2015

Green Infrastructure Guide

Conservation Advisory Council

City of Newburgh, New York

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Green Infrastructure Guide

Welcome to the **City of Newburgh Conservation Advisory Council Green Infrastructure Guide**. The purposes of this Guide are to (1) inform the City Council, Planning Board, Zoning Board of Appeals and public about the importance of green infrastructure and the potential for its increased use in Newburgh and (2) direct the Conservation Advisory Council in its decision-making to address certain environmental impacts from development and redevelopment in the City. The Guide provides narrative text as well as links to important resource documents, and other relevant information, to assist the CAC in its duties and educate others about green infrastructure.

The Green Infrastructure Guide:

- Begins with an overview of green infrastructure, including defining the term and explaining the environmental, social and economic benefits to communities that employ green infrastructure practices.
- It then examines the current use of green infrastructure in the City and discusses how the City has planned for and is working to implement green infrastructure. As part of this section, the Conservation Advisory Council sets forth its Green Infrastructure Policy to guide its review of development projects and its efforts to educate City officials and residents about the importance of using green infrastructure.
- Next the Guide highlights key green infrastructure approaches to address stormwater flows and urban air quality.
- Finally, it concludes with a list of important green infrastructure resources from New York State, federal agencies and other organizations.

Please be aware that this Green Infrastructure Guide is an evolving document. As green infrastructure practices are implemented and their effectiveness evaluated, the contents of this Guide will be improved to serve the needs of the City of Newburgh and enhance the City's environment.

Section I - What is Green Infrastructure?

1. Green Infrastructure Defined

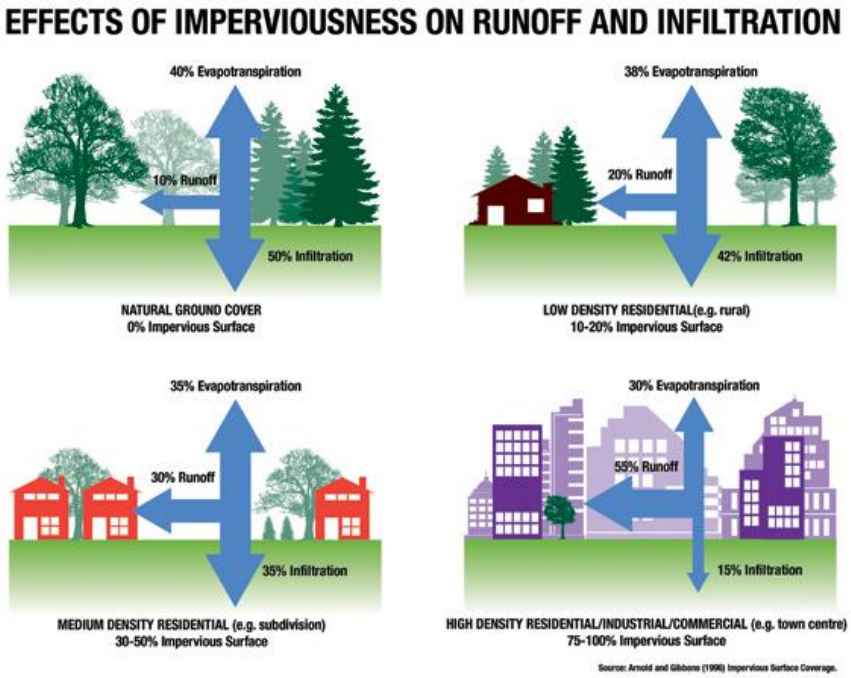
A significant portion of the City of Newburgh is hardscape, covered by buildings, parking lots, streets and other impervious surfaces, which prevent rain and snow from soaking into the ground. In a city like Newburgh, a typical city block generates more than five times the stormwater runoff produced on a woodland area of the same size. Stormwater travels over the land's surface, picking up contaminants like oil, fertilizer and other chemicals, and then flows either directly into streams, ponds and the Hudson River, or into storm sewers that then discharge into these same water bodies. In either case, the flow of contaminants into water bodies reduces water quality, negatively impacting both ecological and human health (see Figure 1 below).

This is made worse because areas of Newburgh are serviced by a combined sewer system (CSS). These sewers collect rainwater, domestic sewage, and industrial wastewater all in the same pipes. This combined sewage is then transported to the City's sewage treatment plant, or waste Water Treatment Facility (WWTF) before being discharged into the Hudson River. At times, during periods of heavy rainfall

or snowmelt, the wastewater volume in a CSS exceeds the capacity of the wastewater treatment plant. When this happens, CSSs are designed to overflow and discharge excess raw wastewater directly into the Hudson River or the Quassaick Creek. This is known as a combined sewer overflow.

In some of the newer areas of the City, storm and sanitary sewer lines are separated; but even in those areas, because there is no place to discharge stormwater, the storm and sanitary sewer lines are reconnected and the combined sewage is directed to the WWTF.

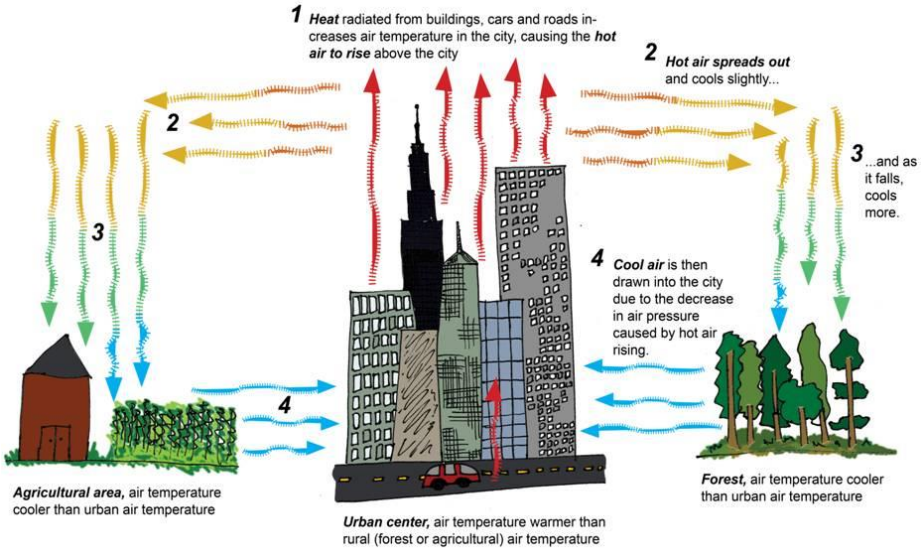
Figure 1:



Not only does stormwater carry pollutants into the water bodies like the Hudson River and the Quassaick Creek, the increased flow of this stormwater can cause flooding, deposition of silt, stream bank erosion, obstructions to fish passage, habitat loss, and loss of tree canopy along stream corridors. The damage wrought by this situation is likely to be exacerbated over the coming decades as climate change is predicted to produce storms of greater ferocity, generating larger volumes of rain over shorter periods of time.

These same developed areas also tend to increase urban air temperature relative to rural areas because concrete, pavement, and other impervious surfaces tend to absorb and retain heat, a circumstance known as the urban heat island effect (see Figure 2 below). With higher temperatures, the amount of energy needed to cool buildings is increased leading to greater energy demand. The higher temperatures also exacerbate human respiratory and other health related problems.

Figure 2:



(Source: https://bloomington.in.gov/documents/viewDocument.php?document_id=7061)

Green infrastructure refers to using and enhancing natural systems to absorb and filter pollutants from the air and water, protect communities from flooding and storm surges, reduce erosion, and create healthier, more sustainable urban environments. Green Infrastructure includes both landscape level strategies, such as the adoption of stream protection overlay zones with associated riparian buffers and flood plain designations; the creation of pocket parks within existing neighborhoods; and site specific practices such as green roofs, bioswales, tree planters and rain gardens among many others. In the context of this Guide, the CAC uses the term green infrastructure to include both landscape level and site-specific strategies and techniques that reduce stormwater flow and mitigate its impacts as well as strategies and techniques that seek to improve urban air quality. In some cases, particular green infrastructure practices, like green roofs, mitigate stormwater impacts and urban air quality simultaneously.

