbox"/> Fertilizer controls	
	<input type="checkbox"/> Other	
	<input type="checkbox"/> 4. Erosion controls	
	5. Vegetation	
	<input type="checkbox"/> Minimum % required	
	<input type="checkbox"/> Planting required	
	<input type="checkbox"/> Maximum cultivated/lawn area	
	<input type="checkbox"/> 6. Forestry practice rules	
	<input type="checkbox"/> 7. Highway maintenance chemical rules	
	8. Drainage controls	
	<input type="checkbox"/> Peak runoff limits	
	<input type="checkbox"/> Other quality controls	
	<input type="checkbox"/> 9. Hazardous substance storage rules	
	<input type="checkbox"/> 10. Seal abandoned wells	
	<input type="checkbox"/> 11. Septic system cleaner ban	

Subdivision Control Checklist

SUBDIVISION CONTROL	NOTES
<input type="checkbox"/> 1. Do special rules apply within watershed	
<input type="checkbox"/> 2. Watershed treatment design approval	
3. Stormwater rules	
<input type="checkbox"/> Open drainage encouraged	
<input type="checkbox"/> Peak flow increase limited	
<input type="checkbox"/> Settling basins required	
<input type="checkbox"/> Sumps, oil traps, etc. required	
<input type="checkbox"/> Facility maintenance required	
<input type="checkbox"/> 4. Nutrient loading limits	
<input type="checkbox"/> 5. Slope grade limits	
<input type="checkbox"/> 6. Erosion control plan required	
<input type="checkbox"/> 7. Waterbody/wetland protections	
8. Road design can fit topography	
<input type="checkbox"/> Rules vary by terrain type	
<input type="checkbox"/> Narrow (<20') roads o.k.	
<input type="checkbox"/> Steep (>10%) roads o.k.	
<input type="checkbox"/> Womdomg (<100') radius o.k.	
<input type="checkbox"/> "Leveling" not required	
<input type="checkbox"/> Required shoulders <4'	
<input type="checkbox"/> ROW cleared only as needed	
<input type="checkbox"/> 9. Open space dedication required	
<input type="checkbox"/> 10. Flood zone rules	
<input type="checkbox"/> 11. Pervious surface as an option	
<input type="checkbox"/> 12. Impact study required	

Policy Checklist

SUBDIVISION CONTROL	
<input type="checkbox"/> Preservation of Undisturbed areas	Delineate and place into permanent conservation easement undisturbed forests, native vegetated areas, riparian corridors, wetlands, and natural terrain.
<input type="checkbox"/> Preservation of Buffers	Define, delineate and place in permanent conservation easement naturally vegetated buffers along perennial streams, rivers, shorelines and wetlands.
<input type="checkbox"/> Reduction of Clearing and Grading	Limit clearing and grading to the minimum amount needed for roads, driveways, foundations, utilities and stormwater management facilities.
<input type="checkbox"/> Locating Development in Less Sensitive Areas	Avoid sensitive resource areas such as floodplains, steep slopes, erodible soils, wetlands, mature forests and critical habitats by locating development to fit the terrain in areas that will create the least impact.
<input type="checkbox"/> Open Space Design	Use clustering, conservation design or open space design to reduce impervious cover, preserve more open space and protect water resources.
<input type="checkbox"/> Soil Restoration	Restore the original properties and porosity of the soil by deep till and amendment with compost to reduce the generation of runoff and enhance the runoff reduction performance of practices such as downspout disconnections, grass channels, filter strips, and tree clusters.
<input type="checkbox"/> Roadway Reduction	Minimize roadway widths and lengths to reduce site impervious area.
<input type="checkbox"/> Sidewalk Reduction	Minimize sidewalk lengths and widths to reduce site impervious area.
<input type="checkbox"/> Driveway Reduction	Minimize driveway lengths and widths to reduce site impervious area.
<input type="checkbox"/> Cul-de-sac Reduction	Minimize the number of cul-de-sacs and incorporate landscaped areas to reduce their impervious cover.
<input type="checkbox"/> Building Footprint	Reduction Reduce the impervious footprint of residences and commercial buildings by using alternate or taller buildings while maintaining the same floor to area ratio.
<input type="checkbox"/> Parking Reduction	Reduce imperviousness on parking lots by eliminating unneeded spaces, providing compact car spaces and efficient parking lanes, minimizing stall dimensions, using porous pavement surfaces in overflow parking areas, and using multi-storied parking decks where appropriate.

Appendix

Some resources for watershed plans:

Watershed Impact Assessment Guidance for Public Lands and Facilities

U.S. Environmental Protection Agency (EPA) Office of Water. April 2005

Handbook for Developing Watershed Plans to Restore and Protect Our Waters

U.S. Environmental Protection Agency (EPA) 841-B-08-002. March 2008

Considerations in the Design of Treatment Best Management Practices (BMPs) to Improve Water Quality

U.S. Environmental Protection Agency (EPA/600/R-03/103) September 2002

NYS Stormwater Management Design Manual 2010

New York Department of Environmental Conservation. August 2010

Barriers to Green Infrastructure in the Hudson Valley

Hudson River Estuary Program. 2012

9 Ways to Make Green Infrastructure Work in Cities & Towns

Regional Plan Association. November 2012

Watershed BMP for Water Quality Protection, Management and Restoration

Robert Kennedy, ERDC TN-WRAP-02-04. May 2002

Some online resources for watershed plans:

U.S. Environmental Protection Agency Green Infrastructure Technologies, Tools and Case Studies:

http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

The Center for Watershed Protection

<http://www.cwp.org>

Green Infrastructure Examples for Stormwater Management in the Hudson Valley

<http://www.dec.ny.gov/lands/58930.html>

The International Stormwater Best Management Practices (BMP) Database

<http://www.bmpdatabase.org>

New York State Environmental Facilities Corporation Green Innovation Grant Program

<http://www.efc.ny.gov/Default.aspx?tabid=461>

Department of State, Office of Planning & Development, Water Resources Management

<http://www.dos.ny.gov/opd/programs/waterResourcesMgmt>

