An ANJEC Resource Paper

Municipal Techniques:
Long Term Control Plans, Stream Daylighting and Combined Sewer Overflow programs

P.O. Box 157 • Mendham, NJ 07945 • Tel: 973-539-7547 • Email: info@anjec.org • Website: www.anjec.org

INSIDE

A Collapsing Stormwater Infrastructure

In 21 communities throughout New Jersey, stormwater infrastructure consists of a combined stormwater and sanitary sewer system that collects multiple sources of water into one pipe. As communities continue to develop, large areas become covered in impervious surfaces such as pavement and roofs, preventing rainwater from percolating into the ground. This is referred to as the "urban water cycle," where impervious or hard surfaces have decreased the amount of infiltration and transpiration[1] that takes place throughout the natural water cycle (see Figure #1). Therefore, not only is the local groundwater system

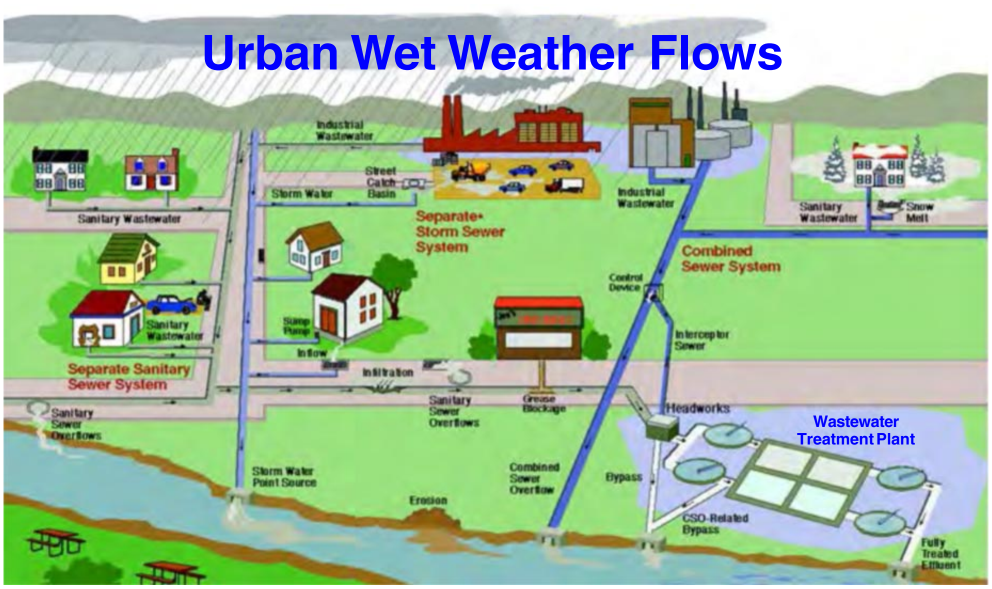


Figure 1: *The "urban water cycle," where impervious or hard surfaces have decreased the amount of infiltration and transpiration[1] that takes place throughout the natural water cycle.*
Source: EPA

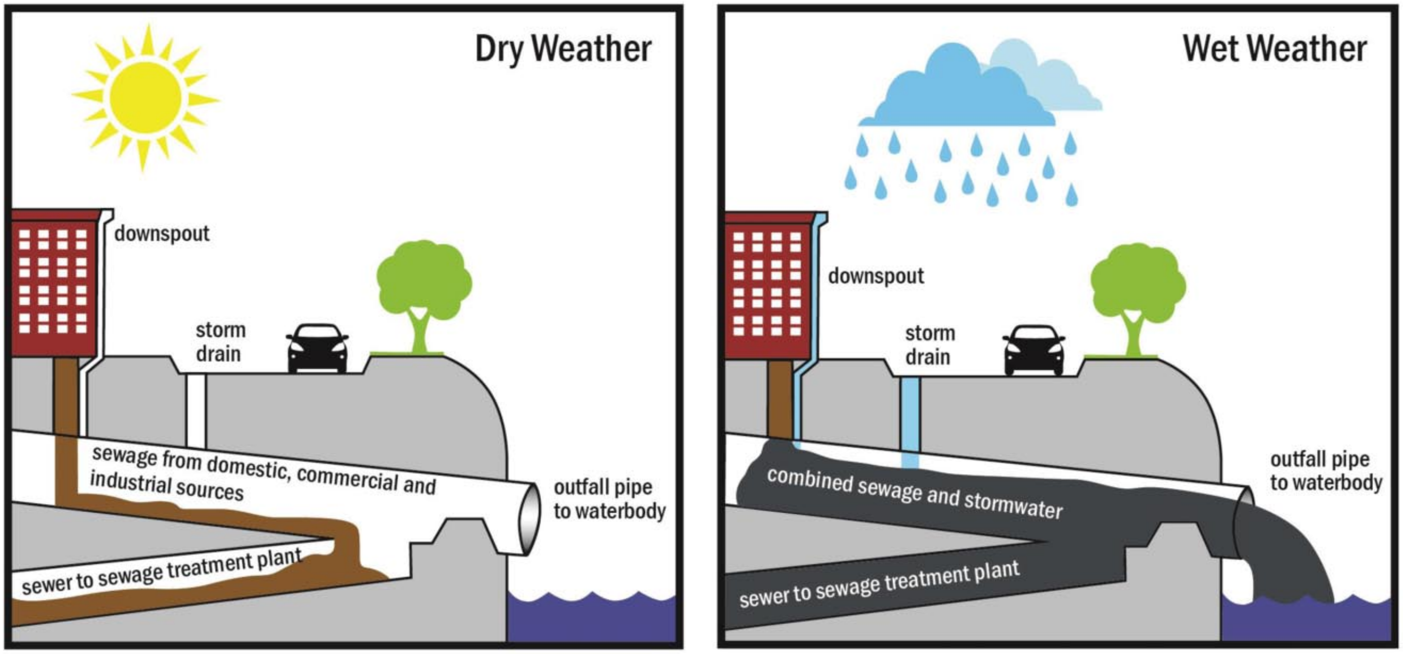


Figure 2: ***A combined sewer system (CSS) collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe.***

Source: EPA

starved for recharge (the processes by which ground water is absorbed into the zone of saturation)[2] , but there is also an increase of stormwater run-off into sewer systems that carry sanitary sewer waste. This causes localized flooding and nonpoint source pollution[3] when stormwater flushes pollutants from impervious surfaces to local waterways.