A term related to green infrastructure, but not synonymous with it is “low impact development” (LID). LID focuses on strategies to mitigate the adverse impact of site-specific development on the environment, principally with respect to stormwater. As the U.S. EPA notes, it “is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.”

As used by the City of Newburgh CAC in this Green Infrastructure Guide, LID principles aim to:

- preserve and recreate natural landscape features;
- restrict building on designated sensitive areas, such as wetlands and steep slopes;
- minimize impervious hardscape to create functional and aesthetically appealing site drainage;
- treat stormwater as a resource rather than a waste product; and
- appropriately design projects in harmony with their sites to reduce onsite stormwater generation.

2. Benefits of Green Infrastructure

The City of Newburgh CAC stresses the benefits of green infrastructure strategies for adapting to climate change, reducing stormwater flows, improving water quality, bettering air quality, lowering heat stress, creating greater biodiversity, conserving energy, sequestering carbon, preserving and expanding natural habitats for animals and plants, enhancing aesthetics, increasing property values, and improving the livability of our neighborhoods.

These benefits, particularly in an urban environment, are significant, varied and yet related. As the U.S. EPA notes, these benefits include:

Reduced and Delayed Stormwater Runoff Volumes – Green infrastructure reduces stormwater runoff volumes and lowers peak flows by using the natural retention and absorption capabilities of vegetation and soils. By increasing the amount of pervious ground cover (i.e., ground cover that allows rain and snow melt to soak into the soil), green infrastructure techniques increase stormwater infiltration rates, thereby reducing the volume of runoff entering the City's combined and separate sewer systems, and ultimately the Quassaick Creek and Hudson River.

Reduced Localized Flooding – By increasing the absorption of rain and snowmelt through various green infrastructure approaches, there is less stormwater available to pond in roadways, homes and businesses lessening localized flooding.

Enhanced Groundwater Recharge **–** The natural infiltration capabilities of green infrastructure technologies can improve the rate at which groundwater aquifers are 'recharged' or replenished. This is significant because groundwater provides about 40% of the water needed to maintain normal base flow rates in our rivers and streams. Enhanced groundwater recharge can also boost the supply of drinking water for private and public uses.

Stormwater Pollutant Reductions – Green Infrastructure techniques infiltrate runoff close to its source and help prevent pollutants from being transported to nearby surface waters. Once runoff is infiltrated into soils, plants and microbes can naturally filter and break down many common pollutants found in stormwater.

Reduced Sewer Overflow Events – Using the natural retention and infiltration capabilities of plants and soils, green infrastructure reduces the frequency of sewer overflow events by reducing runoff volumes and by delaying stormwater discharges. This benefit is critical in a city like Newburgh where people swim and recreate in the Hudson River, the discharge point for the City's wastewater treatment facility for the City's combined and separate storm sewers.

Increased Carbon Sequestration - The plants and soils that are part of the green infrastructure approach serve as sources of carbon sequestration, where carbon dioxide is captured and removed from the atmosphere via photosynthesis and other natural processes. By capturing carbon, the vegetation reduces the amount of carbon that may otherwise wind up in the atmosphere contributing to climate change.

Urban Heat Island Mitigation and Reduced Energy Demands - Urban heat islands form as cities replace natural land cover with dense concentrations of hardscape that absorb and retain heat. Additionally, tall buildings and narrow streets trap and concentrate waste heat from vehicles, factories, and air

conditioners. By providing increased amounts of urban green space and vegetation, green infrastructure can help mitigate the effects of urban heat islands and reduce energy demands. Trees, green roofs and other green infrastructure can also lower the demand for air conditioning energy, thereby decreasing emissions from power plants.

Improved Air Quality - Green infrastructure relies on trees and vegetation in urban landscapes, which can contribute to improved air quality. Trees and vegetation absorb certain pollutants from the air through leaf uptake and contact removal. If widely planted throughout a community, trees and plants can even cool the air and slow the temperature-dependent reaction that forms ground-level ozone pollution (smog).

Additional Wildlife Habitat and Recreational Space - Greenways, parks, urban forests, wetlands, and vegetated swales are all forms of green infrastructure that provide increased access to recreational space and wildlife habitat.

Improved Human Health - An increasing number of studies suggest that vegetation and green space - two key components of green infrastructure - can have a positive impact on human health. Recent research has linked the presence of trees, plants, and green space to reduced levels of inner-city crime and violence, a stronger sense of community, improved academic performance, and even reductions in the symptoms associated with attention deficit and hyperactivity disorders. In a recent study from London, England published in the journal *Landscape and Urban Planning*, results showed that Londoners who live near more street trees get prescribed fewer antidepressants. According to the study, this association held true even when controlling for other local variables like socioeconomic status.

Increased Land Values - A number of case studies suggest that green infrastructure can increase surrounding property values. In Philadelphia, a green retrofit program that converted unsightly abandoned lots into "clean & green" landscapes resulted in economic impacts that exceeded expectations. Vacant land improvements led to an increase in surrounding housing values by as much as 30%. This translated to a $4 million gain in property values through tree plantings and a $12 million gain through lot improvements. Green infrastructure can also provide benefits to commercial properties where such approaches like street trees enhance the streetscapes within central business districts by making them more visually appealing and safer for pedestrians.

Increased Cost Efficiency – Green Infrastructure can also be cost effective. For example, a study released by the U.S. EPA in 2014 estimated that the City of Lancaster, PA would reduce its gray infrastructure capital costs by $120 million and reduce wastewater pumping and treatment costs by $661,000 per year by employing green infrastructure techniques within the City's combined sewer system (CSS) area. These benefits exceed the costs of implementing green infrastructure in the CSS area, which were estimated to range from $51.6 million if green infrastructure projects were integrated into planned improvement projects to $94.5 million if green infrastructure projects were implemented as stand-alone projects.

For more information on the public and private benefits of green infrastructure, please visit: http://water.epa.gov/infrastructure/greeninfrastructure/gi_why.cfm#WaterQuality

Section II - Green Infrastructure and the City of Newburgh

1. Planning for and Implementing Green Infrastructure in the City of Newburgh

Recognizing the importance of green infrastructure to the protection of the City's environment and public health, Newburgh seeks to integrate these practices into the City's fabric. In its 2008 sustainable comprehensive plan update, Plan-It Newburgh, the City established several goals and supporting strategies that, if implemented, will advance the use of green infrastructure. First, the City seeks to ensure the proper management of the natural environment to protect critical areas and conserve land, air, water and energy resources (Natural Resources Goal 2) for the purpose of maintaining their ecological functioning by:

- Prohibiting development in environmentally sensitive locations within the City limits;
- Including environmental protection and enhancement as an integral part of all City projects;
- Encouraging the use of Open Space or Cluster Zoning to focus new growth away from environmentally sensitive areas;
- Preventing or limiting development activity in hydrologically sensitive areas to protect a full range of wetlands and riparian functions; and
- Providing buffer planting requirements in the zoning code with an approved planting list.

Second, the City wants to reduce impervious cover and promote stormwater management best practices (Municipal Services Goal 3) by:

- Allowing the use of permeable surfaces for driveways and parking areas in residential and commercial developments; and
- Encouraging best management practices by minimizing and treating stormwater at its source, including the use of grass swales, rain gardens and green building techniques.

Third, the City desires to improve residents' quality of life by maintaining an equitable distribution of parks and open spaces and their interconnections (Natural Resources Goal 4). To achieve this goal the City recommends, among other strategies, to:

- Identify vacant City-owned properties and evaluate them for use as pocket parks or community gardens;
- Revise local ordinances to protect the City's open spaces through overlay zones or site plan requirements; and
- Include environmental protection and enhancement as an integral part of all development projects.

When implemented, the City's current Rezoning initiative will support these goals and strategies through a number of critical amendments, including the adoption of environmentally supportive zoning districts. First, the adoption of the Water Protection Overlay (WPO) District will promote the ecological health, biodiversity and natural habitats of and provide special protection to the City's creeks, stream corridors and waterbodies. The purpose of the WPO is to regulate land uses within or adjacent to a stream corridor or waterbody to protect water quality, biodiversity, scenic resources and reduce the risk of damage from flooding. The WPO includes and regulates all lands within 100 feet of the top of the bank on each side of the following waterbodies: Quassaick Creek and the ponds along its course:

(Muchattoes Lake, Stroock's Pond Harrison Pond); Gidneytown Creek and its tributary running parallel to route I-84; the unnamed stream Crystal Lake; Muchattoes Lake; the unnamed Stream that flows into Miller's Pond, through Crystal Lake and joins the Quassaick Creek at Little Britain Road east of Cerone Place; and that portion of the Hudson River that is not within the Planned Waterfront zoning district. Where there is no clearly defined bank, the district boundary shall be measured from the mean high-water line of the waterbody. All parcels having any part within the WPO will be subject to Site Plan review and approval, including recommendations from the City's CAC, and may not be exempted from that requirement.

Similarly, the establishment of the Conservation Development District (CDD) will use clustering and low impact development principles (discussed below) that encourage conservation of environmental resources in exchange for flexibility in bulk and area requirements and the potential for granting more intensive development if conservation goals are achieved. The primary conservation goals of the CDD are to: preserve and enhance open space, scenic views and environmentally sensitive features; protect steep slopes and flood plains by preserving vegetative cover to minimize the impacts of erosion and sedimentation; provide opportunities for on-site storm water management and groundwater recharge; encourage flexibility in the design of residential land uses that may not be permitted under traditional zoning regulations; promote a range of housing types; create on site recreation opportunities, and promote integration with neighboring land uses through trails and waterfront access points. Generally, density and dimensional standards in the CDD shall be approved by the City Planning Board based on the physical characteristics of the site; however, the number of dwelling units allowed in a CDD would be equal to the gross area of the CDD site, less environmental resources, divided by 3,000 square feet. The City Planning Board may grant a 20 percent density bonus if the proposed development substantially advances the environmental protection goals of the district. Importantly, development in the CDD also requires that 50 percent of the net land area of the parcel be preserved as open space by a permanent conservation easement or deed restriction. Like projects proposed with the WPO District, projects proposed within the CDD are subject to recommendations from the CAC.

While these landscape level land use approaches are vital to ensuring the continued integrity and ecological functioning of the City's existing open spaces, they must be supported by site-specific green infrastructure practices to address stormwater and urban air quality. These practices are beginning to occur within the City and will become standard practice as various City boards and commissions, including the Conservation Advisory Council, work to integrate green infrastructure approaches into local land use approvals.

2. Requiring the Use of Green Infrastructure to Address Stormwater

As noted above, developed areas disrupt the land's ability to absorb stormwater. Because land development is approved at the local level, federal and state laws require urbanized communities, like the City of Newburgh, to establish stormwater management programs whose goal is to maintain pre-development runoff conditions.

In New York State, the regulation of stormwater is administered by the Department of Environmental Conservation (DEC) under delegation by the U.S. EPA pursuant to the federal Clean Water Act. DEC implements the federal program through the issuance of two statewide General Permits under its State Pollutant Discharge Elimination System (SPDES):

- Under the SPDES General Permit for Stormwater Discharges from Construction Activity (GP-02-01), construction site operators must notify the state of any project disturbing one acre or more

of soil, prepare a formal written Stormwater Pollution Prevention Plan (SWPPP) and adhere to the provisions of the plan during and after construction.

- Under the SPDES General Permit for Stormwater Discharges from Municipal Separate Stormwater Sewer Systems, or MS4s (GP-02-02), regulated MS4s, like the City of Newburgh, must establish stormwater management programs that reduce the discharge of pollutants to the maximum extent practicable, including reviewing and approving SWPPPs and regulating illicit discharges to the stormwater sewer system.

To help construction site operators comply with the requirements for managing stormwater during construction activities that disturb one acre or more of land, DEC developed the New York Standards and Specifications for Erosion and Sediment Control. The standards and specifications listed in the manual have been developed over time to reduce the impact of soil loss from construction sites to receiving water bodies and adjacent properties. The manual follows low impact development principles and provides designers with details on how to plan a site for erosion and sediment control and how to select, size, and design specific practices to meet these resource protection objectives.

Similarly, DEC published the New York State Stormwater Management Design Manual to assist project designers and regulated MS4 municipalities to satisfy their obligations under state regulations concerning post-construction circumstances. This manual, which DEC updated in January 2015, provides an overview on how to size, design, select, and locate stormwater management practices at a development site to comply with State stormwater performance standards. Because of the many benefits provided by green infrastructure, DEC amended the Design Manual in 2010 to prioritize the use of green infrastructure techniques. A number of the techniques described in Chapter 5 of the Design Manual are discussed more fully below.

The City of Newburgh is regulated as an MS4 and adopted its Stormwater Management Program in 2007. As part of this program, the City enacted a stormwater ordinance that establishes site and development standards that must be satisfied for subdivisions, site plans and construction projects where one acre or more of soil will be impacted. Under the ordinance, most development projects will require the preparation and approval of a Stormwater Pollution Prevention Plan (SWPPP), that, when implemented will result in no increase in peak stormwater discharge from the project site's predevelopment conditions as compared to its post development conditions. Projects subject to this requirement include:

- the subdivision of land;
- the approval of a site plan;
- the issuance of a building permit where greater than one acre of property will be impacted;
- the construction or extension of an existing City street or property, or private roadway; alteration of an existing drainage system or watercourse;
- redevelopment of existing sites; or
- such other project undertaken within the boundaries of the City or on or adjacent to property in which the City has an interest which poses an impact upon such property and which in the opinion of the City Engineer requires the creation and implementation of such plan to satisfy the purpose and objectives of the stormwater management program.

Where a SWPPP is required, the plan must be prepared in accordance with the New York State Stormwater Management Design Manual, including the emphasis on the use of green infrastructure. These plans are reviewed by the City of Newburgh engineer, who serves as the City's stormwater

management officer. Upon review, a SWPPP is provided to the applicable land use board or City department for consideration as part of the development approval process.

3. The City's Current Green Infrastructure

SUNY-Orange, Newburgh Campus vegetated roof and rainwater harvesting system (Image courtesy of SUNY-Orange)

The City of Newburgh's parks, stream corridors, and urban tree canopy comprise larger, system-wide green infrastructure within the City. Currently, the City contains 341 acres of dedicated parkland, including approximately 32 acres of active parks and 309 acres of passive parks. The greater percentage of City-owned passive parkland, however, is the area surrounding Washington Lake, which is 270 acres located in the Town of Newburgh. These areas serve to reduce stormwater flows, reduce pollutant loads into the City's storm sewers and combined sewers, lessen urban air temperatures, provide wildlife habitat, and provide active and passive recreational opportunities for Newburgh residents. Please see the City of Newburgh Parkland Map here.

Newburgh also has several examples of site-specific green infrastructure practices. On the SUNY-Orange Newburgh campus, the college installed a vegetated roof as well as rain gardens to reduce stormwater flows from the development of Kaplan Hall. The green roof is located above the campus's parking garage and comprises part of an expansive plaza that overlooks the Hudson River.

Another site-specific project located within the City is found at the City's Water Treatment Plant. The Orange County Soil and Water Conservation District collaborated with Water Treatment Plant staff to install three separate rain gardens on the plant's property located at 493 Little Britain Road. The gardens serve to catch stormwater runoff from impervious surfaces such as plant's parking areas and prevent it from leaving the site and flowing into catch basins. Below are two pictures of the rain gardens after installation.