A combined sewer system (CSS) collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe (see Figure #2). In dry weather conditions, it transports all of the wastewater it collects to a sewage treatment plant for processing. Treated wastewater is then discharged to a water body. At times of heavy rainfall or snowmelt, and especially in highly developed areas, the volume of wastewater can exceed the capacity of the CSS or treatment plant. Combined sewer overflows (CSO) were designed to discharge the untreated stormwater and wastewater directly into nearby streams, rivers, and other water bodies, and may cause excess flooding and pollute these waters.

The Danger of Combined Sewer Overflows (CSOs)

Combined sewage can overflow into not only waterways, but if the overflow control devices are inadequately sized, it can also back up into streets, public spaces such as parks, and even residential basements. This polluted runoff from CSOs is a serious environmental and health issue. While there are regulations in effect to address untreated pollutants (see: *www.epa.gov/enforcement/clean-water-act-cwa-and-federal-facilities*) there are still untreated waste and debris that make their way into our waters. The effects of CSOs limit growth potential, quality of life and the environmental quality of New Jersey's cities. "Combined sewage overflows contain untreated human and industrial waste, toxic materials, and debris. They are a major water pollution concern for the approximately 772 cities in the U.S. that have combined sewer systems." [10] In New Jersey there are over 200 CSOs discharging to rivers and tidal estuaries. They are primarily located in the older urban areas of the northeastern part of the state and in the Camden vicinity. According to the New York New Jersey Baykeeper (*http://nynjbaykeeper.org/*), these overflows are responsible for discharging 23 billion gallons of sewage-contaminated water per year in New Jersey. Additional discharges coming from New York City also impact the Hudson River and the New York Harbor.

After a period of relative inactivity of over twenty years, the New Jersey Department of Environment Protection (NJDEP) has begun to issue individual permits regulating combined sewer overflows. Issued permits and comment responses may be found at: *www.nj.gov/dep/dwq/cso-commcoll.htm*.

These new permits replace the ineffective and highly criticized general permits previously in place. According to the NJDEP, *"The goal of the CSO permits is to meet the requirements of the Clean Water Act and the National CSO Policy by reducing or eliminating the remaining CSO outfalls in New Jersey. In order to achieve the reduction or elimination of outfalls, CSO permittees will need to reduce flooding, ensure proper operation, maintenance and management of existing infrastructure and* ***provide opportunities for green infrastructure****."* (emphasis added)

These objectives, including the use of green infrastructure, are to be achieved through the preparation and execution of Long Term Control Plans (LTCPs). It is important to note that these plans must involve the public "throughout the process."

The required public participation should be facilitated by the creation of "Supplemental CSO Teams "that will continually advise the process as it moves forward. It is important that environmental commissions among others are included on these teams to advocate for green infrastructure as one of the techniques to cure the sewer overflow problem. Guidance for Supplemental CSO Teams can be found at: *www.nj.gov/dep/dwq/pdf/supplemental-team-resource-doc-5.9.16.pdf*

Guidance for the preparation of LTCPs can be found at: *www.nj.gov/dep/dwq/pdf/1995-09-ltcp-guid-epa-832-B-95-002.pdf*. Specific guidance on the public participation process is found in section 2.1 of this document.

Choosing the Right Long Term Control Plan (LTCP)

Under the federal *Clean Water Act*, combined sewer discharges are prohibited without a permit. In NJ, the permit program is administered by the Department of Environmental Protection (NJDEP) and is an essential tool for the control of CSOs. The permits require the development of a Long Term Control Plan (LTCP) – a system-wide evaluation of the sewage infrastructure, and the hydraulic relationship between the sewers, precipitation, treatment capacity and overflows. As part of the LTCP, the permittee must evaluate alternatives that will reduce/eliminate the discharges, and develop a plan and implementation schedule for that reduction.[8] The permittee must also establish a public participation process that actively involves the affected public throughout the process.

As an organization that provides leadership and support for environmental commissions and other local boards and public officials, ANJEC can help you participate in the LTCP and Supplemental CSO team process by providing PowerPoint presentations, resource papers, and answering questions one-to-one through our resource center. Our website features information about green infrastructure, stream daylighting and links to other valuable information.

Choosing a "Green" LTCP

A LTCP using traditional *gray infrastructure* uses concrete and metal pipes, holding tanks, pumps, water tunnels, and treatment plants. Due to the size of the urban run-off problem these facilities tend to be large and expensive. To get an idea of what can be involved see *http://nationalgeographic.com/news/2014/7/140703-combined-sewer-overflow-washington-storm-water-tunnel/* that depicts and explains the efforts being made in Washington D.C. to control stormwater flows into their combined sewer system.

On the contrary, a *green infrastructure or "GI"* approach seeks to prevent stormwater from entering piped infrastructure in the first place.[3] GI uses a set of stormwater management practices that use or mimic the natural water cycle to capture, filter, absorb and/or re-use stormwater. This approach is a cost-effective, sustainable, and environmentally friendly LTCP practice that controls stormwater runoff while also improving the appearance and value of wastewater infrastructure.

"The use of green infrastructure encourages the idea that stormwater is a resource that can be reused, instead of being treated as a nuisance that needs to be removed as quickly as possible." [8]

Why Implement Green Infrastructure?