Rain gardens installed at the City of Newburgh Water Treatment Plant (Images courtesy of Orange County Soil & Water Conservation District

4. The CAC and Green Infrastructure

The Newburgh City Council has given the CAC a number of responsibilities that will advance the use of green infrastructure throughout the City. These responsibilities include:

- Advising various City agencies on greening the City's infrastructure;
- Studying problems and identifying the City's needs in connection with stormwater management, green infrastructure, sustainability and watershed protection;
- Making recommendations to the City Council as to desirable policy, promotion activities, and legislation concerning urban forestry and a tree maintenance program;
- Reviewing and making recommendations on any development application that seeks approval for the use or development of City's open space and natural resources;
- Providing an advisory consistency recommendation in accordance with the City's Local Waterfront Revitalization Program policy standards for any project within the Local Waterfront Revitalization Area;
- Reviewing and making recommendations on any application for sidewalk repair or replacement;
- Advising and making recommendations to the City's Superintendent of Public Works regarding the planting, pruning or removal of City trees. (6) Funding and training opportunities for tree maintenance and plantings and green infrastructure techniques; and
- Advising the Superintendent of Public Works, the Engineering Department, and the Water Department as to stormwater management relating to green infrastructure.

To facilitate these responsibilities, the CAC is taking the novel approach of working to identify some of the City's built environment that may be converted into green infrastructure (discussed specifically, below). The Natural Resources Inventory (NRI), which is currently being prepared, will highlight existing streets, medians, sidewalks, hard-packed underutilized and vacant lots, surface parking, and other impervious areas to be analyzed for their potential contributions to green infrastructure functions, including stormwater management.

As part of this NRI effort, the CAC will be incorporating the results of the *City of Newburgh Green Infrastructure Feasibility Report* prepared by eDesign Dynamics (EDD) with support from Hudson River Sloop Clearwater (Clearwater) and the Quassaick Creek Watershed Alliance (QCWA). EDD, Clearwater, and QCWA worked with the City of Newburgh to address local water quality concerns, the federal Clean Water Act, Combined Sewer Overflows (CSOs), natural hydrologic systems, and the potential role to be played by green infrastructure approaches for residents of Newburgh. EDD developed specific green infrastructure interventions in collaboration with stakeholders and are intended to complement the City's draft Long Term Control Plan (LTCP) to address combined sewer overflows (CSOs), regular and on-going road reconstruction work, and future land use planning. Of the many locations identified for possible green infrastructure practices, those with the highest potential to reduce CSOs and improve water quality in the Hudson or the Quassaick were chosen for further elaboration. The potential green infrastructure sites identified by EDD, along with its recommended green infrastructure techniques, will be incorporated into the CAC's NRI. These sites and recommended practices will serve as initial priority locations for the CAC when conducting project reviews.

In addition to identifying potential green infrastructure sites, the CAC has adopted a **Green Infrastructure Policy** that will guide its review of those development projects that are brought before it. This policy recognizes the critical importance of green infrastructure to the protection and enhancement

of the City's natural resources, the health of its residents, and the City's long-term, sustainable economic growth. Simultaneously, the policy recognizes that the CAC is an advisory body only and that its efforts to promote and encourage the use of green infrastructure, where otherwise not required by State law, will be based upon its ability to persuade the City Council, land use boards and residents of the benefits that will accrue to the City through green infrastructure's use.

To ensure that green infrastructure practices become integrated into the City's land use planning and approval processes, the Newburgh CAC advances the following **Green Infrastructure Policy** consistent with low impact development strategies and green infrastructure practices found in New York State:

1. ***Avoid Development Impacts:***
    a. Prioritize redevelopment of existing buildings;
    b. Promote infill development of vacant parcels where such parcels are not currently being used for community gardens or other open space uses;
    c. Where new development is to occur, employ Low Impact Development principles that preserve existing site natural resources and features such as wetlands, stands of trees, and natural topography; develop only in the least environmentally sensitive areas of the site; and use conservation design techniques.

2. Limit Site Impervious Surface:
    a. Employ Low Impact Development principles to reduce the amount of impervious surface necessary to support site development, including appropriately limiting building footprints and reducing the number of parking spaces to support site use.

3. Manage Development Impacts:
    a. Utilize a site's natural features and green infrastructure techniques to slow down stormwater runoff, promote infiltration and evapotranspiration, and minimize the need for the structural stormwater controls;
    b. Where appropriate, plant native trees and plants to increase a site's tree canopy and vegetation to improve local air quality.

4. Enhance the City's Natural Environment
    a. Where the City is undertaking street or sidewalk improvements, look for opportunities to add to the City's tree canopy by planting new street trees and integrating specific green infrastructure techniques like bioswales and curb cuts that flow into tree pits.
    b. Look for opportunities to add green infrastructure practices to existing City buildings such as green roofs and green walls to serve as demonstration projects to City residents and developers.

5. ***Coordinate Intermunicipal Cooperation to Ensure Watershed Protection***
    a. Work with City of Newburgh departments, DEC's Hudson River Estuary Program, and other appropriate stakeholders to develop an intermunicipal hazard mitigation plan with adjoining municipalities to ensure the long-term protection of the City's water supply.

In light of the CAC's Green Infrastructure Policy, the Green Infrastructure Guide below highlights particular green infrastructure practices to reduce the generation of and impacts from stormwater as well as improve the City's local air quality.

Section III – Green Infrastructure Practices to Reduce Stormwater Flows and Mitigate its Impacts

As discussed above, green infrastructure to address stormwater includes a wide array of practices at multiple scales to manage and treat stormwater, maintain and restore natural hydrology and ecological function by infiltration, evapotranspiration, capture and reuse of stormwater, and establishment of natural vegetative features. Above, the Guide highlighted some of the municipal scale approaches that the City of Newburgh is likely to take through its eventual adoption of the Rezoning initiative. These include the protection of waterways throughout the City with the creation of a Water Protection overlay zone and the establishment of a Conservation Design District that relies on clustering and site design to preserve natural landscape features. Similarly, the City's emphasis on redeveloping its downtown core and waterfront by reusing existing buildings will serve to lessen development demand on the City's remaining open areas.

The green infrastructure practices introduced below focus on site- and neighborhood-specific practices and runoff reduction techniques and are drawn from Chapters 3 and 5 of the New York State Stormwater Management Design Manual. When implemented, these practices will result in stormwater runoff reduction that will protect and enhance the City's stream corridors and the Hudson River. These practices will also improve the visual environment of the City by adding new greenscape to the more developed portions of the City.

Green infrastructure techniques to address stormwater can be grouped into four broad categories:

- **Low Impact Development (LID) techniques**, such as preserving undisturbed site areas and natural features, reducing grading and site clearing, and siting structures in the least sensitive areas of a site – they reduce the amount of impervious surface to be placed on a parcel of land.
- **Infiltration techniques**, such as permeable pavements, disconnected downspouts, and rain gardens—they are engineered structures or landscape features designed to capture and infiltrate stormwater, reduce runoff volume, and treat or clean runoff.
- **Evapotranspiration practices**, such as green roofs, bioswales, trees, and other vegetation—they can reduce stormwater runoff volumes by returning water to the atmosphere through evaporation of surface water or through transpiration from plant leaves. Trees and shrubs can also filter air pollutants and improve air quality.
- **Capture and reuse practices**, such as rain barrels and cisterns—they capture stormwater for non-potable household uses, irrigation, or gradual infiltration.

Table 1, below, is drawn from Chapter 3 of the Stormwater Management Design Manual and lists many of the LID techniques that are to be used in the development of SWPPP where an acre or more of soil will be disturbed during construction activities:

Table 1 – Planning Practices for Preservation of Natural Features & Impervious Surface Reduction

Group	Practice	
Preservation of Natural Resources	Preservation of Undisturbed Areas	Delineate and place into permanent conservation easement undisturbed forests, native vegetated areas, riparian corridors, wetlands, and natural terrain.

	Preservation of Buffers	Define, delineate and place in permanent conservation easement naturally vegetated buffers along perennial streams, rivers, shorelines and wetlands.
	Reduction of Clearing and Grading	Limit clearing and grading to the minimum amount needed for roads, driveways, foundations, utilities and stormwater management facilities.
	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.
	Open Space Design	Use clustering, conservation design or open space design to reduce impervious cover, preserve more open space and protect water resources.
	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.
Reduction of Impervious Cover	Roadway Reduction	Minimize roadway widths and lengths to reduce site impervious area
	Sidewalk Reduction	Minimize sidewalk lengths and widths to reduce site impervious area
	Driveway Reduction	Minimize driveway lengths and widths to reduce site impervious area
	Cul-de-sac Reduction	Minimize the number of cul-de-sacs and incorporate landscaped areas to reduce their impervious cover.
	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.
	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.

These practices are described more fully in Chapter 5 of the Stormwater Management Design Manual and may be found here.

The remaining green infrastructure techniques that infiltrate, evapotranspirate, capture and reuse stormwater are engineered practices that can be incorporated into site design to allow for site-level management of runoff. Together, these practices result in less stormwater runoff by promoting groundwater recharge, increasing water losses through evapotranspiration (the evaporation of water from plant leaves (transpiration) and evaporation of water from the land's surface) and emulating a site's preconstruction hydrology.

Table 2, below, adapted from Chapter 5 of the Stormwater Management Design Manual, lists a number of runoff reduction green infrastructure practices, provides a brief description of the practice and shows an image of the practice in use in New York State.

Table 2 – NYS Green Infrastructure Practices to Reduce Stormwater Runoff

Practice	Description	Image
Vegetated open swale Harrier Hill Park, Stockport, Columbia County, vegetated swale (Image courtesy NYS DEC)	The natural drainage paths, or properly designed vegetated channels, can be used instead of constructing underground storm sewers or concrete open channels to increase time of concentration, reduce the peak discharge, and provide infiltration.	
Tree planting / tree box Rome, NY street trees (Image courtesy NYS Environmental Facilities Corporation)	Plant or conserve trees to reduce stormwater runoff, increase nutrient uptake, and provide bank stabilization. Trees can be used for applications such as landscaping, stormwater management practice areas, conservation areas and erosion and sediment control.	
Disconnection of rooftop runoff (Image courtesy NYS Environmental Facilities Corporation)	Direct runoff from residential rooftop areas and upland overland runoff flow to designated pervious areas to reduce runoff volumes and rates.	

Stream daylighting for redevelopment projects Sawmill River, Yonkers, NY (Image courtesy http://frogma.blogspot.com)	Stream Daylight previously-culverted/piped streams to restore natural habitats, better attenuate runoff by increasing the storage size, promoting infiltration, and help reduce pollutant loads.	
Rain garden SUNY-Orange rain garden, Middletown, NY (Image courtesy NYS DEC)	Manage and treat small volumes of stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression.	
Green roof Beacon Institute Green Roof Beacon, NY (Image courtesy NYS DEC)	Capture runoff by a layer of vegetation and soil installed on top of a conventional flat or sloped roof. The rooftop vegetation allows evaporation and evapotranspiration processes to reduce volume and discharge rate of runoff entering conveyance system. In summer, depending on the plants and depth of growing medium, green roofs retain 70-90% of the precipitation that falls on them; in winter they retain between 25-40%.	
Stormwater planter Portland, OR (Image courtesy NJ Future)	Small landscaped stormwater treatment devices that can be designed as infiltration or filtering practices. Stormwater planters use soil infiltration and biogeochemical processes to decrease stormwater quantity and improve water quality.	

Rain tank/Cistern Buffalo, NY rain barrel (Image courtesy Buffalo Niagara Riverkeeper)	Capture and store stormwater runoff to be used for irrigation systems or filtered and reused for non-contact activities.	
Porous Pavement Beacon Institute porous pavers Beacon, NY (Image courtesy NYS DEC)	Pervious types of pavements that provide an alternative to conventional paved surfaces, designed to infiltrate rainfall through the surface, thereby reducing stormwater runoff from a site and providing some pollutant uptake in the underlying soils.	

Section IV – Green Infrastructure to Address Urban Air Quality

A. Urban Forests

As discussed above, urbanized communities like the City of Newburgh experience air quality issues, including increased air pollutant emissions and increased temperatures that are not found in less developed areas. Green infrastructure, in the form of urban forests, will play an important role in addressing these concerns.

Urban neighborhoods are protected by tree canopies covering streets, sidewalks, private lots, parks, and other private and public lands. Similarly, trees on private lots shade residences, workplaces, and shopping areas. These trees are sometimes called urban forests and they constitute a large percentage of a community's green infrastructure.

Urban forests help reduce energy consumption. With leaves on, the urban tree canopy shades buildings, sidewalks, streets and other structures keeping them cooler during the warmer months, which reduces the need for air conditioning. Trees placed in the proper location along with correct tree species selection, can shelter buildings from cold winds in winter months reducing heating costs. Taken together, these uses of trees lower overall energy consumption in urbanized communities.

Urban forests also sequester carbon that might otherwise contribute to global climate change. Between 1990 and 2012, the amount of carbon sequestration by urban trees increased by 46.3 percent in the

United States. While the total amount of sequestration contributed by urban trees is small compared to that in rural areas, it remains important. In New York City, its 5.2 million trees remove over 42,000 tons of carbon each year and store about 1.35 million tons of carbon valued at $24.9 million.

Additionally, trees in urbanized communities also have positive effects on human health. As noted by the New York State DEC, "studies have found that exposure to trees reduces the symptoms of stress and depression, can aid in the recovery from surgery, and reduce the incidence of domestic violence." In a recent study from London, England published in the journal *Landscape and Urban Planning*, results showed that Londoners who live near more street trees get prescribed fewer antidepressants. According to the study, this association held true even when controlling for other local variables like socioeconomic status.

While land use regulations and project approvals can be used to preserve urban trees, efforts need to be made to plant new trees. For example, New York City initiated its MillionTreesNYC program in 2007, a citywide, public-private initiative that seeks to plant and care for one million new trees across the City's five boroughs over the next decade. New York City hopes that by planting one million additional trees, it can increase its urban forest by 20 percent, while achieving the many quality-of-life benefits that come with planting trees.

As part of its Natural Resource Inventory, the City of Newburgh CAC is currently conducting a tree inventory. This inventory will quantify the City's trees to determine the extent of the City's urban tree canopy, the number of tree species located within the City, and the value of environmental benefits provided by those trees. This information will aid the CAC in determining which areas of the City should be targeted for increased tree plantings as street and sidewalk improvements are constructed by the City.

B. Green Roofs and Walls

Augmenting the benefits of urban forests, vegetation on buildings can enhance green infrastructure in urbanized environments like the City of Newburgh. Green roofs, sometimes also called eco-roofs or vegetated roofs, are specially designed rooftop gardens or lawns that retain stormwater, provide habitat, improve building efficiency, and increase a community's aesthetics.

Importantly, green roofs and walls also improve urban air quality. Through the daily dew and evaporation cycle, plants on vertical and horizontal surfaces are able to cool urbanized areas during hot summer months. They reduce the Urban Heat Island (UHI) effect through the vegetation's absorption of light that would otherwise be converted into heat energy. Additionally, by covering rooftops that are often black, the ability of those rooftops to absorb and retain the heat from the sun is lessened. In turn these circumstances reduce the demand for building cooling and the electricity needed to power cooling systems. Like urban forests, green roofs also capture airborne pollutants and atmospheric deposition, filter noxious gases and sequester carbon.

Green walls, which are similar to green roofs, but are located on the facades of buildings, provide similar air quality benefits. A green wall is a vertical garden that is pre-planted in panels and then attached to the facade of the building. The plants stay in their vertical positions because their root structures are anchored in 2-4 inches of soil kept within the panel. As with green roofs, green walls capture airborne pollutants and atmospheric deposition, filter noxious gases, sequester carbon and reduce ambient air temperatures.

Where appropriate, the CAC will look for opportunities to promote the use of green roofs and walls during the review of site plans and other land use approvals where the CAC is to provide its recommendations to the appropriate land use board.