Green Infrastructure provides multifaceted benefits for all those involved:

- **Environmental** – reduces stormwater runoff and pollutants, enhances groundwater recharge, increases carbon sequestration, increases urban vegetation and wildlife habitat, improves air quality, and provides relief from "urban heat island" effects.
- **Health** – naturally cools urban environments ("urban heat island"), increases recreational space in urban areas, promotes more physically active and healthier lifestyles, improves water quality, and decreases spread of disease or harmful bacteria.
- **Economic Development** – increases land values and recreational spaces, is aesthetically pleasing and makes a community more attractive, creates jobs during installation, operation and maintenance, and the market supports higher rents in projects that employ GI.
- **Energy Savings** – reduces energy demands on adjacent buildings, mitigates air pollution, reduces green-house gas emissions, and avoids pumping and treatment costs.
- **Environmental Justice** – particularly benefits dense urban areas-many of which suffer from among the worst environmental pollution and infrastructure disinvestment in the U.S.
- **Education** – raises public awareness of importance and type of measures that reduce stormwater pollution and creates a public consciousness about water.

See the New Jersey Developers' Green Infrastructure Guide for side-by-side comparisons of gray vs. green stormwater management practices in various properties: *www.njfuture.org/wp-content/uploads/2017/03/NJ-Developers-Green-Infrastructure-Guide_FINAL_web.pdf*

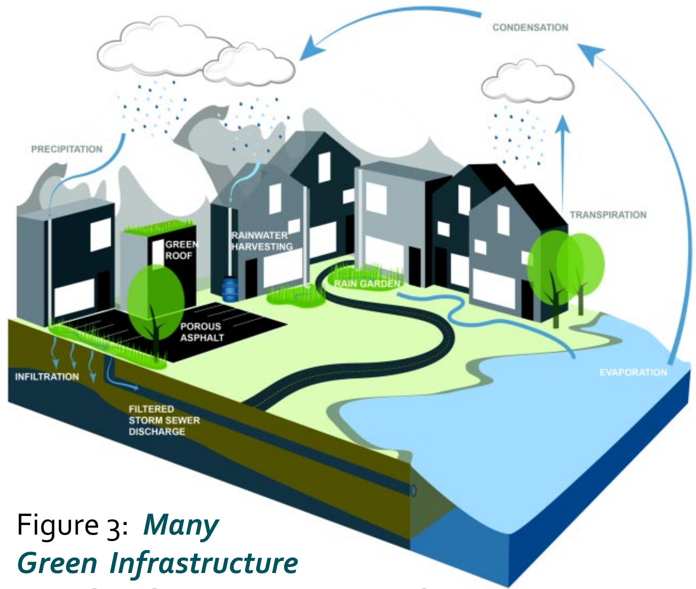


Figure 3: ***Many Green Infrastructure practices incorporate vegetation to help treat runoff and promote infiltration and transpiration.***
Source: Rutgers Green Infrastructure Guide

Different GI Practices

The variety and adaptability of the many techniques available allow these approaches to be used in a wide variety of circumstances. Green infrastructure can also be combined with traditional "gray infrastructure" practices and portions of existing systems. For example, the monumental Washington DC tunnel plan also includes green infrastructure to avoid the production of stormwater. Philadelphia has taken a leadership position in the use of green infrastructure in a dense urban landscape.

One important goal of green infrastructure practices is to ***disconnect*** impervious surfaces that are now connected (i.e., downspouts that drain directly to sewer systems, streets or local waterways). GI practices are designed to intercept, capture, and infiltrate stormwater runoff before it enters the sewer systems or local waterways – starting where rain falls and following its journey through the water cycle. GI practices work to remediate the damages caused by the urban water cycle to help restore the natural water cycle. Many GI practices incorporate vegetation to help treat runoff and promote infiltration and transpiration. Furthermore, these practices can "help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while providing communities with aesthetic and natural resource benefits" [2] (See Figure #3)

Here are some GI practices that disconnect rainwater from impervious surfaces:

1) Green Roof – Absorb and drain at the source

- A *green roof* is a system of lightweight soil mix and plants. The plants absorb and transpire some of the rain that falls on the roof, and some of the excess is stored in the soil layer below. Layers of soil and plants can be as thin as just a few inches, or as thick as several feet depending on the structural capacity of the building and the types of plants that are used. [7]
- Benefits include: better temperature regulation on the roof surface (cooler in summer, warmer in winter), lower heating and cooling costs, stormwater management (reduced runoff and delayed discharge), a more aesthetically pleasing and healthy environment in which to work and live, and improved return on investment compared to traditional roofs.
- See photo #1

2) Cisterns & Rain Barrels – Harvest stormwater runoff for non-potable (non-drinkable) water usage (such as watering lawns and gardens, vehicle washing, air conditioner cooling)

- *Cisterns* are partially or fully buried tanks with a secure cover and a discharge pump. Cisterns can collect water from multiple downspouts or even multiple roofs. A spigot at the base of the cistern tank allows water to be removed without an electronic pump system. Unless buried below the frost line, cisterns should be drained in the winter months to prevent freezing where the water collects.
- *Rain barrels* are small-scale devices available for owner installation that can store a limited amount of rainfall for non-potable uses such as garden watering, thereby lowering demand for potable water. These also need to be drained in the winter months.
- Best applied in areas with existing buildings and exterior downspouts