Section V – City of Newburgh CAC Green Infrastructure Technical Recommendations

One of the CAC's primary responsibilities is to review certain land development applications and all permit applications for sidewalk repair or replacement. In the context of these project reviews, the CAC will evaluate permit applications consistent with its **Green Infrastructure Policy**. In accordance with Paragraphs 3 and 4 of the Policy, the CAC seeks to enhance the City's environment by having project applicants install appropriate green infrastructure practices, particularly new street trees and their tree pits.

To assist project applicants in addressing this policy, the CAC incorporates a number of the recommended Green Infrastructure Design Guidelines prepared on behalf of the City of Newburgh by eDesign Dynamics as part of its *Green Infrastructure Feasibility Report* along with practices recommended by DEC.

1. Sizing Criteria

Sizing of green infrastructure should be based on a volume associated with a standard rainfall event. It is recommended that GREEN INFRASTRUCTURE practices in Newburgh be sized to accommodate the NYSDEC Water Quality Volume (WQv). NYSDEC defines the WQv as the volume of runoff resulting from the 90th percentile rainfall event, which
for Newburgh is estimated to be 1.1 inches of rain. As per DEC:

WQv = [(P)(Rv)(A)] / 12, where:
Rv = 0.05+0.009(I); I = Percent Impervious Cover; minimum Rv=0.02
P = 90th percentile rainfall event in inches = 1.1 inches
A = catchment area in acres

Using the WQv to size green infrastructure allows for a significant reduction in runoff from entering the combined sewer system, with approximately 90% of rainfall events being completely managed and larger events (greater than 1.1 inches) being partially managed. The WQv also has the added benefit of allowing green infrastructure systems to treat stormwater in separate sewer systems, provided a 24-hour extended detention, as per DEC's guidelines. Note: the WQv is a target volume, and should not be used as the sole criteria in evaluating green infrastructure opportunities. Green infrastructure systems are still effective when the WQv cannot be fully managed. Additionally, providing excess capacity beyond the WQv may not always be cost-effective, but can provide additional storage and opportunity to expand the contributing area. Finally, when designing green infrastructure practices that require excavation, a maximum depth of five feet below existing grade shall be used to avoid high construction costs associated with shoring.

2. Buried Utility Setbacks

As construction of green infrastructure systems generally involves excavation and occasional use of buried pipe, a setback from existing buried utilities is typically required. To determine the location of these utilities a survey shall be performed on site, as part of the initial feasibility analysis. In some cases the utility may possess an easement to allow for their own excavation and repair. Examples of subsurface infrastructure include gas, electric, cable, water, sewer, and telecom. A utility setback of three feet from the lateral extent of the utility is recommended, though in some cases, such as high-tension electrical lines, the setback can be as high as five feet. When developing its guidelines, Newburgh should establish a convention that meets with the approval from all relevant utility owners.

3. Foundation Setbacks

Where green infrastructure systems intend to promote infiltration (ie: unlined retention-type systems), a setback from existing building foundations or other subsurface utility vaults should be established in order to prevent intrusion, basement flooding and corrosion. These setbacks vary nationally from between five and twenty feet, though ten feet is becoming standard. In some dense urban areas, the setback can be reduced to five feet with the use of a vertical barrier lining the sides of the infiltration-based system to limit the lateral movement of water. This technique, however, has not yet been demonstrated to be effective. When the green infrastructure practice does not allow for infiltration (ie: pure detention systems with complete liners), setback from foundations should be based on structural concerns rather than risk of flooding.

4. Depth to Bedrock or Seasonally High Water Table

Most sets of guidelines require that infiltration-based green infrastructure remain a certain distance above bedrock and above the seasonally high water table. These conditions are determined using a geotechnical probe or drill rig under the guidance of a professional geologist or engineer. At the time of drilling, it is also common to perform an infiltration test on the in situ soils at the depth prescribed for the bottom of the green infrastructure. The NYSEFC specifies that green infrastructure must be installed at least three feet over bedrock and seasonally high water table.

5. Guidelines for Green Infrastructure in the Right-of-Way

When designing green infrastructure in the Right-of-Way (ROW) it is important to adhere to all local and state agency regulations (see Regulatory Approval and Permits below). In addition, minimum setbacks are recommended to allow for clear access of pedestrians and vehicles, and protection of existing structures. The most important consideration for designing green infrastructure in the ROW is allowing a five foot minimum clear path for pedestrian access on sidewalks. For high density neighborhoods the minimum clearance can be greater. Table 1 below lists suggested minimum distances for designing and constructing green infrastructure in the ROW.

Table 3 – Suggested Setbacks for Green Infrastructure Practices Located in the Right-of-Way

Recommended minimum distance/setback	From
Five feet	Existing structures and street furniture such as traffic signs, street lighting, fire hydrants, benches etc.

Five feet	Pedestrian ramps.
Five feet	Legal curb cuts/driveways.
Five feet	Property lines.
Three feet	Subsurface infrastructure including gas, electric, water, sewer, telecom, etc.
Drip line	Existing tree canopies.
Ten feet	Existing building foundations

6. Soil Tests

When geotechnical borings are to be performed, it is advisable to perform waste classification testing of the in situ soil at elevations that would fall within the proposed green infrastructure. Since green infrastructure designs often require replacing existing soil with gravel and engineered soil, the cost of disposal of excavated soils should be considered in advance. In urban areas, legacy contamination may trigger costly disposal fees when certain constituents exceed safe concentrations. Environmental laboratories are equipped to perform a set of tests based on the local or state regulatory requirements for solid waste disposal. At least one composite sample taken from the proposed location should be tested well in advance of construction.

7. Infiltration Tests

A number of protocols are available for testing the infiltration capacity of undisturbed soils. In urban areas it is common to find a large quantity of fill material placed over the natural soil, making it difficult to assess the capacity at points below the surface. When geotechnical work is to be performed, it is common to require an infiltration test at the elevation of the bottom of the proposed green infrastructure. Infiltration can be measured using the standard protocol described in ASTM D6391-11. Alternatively, some municipalities recommend performing the test in an open pit. The City of Newburgh will need to select its preferred method, based on local costs and conditions, and establish a precise protocol and minimum infiltration rate for infiltration-based systems.

8. Tree Species

When planting trees, the tree species and size should be appropriate for location and soil type among other factors. The City of Newburgh lies within the US Department of Agriculture Tree Hardiness Zone 6a. Given this location, and based upon the expertise of the DEC, the CAC recommends that the following species of trees be considered:

[Insert list of tree species currently recommended by CAC]

For further information about performing a tree site assessment and selecting an appropriate tree species, please visit: http://www.hort.cornell.edu/uhi/outreach/recurbtree/pdfs/~recurbtrees.pdf

9. Tree Pits

Finally, tree pits provided for street trees should adhere to the following specifications:

(a) **Tree Pit Size** – Tree pits should be as large as possible to allow for ample growing space for tree roots and crown. The overall width of a sidewalk can limit the size of a tree pit. Ideal tree pit sizes are 4 feet by 10 feet or 5 feet by 10 feet where space allows. If the recommended tree pit size does not match the builder's pavement plan, the plan must be revised.

(b) **Backfill** - Material shall consist of natural loam topsoil with the addition of humus only, and no other soil type, such as a sand or clay soil type, shall be accepted. Topsoil must be free from subsoil, obtained from an area which has never been stripped. It shall be removed to a depth of one (1) foot, or less if subsoil is encountered. Topsoil shall be of uniform quality, free from hard clods, stiff clay, hardpan, sods, partially disintegrated stone, lime, cement, ashes, slag, concrete, tar residues, tarred paper, boards, chips, sticks or any other undesirable material. If a truckload of topsoil is considered by the Agency to contain too much undesirable material to be corrected on the site, the entire truck load shall be rejected. No topsoil shall be delivered in a frozen or muddy condition. Topsoil shall comply with the following requirements:

i. Organic Matter. Must be between eight (8) and twelve (12) percent by weight, as determined by the Dry Combustion Method for Total Carbon and Organic Carbon (using a multiplying factor of 2) as described in Methods of Soil Analysis, #9, Part 2, 2nd ed. published by the American Society of Agronomy. The organic content shall not exceed fourteen percent (14%).
ii. pH range. Shall be 6.0 to 7.0 inclusive.
iii. Sieve Analysis (by Wash Test, ASTM Designation C-117). Passing 2" sieve (100%); Passing 1" sieve (95% to 100%); Passing #4 sieve (90% to 100%); Passing #100 sieve (30% to 60%).
iv. Clay. The test method to measure the clay content of the soil shall be ASTM D 422.