3) Downspout Planter – Store runoff and slowly release it after the storm event

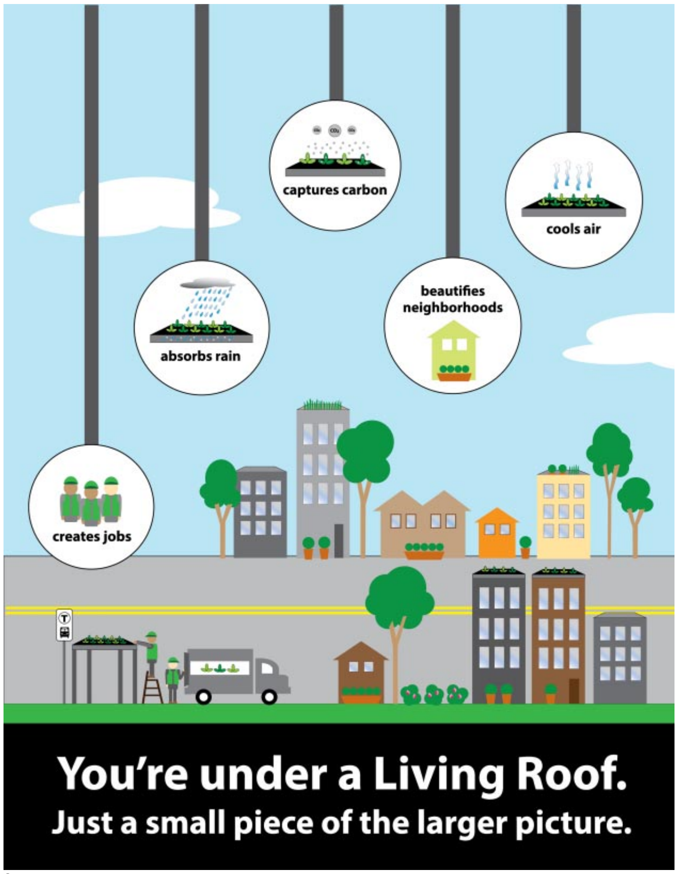
- *Downspout planter boxes* are a decorative garden planter filled with gravel, soil and vegetation that utilizes rainfall from the roof as irrigation. [5]
- They have the capacity to store rooftop runoff during rainfall events and release it slowly back into the system through an overflow into another planter box – by building multiple boxes connected by an underdrain pipe.

4) Bioretention & Rain Gardens, Stormwater Planter – Infiltration and storage (filter water using soil, recharge groundwater)

- A *rain garden* or *bioretention system* is a landscaped, shallow depression that captures, filters, and infiltrates stormwater runoff. It is a garden of native plant species situated at the base of a drainage area.

Photo 1: ***US Coast Guard HQ Washington DC layers on a green roof, of soil and plants can be as thin as just a few inches, or as thick as several feet depending on the structural capacity of the building and the types of plants that are used.***

Photo credit: General Services Administration



Source: EPA

Stormwater can be directed into the rain garden to filter, infiltrate, and transpire water.

- *Stormwater planters* are vegetated structures that are built into the sidewalk to intercept stormwater runoff from the roadway or sidewalk. Concrete walls are installed to match the existing curb and to frame the planter as a curb.

5) Bioswales, Filterstrips – Move water from one location to another while filtering pollutants.

Bioswales are landscape features that convey stormwater from one location to another while removing pollutants and allowing water to infiltrate. They are often designed for larger scale sites where water needs time to move and slowly infiltrate into the groundwater.

- Construction: bed of native plants or grasses bordered by two slopes and inlets on either side to flow water into the bioswale, may contain check dams to slow the flow of water
- Good for systems that are adjacent to a roadway or parking area

Filter strips are areas of natural vegetation, often grasses, planted strategically between fields and surface waters that convey stormwater from impervious areas toward streams. They are adapted from common agricultural practices.

- Stormwater must flow gently onto the filter strip and must not be allowed to develop channels.

6) Permeable Pavements – Infiltration of water through road surfaces and sidewalks

- Have high utility in urban settings
- Pervious concrete and porous asphalt are the most common permeable pavements.
- Pavers and grass filled concrete or plastic matrices are also used.
- Porous asphalt and concrete are made by reducing the very fine materials normally added to their mixes. The lack of fine materials allows water to quickly pass through into an underlying layered system of stone that temporarily stores the water, allowing it to filtrate into the underlying uncompacted soil or the bed may be under-drained to convey water to an existing storm sewer system.
- Mixes of polyester, stone and crumb rubber are primarily used for footpaths and bikeways.
- Porous paving is best applied in areas where pavement is desired but run-off rate and volume needs to be reduced (flat/level areas of foot or bicycle traffic, parking spaces).
- It should not be used for areas of heavy car or truck traffic, or where nearby industrial, agricultural, or landscape operations may lead to heavy sediment or organic material accumulation that could clog the system. Construction site management should prevent the deposit of silt on porous paving.
- Clogging is not as serious a concern as might be expected since porous asphalt is capable of passing water at a rate of up to 1000 gallons per minute. Even if 50% clogged the permeability will still allow 500 inches per hour of water to infiltrate. Road salt is not usually a problem but sand and road grit should be avoided. Permeability can often be restored by normal power washing.

*For a local example of permeable pavement, see *www.epa.gov/water-research/experimental-permeable-pavement-parking-lot-and-rain-garden-stormwater-management*

** For case studies of GI practices and more information on how to implement GI practices see the Green Infrastructure Guidance Manuals at: *http://water.rutgers.edu/GreenInfrastructureGuidanceManual.html*

***For more information on GI, see: *https://njaes.rutgers.edu/fs1197/*

Taking Action: The Transition from Gray to Green Infrastructure

One approach is to identify GI opportunities: target hard impervious surfaces, areas with infiltration potential (pervious surfaces), high-visibility sites, and public community spaces that are not wet. Some examples of good host sites for GI: churches, libraries, schools, municipal buildings, parks, and deteriorating paved areas.

1) Site investigation: Know your stormwater system.

- Is it a combined sewer system (CSS) with problem CSOs, or a separate storm sewer system (SSS)?
- What is the extent and character of the "sewershed"?
- Are there points of overflow and back-up in response to rainfall?
- Are discharges causing water quality problems?
- Are pipes and outfall structures sound and stable?
- Is there stream scouring (localized erosion) present at the outfall?
- Is aquatic habitat being degraded?
- Consider the "technical" criteria of the site: Determine depth to bedrock and groundwater. Evaluate soils for permeability, the presence of toxics and other relevant engineering conditions. Investigate property ownership, (public, private, unclear title, and deed restrictions) Evaluate the possibility of local "buy in" by neighborhood groups and other potential partners.

2) Establish effective partnerships with, for example: elected officials, a park superintendent, relevant government agencies, community groups, a stormwater utility manager, a water regulatory agency, the department of public works, the environmental commission, universities, engineering schools, and the N.J. Department of Environmental Protection.

3) Leverage Funding Opportunities: Explore funding availability (both grants and loans) early in the process. A good overview of government funding available in New Jersey can be found at *www.nj.gov/dep/dwq/pdf/funding-stormwater-projects-oct%202014.pdf*. The availability of government funding based on Federal sources is currently in flux with some previously important programs proposed for termination.
Water purveyors may contribute, and watershed and other environmental groups can apply for grants to implement GI projects that benefit downstream waters, create wildlife habitat, reduce urban heat, and expand the tree canopy.

4) Community Collaboration: Facilitate public interest by working with community groups, holding outreach events, and educating the public about the water infrastructure that lies below the surface. Attend local community events and group meetings to share information about green infrastructure opportunities.

Photo group 2: ***Daylighting of the Saw Mill River in Yonkers, NY.***
Photo credits: YonkersNY.gov

Stream Daylighting and Green Stormwater Infrastructure as a part of Combined Sewer System Long Term Control Plans

NJDEP released new permits for combined sewer systems, which became effective July 1, 2015. According to the NJDEP, the process is:

"The goal of the CSO permits is to meet the requirements of the Clean Water Act and the National CSO Policy by reducing or eliminating the remaining CSO outfalls in New Jersey. In order to achieve the reduction or elimination of outfalls, CSO permittees will need to reduce flooding, ensure proper operation, maintenance and management of existing infrastructure and ***provide opportunities for green infrastructure***. These permits reinforce the importance of properly operated and maintained water infrastructure systems in protecting public health and the environment and supporting economic redevelopment. A major emphasis of the permit process is the development of regional strategies to reduce the amount of stormwater that flows into combined sewer systems, through the development and implementation of a Long Term Control Plan." (emphasis added). Note that a specific purpose of the permits is to encourage and implement green stormwater infrastructure approaches in areas served by combined sewer systems. To learn more about this initiative see: *www.nj.gov/dep/dwq/cso.htm*

There is also a new emphasis on public participation in the preparation of LTCPs required by the new CSO permits. The National CSO Policy identifies the following essential elements of a LTCP:

1. Characterization, monitoring, and modeling activities as the basis for selection and design of effective CSO controls;
2. A ***public participation process that actively involves the affected public*** in the decision-making to select long-term CSO controls;
3. Consideration of sensitive areas as the highest priority for controlling overflows;
4. ***Evaluation of alternatives*** that will enable the permittee, in consultation with the National Pollution Discharge Elimination System permitting authority, Water Quality Standards authority, and the public, to select CSO controls that will meet Clean Water Act (CWA) requirements;

Photo: ***Assunpink Creek Stream Daylighting project in Trenton, NJ.***

Photo credit: Stephen Souza and Mark Gallagher, Princeton Hydro

5 Cost/performance considerations to demonstrate the relationships among a comprehensive set of reasonable control alternatives;
6 Operational plan revisions to include agreed-upon long-term CSO controls;
7 Maximization of treatment at the existing Publically Owned Treatment Works treatment plant for wet weather flows;
8 An implementation schedule for CSO controls; and
9 A post-construction compliance monitoring program adequate to verify compliance with water quality-based CWA requirements and ascertain the effectiveness of CSO controls.

It is important that green stormwater infrastructure be considered as an alternative, either alone or in combination with the more traditional "gray infrastructure" approaches that often dominate discussions.

ANJEC urges environmental commissions and concerned citizens to avail themselves of opportunities to participate, including regular participation in the "Supplemental CSO Team" that should be established for each permit area.

Groups that can be considered for inclusion:
- Community/neighborhood groups
- Environmental groups
- Recreational water users
- Business, industry, and redevelopment community
- Local institutions (ex: academic, business, healthcare)
- Representatives of local government
- Faith-based and social service organizations

(see: *www.nj.gov/dep/dwq/pdf/supplemental-team-resource-doc-5.9.16.pdf*).

Commissions should avail themselves of the many evolving opportunities for Green Stormwater Infrastructure education, including ANJEC materials from our website, *www.anjec.org)*, workshops, webinars, and materials and training offered by the Rutgers Cooperative Extension Service, Water Resources Program (*water.rutgers.edu/*) among others.

Stream Daylighting as a LTCP Component and in Separate Storm Sewer Areas

In many urban and suburban areas, the natural drainage system of a landscape (streams, rivers, etc.) has been replaced with a network of storm water collection and transport systems, sometimes combined with sanitary sewers in areas with combined sewer systems. In addition to overburdening wastewater treatment plants (resulting in releases of contaminated water from CSOs) these networks, in areas with separate stormwater systems, rapidly convey stormwater runoff to local rivers and streams resulting in water quality degradation, erosion, siltation, and other negative aquatic impacts. The capacity of the drainage systems may not be large enough to accommodate the increased run-off from new development or they may not be functioning as intended as pipes and culverts degrade over time.

Undercapacity drainage systems, even if not tied to combined sewers, can trigger a series of events such as flooded basements, rising insurance costs, reduced property values, owners eventually moving out, and disinvestment that eventually results in neighborhood decline.

Where natural streams have been "captured" by these systems, stream daylighting is a large or small scale green infrastructure method that can revitalize streams by uncovering some or all of a previously covered river, stream, or stormwater drainage in some cases.

Daylighting projects have been carried out in all kinds of situations: from small ephemeral creeks to true rivers, in watersheds tiny and large, on rural farmland and in the central business districts of cities. Most commonly, daylighting projects restore brooks, streams, and rivers. But some projects create ponds or wetlands, often in combination with flowing waterways (Pinkham).

There are several different ways to daylight a stream:

Natural restoration involves restoring a stream to a more natural state. This is the most difficult option. It is most effective overall for aquatic ecologic restoration, flood mitigation, water quality enhancement, and stormwater control.