The Engineer reserves the right to reject topsoil in which more than 60% of the material passing the No. 100 U.S.S. Mesh sieve consists of clay as determined by the Buoyoucous Hydrometer or by the decantation method. All percentages are to be based on dry weight of sample. When the topsoil otherwise complies with the requirements of the specification but show a deficiency of not more than one (1) percent in organic matter, it may be incorporated when and as permitted by the City Engineer. Electrical Conductivity shall be less than 1500 mhos/cm. A higher level would indicate excessive salt content. The testing method must be the saturated paste method.

At final inspection if soil does not appear to meet specifications you will not receive a final sign-off of your permit. If directed, topsoil which varies only slightly from the specifications may be made acceptable by such corrections as the City Engineer deems necessary.

(c) **Mulch** – Shredded bark mulch shall be a natural forest product of 98% bark containing less than 2% wood or other debris. It shall be of White or Red Fir and/or Pine bark of a uniform grade with no additives or any other treatment. Size of bark shall be from 5/8" to 1-1/4".The pH factor should range from 5.8 to 6.2. Shredded bark may also be used.

(d) **Finishing** – Paving blocks, installed in the manner described below, are required within each sidewalk tree pit, unless a tree pit guards is going to be installed. Please note that the City will take action if the tree guard or paving endangers the long-term health and survival of City-owned trees. The City does not allow tree grates to be installed around newly planted or existing trees.

(e) **Paving Blocks**

i. Materials – Granite Block Pavers: Granite blocks shall be new or used and shall be cut from fine to medium grained sound and durable granite. The granite shall be reasonably uniform in quality and texture throughout and shall be free from an excess of mica and feldspar and from seams, scales or evidence of disintegration. If used blocks are utilized they shall be clean, free from mortar, asphalt, etc.

ii. Blocks shall be fairly rectangular in shape and shall be not less than four (4) inches nor more than twelve (12) inches in length; not less than three (3) nor more than five (5) inches in width; not less than three (3) nor more than five (5) inches in depth. The blocks shall be cut so that opposite faces will be approximately parallel and adjoining faces approximately at right angles to each other. Granite blocks shall be so dressed that they may be laid with one (1) inch joints. All blocks shall have one reasonably smooth split head.

iii. Installation – Paving blocks shall be installed using a sand cushion. The sand shall consist of clean, hard, durable, uncoated stone particles, free of lumps of clay and all deleterious substances and shall be so graded when dry, one hundred percent shall pass a ¼ inch square opening sieve; not more than thirty-five percent by weight shall pass a No. 50 sieve. Sand shall conform to ASTM C-33. Trim and tamp the subgrade to smooth, uniform lines prior to placing the pavers. The pavers shall be laid on a sand cushion with a minimum thickness of one inch. The sand cushion shall be compacted by hand tamping, or as directed by the Engineer. Joints between pavers shall be a maximum of one inch and a minimum of three quarters inch in width. Joints around the edge of the pit shall be hand tight. Joints along the inner ring of blocks must be filled with a cement mortar of a wet mixture of one part Portland cement and two parts sand.

For further information, including tree pit drawings, please refer to the Tree Planting Standards prepared by the New York City Department of Parks and Recreation, from which the above tree pit standards are adapted.

Section VI - Green Infrastructure Resources

We hope that the information above has provided you with a good overview of green infrastructure, its many public and private benefits, and how green infrastructure is and will be implemented in the City of Newburgh. For further information about the topics covered in this Green Infrastructure Guide please visit the websites and documents listed below.

Green Infrastructure Generally

New York State Resources

- *2014 Draft New York State Open Space Conservation Plan* – http://www.dec.ny.gov/lands/98720.html
- *Economic Benefits of Open Space Preservation*, Office of the New York State Comptroller (March 2010)- http://www.dec.ny.gov/docs/lands_forests_pdf/openspacepres.pdf
- *Green Infrastructure Plan for Saratoga County*, Saratoga County Board of Supervisors (November 21, 2006) - http://www.saratogaplan.org/documents/FullPlan_LessApp.pdf

Other Resources

- *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits*, Center for Neighborhood Technology and America Rivers (2010) - http://www.cnt.org/media/CNT_Value-of-Green-Infrastructure.pdf

Low Impact Development

New York State Resources

- *Better Site Design*, NYS Department of Environmental Conservation (April 2008) - http://www.dec.ny.gov/docs/water_pdf/bsdcomplete.pdf
- *Low Impact Development Design Strategies: A guide for the communities of the West-of-Hudson portion of the New York City Water Supply System Watershed*, Schoharie County Planning and Development Department (date unavailable) – (on file with CAC)
- *Local Open Space Planning Guide*, New York State Department of State (2004) – http://www.dos.ny.gov/lg/publications/Local_Open_Space_Planning_Guide.pdf
- *Town of Clinton Recommended Model Development Principles for Protection of Natural Resources in the Hudson River Estuary Watershed*, Town of Clinton et al. (June 2006) - http://www.dec.ny.gov/docs/remediation_hudson_pdf/hrewbsdclin.pdf
- *Watershed Design Guide: Best Practices for the Hudson Valley*, Orange County Planning Department and Regional Plan Association (2014) - http://waterauthority.orangecountygov.com/PROJECTS/DESIGN_GUIDE/OC-Watershed-Design-Guide_Final%20(11-24-14).pdf

Federal Resources

- *Open Space Development, Model Ordinances to Protect Local Resources*, US Environmental Protection Agency - http://water.epa.gov/polwaste/nps/openspace.cfm

Other Resources

- *Pembroke Woods: Lessons Learned in the Design and Construction of an LID Subdivision*, Michael Clar P.E. President, Ecosite, Inc. (date unknown) - http://www1.villanova.edu/content/dam/villanova/engineering/vcase/sym-presentations/2003/4A4.pdf
- *Skinny Streets and One-sided Sidewalks: A Strategy for Not Paving Paradise*, Rutgers Cooperative Extension, Water Resources Program http://www.water.rutgers.edu/Educational_Programs/Senior%20Design2008/ELC_PWP50.pdf

Green Infrastructure for Stormwater Reduction and Impact Mitigation

New York State Resources

- *City of Newburgh Green Infrastructure Feasibility Report*, eDesign Dynamics (October 2014) – [insert link when available]
- *Stormwater Management Guidance Manual for Local Officials*, NYS Department of Environmental Conservation (September 2004) - http://www.dec.ny.gov/docs/water_pdf/localall.pdf
- *New York State Stormwater Management Design Manual*, NYS Department of Environmental Conservation (Updated January 2015) - http://www.dec.ny.gov/chemical/29072.html
- *New York Standards and Specifications For Erosion and Sediment Control* (Blue Book), NYS Department of Environmental Conservation (August 2005) - http://www.dec.ny.gov/docs/water_pdf/bluebook.pdf
- *Code and Ordinance Worksheet for Development Rules in New York State, Hudson River Estuary Program*, NYS Department of Environmental Conservation (2011) - http://www.dec.ny.gov/docs/remediation_hudson_pdf/cownys.pdf
- *Barriers to Green Infrastructure in the Hudson Valley: An electronic survey of implementers*, Hudson River Estuary Program, NYS Department of Environmental Conservation and New York State Water Resource Institute at Cornell University (2012) - http://www.dec.ny.gov/docs/remediation_hudson_pdf/giresults12.pdf
- *Grant Funding Opportunities For Green Infrastructure Retrofit Projects*, Lower Hudson Coalition of Conservation Districts (October 2013) - http://www.lhccd.net/uploads/7/7/6/5/7765286/gi_retrofit_funding_opps_2013_10.pdf
- *Green Infrastructure Examples for Stormwater Management in the Hudson Valley*, Hudson River Estuary Program, NYS Department of Environmental Conservation - http://www.dec.ny.gov/lands/58930.html (This website describes a variety of green infrastructure practices, organized both by type and by county)