It has the added benefit of providing aesthetic enhancement, improving terrestrial wildlife habitat and providing passive recreational opportunities.

Architectural restoration involves restoring a stream to the open air while confining the channel within either new or existing structures. This is often a practical solution in dense urban areas. While providing fewer water quality benefits, this type of daylighting can also result in aesthetic enhancement and water-side recreational opportunities.

Cultural restoration celebrates a buried stream through markers or public art used to inform the public of historic watercourses now forgotten. It is often used as "first step" to educate the public about the stream and to begin discussions about either architectural or natural restoration in the future.

"In a combined sewer system where both stormwater and untreated waste water are recombined, the technique can also provide an alternative to conventional sewer separation by diverting stormwater out of the sewage system, while also providing additional water quality and flood mitigation benefits. The design can also provide more aesthetic amenities compared to a strictly grey or traditional infrastructure approach."
(Source: *Daylighting Streams: Breathing Life into Urban Streams and Communities*)

Situations fitted for daylighting

- The pipes or culverts that encase the streams are inadequately sized or are deteriorating and must be replaced. It is sometimes cheaper to daylight than to replace.
- The volume of water flowing into the underground pipes has increased, and now, during storms, the pipes back up and water overflows onto streets and backs up into basements and other places or triggers CSO releases.
- The excavation of a buried stream is an opportunity to "revamp" the downtown area or a neighborhood by creating a setting around the stream that may provide recreational opportunity or even attract new business and activities to the area.
- Unearthing streams can open up more pervious surfaces and give stormwater a place to naturally infiltrate. It can also provide areas to construct other green stormwater facilities like raingardens or infiltration devices.

Photo 3: ***Daylighting Petty's Run in Trenton, NJ.***
Photo credit: Stephen Souza and Mark Gallagher, Princeton Hydro

When carefully designed, stream daylighting can increase the hydraulic capacity of the channel, allowing the stream to have some access to its floodplain. It can also reduce runoff velocities, which ultimately reduces erosion.[5]

How to Find Buried Streams

Many of New Jersey's previously existing watercourses have been piped, filled, and developed over, particularly in older urban areas, suburbs and even in rural agricultural situations. There are several different methods for locating buried or covered streams and waterways.

1) Comparing historic maps to present day maps:

Local historical societies, city archives, libraries, and academic institutions often have collections of historic maps. Historic maps of the desired city/town you are searching for may also be found on online databases such as NOAA (National Oceanic and Atmospheric Administration) Historical Maps and Charts and the Historical Maps of New Jersey page, which is a part of the Rutgers University Library Collections. In older urban areas, old maps of sewer systems that often captured streams may be available from the municipal engineer or Department of Public Works.

Simply locate specific streams or bodies of water on historic maps and compare them to current day maps or actual field conditions to see whether or not there has been a change.

One good example of how to compare historic stream maps to current city maps can be found at *www.phillyh2o.org/maps.htm*.

Photo 4: ***Petty's Run in Trenton, NJ – eliminating flooding while beautifying the area.***

Photo credit: Stephen Souza and Mark Gallagher, Princeton Hydro

2) NJDEP's GeoWeb System

NJDEP's GeoWeb system provides an interactive map with extensive profiles for your desired search. To locate streams or waterways, activate the "Water" layer and the "Streams" and waterbodies coverages. In GeoWeb, several layers and various data criteria can be combined to find what you're looking for. Rowan University has an interactive map project that features several different land data points such as wetlands change, impervious surfaces, and urban growth.

These may be used together to locate potential buried streams. The maps can be found at New Jersey Map: Changing Landscapes in the Garden State (*www.njmap2.com/land-change/map.html*).

Furthermore, interactive maps can be put together with aerial images for further investigation. Stream paths that appear as straight lines rather than a sinuous pattern or join one another at geometric angles may indicate either a buried stream or a ditched channel. Since the straight line may also indicate a ditch, verify this by referring to the aerial image or by field visit. Ditches are often visible whereas buried sections are not.

3) Using your Environmental Resources Inventory (ERI)

You may want to take a look at what is available in your town's environmental resource inventory (ERI), which may also be known as a natural resource inventory (NRI). ERIs are a collection of text, maps, photos, and other visual elements that bring together information on natural resource characteristics and environmental features. They are one important basis for land use planning and community collaboration. Look at the stream coverage map in your ERI to see manmade stream patterns (ditched or piped) for a lead on where streams may have been buried. If former wetlands are built up, you might want to investigate the area because waterways were probably piped for development.

Once you have identified likely candidate areas, confirm them by a field visit. Often the ends of pipes or culverts are visible and flowing water can be heard in stormwater catch basins and manholes. Avoid entering pipes or culverts that may be dark, slippery and could contain toxic sewer gasses.

Costs and Benefits of Stream Daylighting

Daylighting projects can be a cost effective investment if the full range of benefits is evaluated. These costs will inherently increase or decrease depending on a number of factors including: the extent of urbanization and adjacent infrastructure, whether volunteers or in kind donations are used, whether the stream is on public or private land, if property must be purchased, or additional community amenities are added such as parks and greenways. [6]

Cost Issues to consider

It is important to evaluate as many of the possible benefits before making a cost decision. Daylighting can:

- Address urban flooding;
- Slow water velocities;
- Divert water from combined sewer systems;
- Revitalize neighborhoods;
- Provide terrestrial and aquatic wildlife habitat;
- Enhance recreational opportunities;
- Increase property values;
- Reconnect people to nature through the look, feel, and smell of open water and riparian vegetation, and through contact with aquatic and streamside creatures;
- Improve water quality by exposing water to air, sunlight, vegetation, and soil, all of which help transform, bind up, or otherwise neutralize pollutants;
- Be cost effective (one-time cost); and
- Reduce other system costs by keeping stormwater out of combined sewer systems and reducing the corresponding combined sewer overflow treatment or upgrade costs.

These unique projects can also revitalize neighborhoods, increase property value, and benefit nearby businesses by creating an amenity that attracts people to the area on evenings and weekends. [1]

Stream daylighting may be a large project to take on; consequently it has its drawbacks. Daylighting in a highly urbanized area may be difficult. If stream daylighting is possible, displacement of existing use areas such as parking lots and other economic uses can be problematic. Some creativity may also be required to obtain necessary funding. Cost has been estimated at $1,000 per linear foot for the full costs of these projects at market rates. Complications often arise when multiple partners struggle to establish project coordination, obtain necessary permits and define responsibilities for on-going maintenance. In addition, local residents may perceive that the proposed project will be disruptive and damaging to property values.

Case Studies

Roselle, N.J.

In 2008, a daylighting project was conducted in Union County's **Warinanco Park** in Roselle, N.J. As part of a wetlands mitigation plan for a toxic contamination removal project in Rahway, Merck & Co. removed 2,000 feet of a previously buried stream from a culvert and restored it with native planting and a mixture of flows and depths that provide a variety of habitats to support fish and invertebrate life.

The project is on public land and now provides a substantial amenity to the park, complementing and restoring the original 1923 design by the Olmsted Brothers.

Yonkers, N.Y.

Saw Mill River, Yonkers, N.Y.: An ambitious $34 million redevelopment project incorporated daylighting as a centerpiece in the redevelopment area. The project converted an existing parking area that covered the Saw Mill River to a public park with a flowing water amenity. It created 13,775 square feet of aquatic habitat, re-established fish access from the Hudson River, and greatly enhanced real estate values.

* To see more of the economic, ecological, and cultural impacts of this daylighting project visit: https://groundworkusa.org/spotlight/daylighting-saw-mill-river/

Trenton, N.J.

Petty's Run: In Trenton, a portion of Petty's Run was daylighted under the direction of Princeton Hydro, the City of Trenton and the New Jersey Department of Environmental Protection as part of a larger urban revitalization effort. The project created affordable housing and green space on a brownfield. Project partners relocated the stream to avoid contaminated areas, removed 250 feet of pipe and created an adjacent flood-plain meadow. The result is a new green space with flowing water, habitat improvement and a walking trail replacing a degraded urban land-scape subject to flooding. See Photos 3 and 4

For more information about Petty's Run, see: *www.princetonhydro.com/projects/natural-resource-management-projects/river/pettys-run-daylighting/*

Assunpink Creek: The Assunpink Creek in downtown Trenton is presently being daylighted in a joint project between the city of Trenton and the U.S. Army Corps of Engineers. The project will provide two new acres of green space in downtown Trenton, improve water quality, and will give the area a vastly improved community space.

For a look at a time-lapse camera of the stream daylighting work, go to *https://public.workzonecam.com/projects/cityoftrenton/downtowntrenton/workzonecam/archive/timelapse?archiveId=Home*.

Photo: ***Before and after – stream daylighting Petty's Run, Trenton, NJ***

Photo credits: Stephen Souza and Mark Gallagher, Princeton Hydro

Kalamazoo, Michigan

An example of a stream daylighting project that completely transformed a city's economic condition was unearthing **Arcadia Creek** in Kalamazoo, Michigan. "By the 1980s, downtown Kalamazoo had become a depressed area with boarded up, vacant buildings, high crime and declining public use. The streets also flooded often, because the underground pipes backed up as a result of the city's growth. Kalamazoo daylighted five blocks of Arcadia Creek.

To address the flooding problems the city created a large retention pond that holds the high winter flows and releases the water gradually into the stormwater system. In the summer, the city uses the pond area as an amphitheater for outdoor concerts. The amphitheater is popular with local residents and out-of-town tourists. The summer festivals generate about $12 million annually. Today, the re-imagined Arcadia Creek drives an economic revival in the business district. Five festivals are scheduled at the amphitheater site each year and new businesses continue to locate in the Arcadia Creek district" [6]

* For more information on the daylighting project at Arcadia Creek, see: *https://bcourses.berkeley.edu/courses/1307153/files/54592178/download?download_frd=1* , p. 41.

* For more case studies, see the research paper: Pinkham, R. 2000. Daylighting: new life for buried streams. Rocky Mountain Institute. Old Snowmass, Colorado

Conclusion

The deterioration of our stormwater infrastructure, desired water quality improvements, aquatic habitat enhancements and elimination of combined sewer overflow discharges are compelling needs at the present time. The predicted impacts of climate change are also generating concerns about the adequacy of our existing stormwater facilities to cope with more frequent and intense downpours. Concerns about creating sustainable solutions have also increased interest in working with nature and treating water as a resource, rather than a problem.

Green infrastructure, including stream daylighting, can play an important part in addressing these concerns. In the case of CSO abatement, green infrastructure and stream daylighting should be investigated and, wherever feasible, be incorporated into the required Long Term Control Plans. In most cases, these techniques will enhance the urban experience as well as solve the problem of CSO generated pollution.

We must collectively strive to increase efficiency of water use, restore or improve waterways and groundwater, repair decaying stormwater infrastructure, decrease polluted runoff, control floatables and prevent future contamination. These actions, and many more, are essential to maintain healthy freshwater ecosystems and provide safe drinking water to all.[11]

While stream daylighting, as well as other green infrastructure practices, may seem to be large projects to commit to, they have long-term benefits that are necessary as New Jersey continues to evolve and redevelop. Green infrastructure works to restore, preserve, or mimic natural hydrological systems through practices such as permeable pavement, rain gardens, and rainwater capture systems.

Investment in GI can benefit both the environment and the community. There is a multitude of resources available (ANJEC, NJDEP, Jersey Water Works, U.S. Environmental Protection Agency, Rutgers Cooperative Extension Water Resources Program, Phillywatersheds) which provide step-by-step instructions for planning, funding, and implementing GI practices in your neighborhood. There are also many case studies that have shown the long lasting benefits of green infrastructure as opposed to traditional gray infrastructure.