- *Green Infrastructure Model Local Law Project Summary Report: Process, Findings, and Implementation*, Stormwater Coalition of Albany County (November 2013) - http://www.stormwateralbanycounty.org/wp-content/uploads/2011/12/A_GrnInfModLocLawProj_SWCoalAlbCntyNY_2013_Nov_For Distribution.pdf
- *Green Infrastructure Practices at Work Video Series*, Lower Hudson Coalition of Conservation Districts - http://www.lhccd.net/green-infrastructure.html
- *Honey, It's Time to Mow the Roof: Incorporating Green Infrastructure into Municipal Planning*, Sara Jade Pesek and Sarah Kelsen, Clearwaters (Winter 2008) - http://www.nywea.org/Clearwaters/08-4-winter/06-Incorporating.pdf
- *Managing Stormwater for Urban Sustainability Using Trees and Structural Soils*, Urban Horticulture Institute, Cornell University - http://www.hort.cornell.edu/uhi/outreach/pdfs/TreesAndStructuralSoilsManual.pdf
- *Municipal Policies to Promote Green Infrastructure*, Lower Hudson Coalition of Conservation Districts (September 2012) - http://www.lhccd.net/green-infrastructure.html
- *Nyack Green Infrastructure Report*, Consensus of the Nyack Green Infrastructure Roundtable, Village of Nyack (June 24, 2013) - http://nyack-ny.gov/wp-content/uploads/2013/11/Roundtable-Report-FINAL7-1.pdf
- *Reviewing Stormwater Management in Site Design: A Guide for Planning Board Members*, Lower Hudson Coalition of Conservation Districts (2014) - http://www.lhccd.net/uploads/7/7/6/5/7765286/planning_board_sw_guide_version1_2014.pdf
- *Standards for Green Infrastructure*, New York City Department of Environmental Protection, Office of Green Infrastructure (Updated August 29, 2014) - http://www.nyc.gov/html/dep/pdf/green_infrastructure/bioswales-standard-designs.pdf
- *Stormwater to Street Trees: Engineering Urban Forests for Stormwater Management*, US Environmental Protection Agency (September 2013) - http://water.epa.gov/polwaste/green/upload/stormwater2streettrees.pdf
- *Greenstreets: Stormwater Management Portfolio*, Greenstreets Division, NYC Department of Parks & Recreation (2010) - https://www.nycgovparks.org/sub_your_park/trees_greenstreets/images/NYC_Greenstreets-Green_Infrastructure_for_Stormwater_Management.pdf
- *Woody Shrubs for Stormwater Retention Practices*, Northeast and Mid-Atlantic Regions, Ethan M. Dropkin and Nina Bassuk, Cornell University, Department of Horticulture (2014): http://www.hort.cornell.edu/uhi/outreach/pdfs/woody_shrubs_stormwater_hi_res.pdf

Federal Resources

- *Enhancing Sustainable Communities with Green Infrastructure: A Guide to Help Communities Better Manage Stormwater While Achieving Other Environmental, Public Health, Social and Economic Benefits*, US Environmental Protection Agency (October 2014) - http://www.epa.gov/smartgrowth/pdf/gi-guidebook/gi-guidebook.pdf
- *Green Infrastructure and Issues in Managing Urban Stormwater*, Congressional Research Service (March 21, 2014) - http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R43131.pdf
- *Green Infrastructure Barriers and Opportunities in Camden, New Jersey*, U.S. Environmental Protection Agency (August 2013) - http://water.epa.gov/infrastructure/greeninfrastructure/upload/Camden_GI_Evaluation.pdf
- *Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure*, US Environmental Protection Agency (August 2010) - http://www.sustainablecitiesinstitute.org/Documents/SCI/Report_Guide/Guide_EPA_GICaseStudiesReduced4.pdf
- *The Economic Benefits of Green Infrastructure: A Case Study of Lancaster, PA*, US Environmental Protection Agency (February 2014) - http://water.epa.gov/infrastructure/greeninfrastructure/upload/CNT-Lancaster-Report-508.pdf
- *Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites*, US Environmental Protection Agency (July 2013) - http://water.epa.gov/infrastructure/greeninfrastructure/upload/brownfield_infiltration_decision_tool.pdf

Other Resources

- *City of Philadelphia Green Streets Design Manual*, Mayor's Office of Transportation and Utilities (2014) - http://www.phillywatersheds.org/img/GSDM/GSDM_FINAL_20140211.pdf
- *Green Infrastructure: A Landscape Approach*, American Planning Association, Planning Advisory Service, Report Number 571 (January 2013) - https://www.planning.org/pas/reports/subscriber/archive/pdf/PAS_571.pdf
- *Green Infrastructure and the Law*, Planning & Environmental Law: Issues and decisions that impact the built and natural environments, Karen M. Hansen (July 12, 2013) - http://dx.doi.org/10.1080/15480755.2013.824791
- *Green Infrastructure Standards*, District of Columbia, Department of Transportation (2014) - http://ddot.dc.gov/sites/default/files/dc/sites/ddot/publication/attachments/2014-0421-DDOT%20Green%20Infrastructure%20Standards.pdf

- *Nine Ways to Make Green Infrastructure Work for Towns and Cities*, Regional Plan Association (November 2012) - http://www.rpa.org/library/pdf/RPA-9-Ways-to-Make-Green-Infrastructure-Work.pdf
- *Regional and Municipal Stormwater Management: A Comprehensive Approach*, Emmett Environmental Law & Policy Clinic and the Environmental Policy Initiative, Harvard Law School (June 2014) - http://blogs.law.harvard.edu/environmentallawprogram/files/2014/07/Regional-Stormwater-paper_FINAL-6-19-14.pdf
- *Sustainable Urban Infrastructure: Policies and Guidelines Vol. 1*, Chicago Department of Transportation (July 2013) - http://www.cityofchicago.org/content/dam/city/depts/cdot/Sustainable%20Transportation/SUIGv1.pdf

Green Infrastructure for Urban Air Quality

New York State Resources

- *A Municipal Official's Guide to Forestry in New York State*, New York Planning Federation, NYS Department of Environmental Conservation and Empire State Forest Products Association (2005) - http://www.dec.ny.gov/docs/lands_forests_pdf/guidetoforestry.pdf
- *Tree Planting Standards*, New York City Department of Parks and Recreation (February 2014) - https://www.nycgovparks.org/pagefiles/53/Tree-Planting-Standards.pdf

Federal Resources

- *Sustaining America's Urban Trees and Forests*, General Technical Report NRS-62, US Forest Service (June 2010) - http://www.fs.fed.us/openspace/fote/reports/nrs-62_sustaining_americas_urban.pdf

Other Resources

- *Adapting to Urban Heat: A Tool Kit for Local Governments*, Georgetown Climate Center (August 2012) - http://www.law.georgetown.edu/academics/academic-programs/clinical-programs/our-clinics/HIP/upload/Urban-Heat-Toolkit_RD2.pdf
- *Trees in Urban Design*, Paul Crabtree and Lysistrata Hall, Congress for New Urbanism (date unknown) - http://www.cnu.org/sites/www.cnu.org/files/trees_in_urban_design.pdf
- *The Value of Green Infrastructure for Urban Climate Adaptation*, The Center for Clean Air Policy (February 2011) - http://ccap.org/assets/The-Value-of-Green-Infrastructure-for-Urban-Climate-Adaptation_CCAP-Feb-2011.pdf