Stream daylighting should be considered as a part of Long Term Control Plans, wherever feasible and desired. Daylighting* can be implemented when redeveloping a brownfield site to route water away from contaminated areas. In a crumbling pipe system, stream daylighting can remediate multiple environmental issues at once and often proves cost effective. It can improve water quality by restoring natural functions where water quality impairments exist, particularly excessive nitrogen levels. It can completely redefine the economic value of a location by bringing communities closer to nature.

* Rutgers Cooperative Extension Water Resources Program provides several resources including wastewater management papers, fact sheets, case studies, presentations, useful links and tools, and services to municipalities that will guide you through each step of the process to managing your stormwater project.

* See the Rutgers Cooperative Extension Water Resources home page at: *water.rutgers.edu/index.html*

Glossary of Terms

Aquifer Recharge: Aquifer recharge is the process by which rainwater seeps down through the soil into an underlying aquifer. There are many natural processes that determine how much rainwater actually reaches and replenishes an aquifer instead of being evaporated, consumed by plants and animals, or simply running off the ground surface into streams, rivers, lakes, and oceans.

Clean Water State Revolving Fund (CWSRF): Provides loans to finance a wide variety of projects that help to protect, maintain and improve water quality in New Jersey See: www.nj.gov/recovery/infrastructure/cwsrf.html

Community Collaboration: In communities with CSSs and CSOs, permittees are required by the New Jersey Department of Environmental Protection to have the public participate in selecting alternatives to pursue as part of the Long Term Control Plan. Residents can help to identify, support and implement solutions in their communities. More information is found at the NJDEP Division of Water Quality page at www.nj.gov/dep/dwq/cso-commcoll.htm

Combined Sewer Overflow (CSO): In the event of heavy rainfall or snowmelt, the untreated stormwater and wastewater taken up by a combined sewer system may discharge directly to nearby streams, rivers, basements, streets, and other water bodies.

CSO sewer maps, displaying the estimate of total CSO volume and number of outfalls in NJ cities, are available at: www.nj.gov/dep/dwq/cso-sewer-maps.htm

Combined Sewer System (CSS): A wastewater system that collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe

Connected Impervious Surface: When stormwater runoff flows directly from an impervious surface to a local waterway or sewer system

Disconnected Impervious Surface: When stormwater runoff flows from an impervious surface onto a pervious surface or into a green infrastructure practice prior to entering a local waterway or a sewer system

Drinking Water State Revolving Fund (DWSRF): Assists publicly owned and privately owned community water systems and nonprofit, non-community water systems to finance the cost of the infrastructure (including water treatment, storage and distribution lines) needed to achieve or maintain compliance with Safe Drinking Water Act requirements and to protect the public health in conformance with the objectives of the Safe Drinking Water Act (SDWA) See: www.nj.gov/recovery/infrastructure/dwsrf.html

Environmental Justice: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies

Environmental Resource Inventory (ERI): A collection of text, maps, photos, and other visual elements that bring together information on natural resource characteristics and environmental features. Most are done at the municipal level but several county-wide ERIs are available. Many municipal ERIs are available on municipal websites. Also known as Natural Resource Inventory (NRI)

Federal Clean Water Act: Landmark federal legislation that establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters See: www.epa.gov/laws-regulations/history-clean-water-act

Geographical Information System (GIS): A computer system for capturing, storing, checking, analyzing, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map and provide rapid analytical capabilities.

Gray Infrastructure: The traditional approach to managing and treating sewage and stormwater through sewerage mains, tunnels, and wastewater treatment plants

Green Infrastructure: Methods of stormwater management that reduce wet weather/stormwater volume, flow, or change the characteristics of the flow into combined or separate sanitary or storm sewers, or surface waters, by allowing the stormwater to infiltrate, to be treated by vegetation or by soils or to be stored for reuse

Impervious Surface: Any surface that has been covered with a layer of material so that it is highly resistant to infiltration by water; examples include but are not limited to paved roadways, paved parking areas, and building routes. Compacted soils may also act as impervious surfaces.

Leveraged Funding: Using borrowed money: specifically, the use of various financial instruments or borrowed capital to increase the potential return of an investment

Long Term Control Plan (LTCP): A system-wide evaluation of the sewage infrastructure, and the hydraulic relationship between the sewers, precipitation, treatment capacity and overflows in areas with combined sewer systems and CSOs. The essential steps for a LTCP can be found at the NJDEP Division of Water Quality page at www.nj.gov/dep/dwq/cso-longtermplans.htm

NJDEP "Combined Sewer Overflow Permits": The Department of Environmental Protection's guidelines governing CSO permittees and CSO communities to reduce or eliminate CSOs The guideline is found at the NJDEP Division of Water Quality page at www.nj.gov/dep/dwq/cso.htm

NJ-GeoWeb Systems: Users of this application can locate areas of interest, view and interact with the NJDEP's GIS data, and query related environmental information. NJ-GeoWeb presents users with a suite of customized profiles to choose from, where users can work within a more tailored application that includes specific datasets, tools, searches, and reports developed to address the interests of the general public, targeted groups of users, and the regulated community. This service is available 24/7 and is free to all. You can access GeoWeb at www.nj.gov/dep/gis/geowebsplash.htm.

Nonpoint Source Pollution: Pollution that is picked-up and transported by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and

Glossary of Terms continued

carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters. Often included are fertilizers, herbicides, and insecticides from agricultural lands and residential areas; oil, grease, and toxic chemicals from urban runoff and energy production; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks.

"Sewershed": A term derived from an analogy to the concept of a natural watershed, which refers to an area draining to a single point in a stream network. Sewersheds are determined by curbs, storm drains, settling basins, pipes, and outfalls to streams. Storm sewersheds are increasingly being seen as targets for improved design to reduce the amount of storm water that is generated within them. Greening, reducing impervious surface, and on-site retention and management of rain water using green roofs, rain gardens, and the like, are strategies to reduce the negative outputs from storm sewersheds. A sanitary sewershed is composed of the sanitary sewer system collection network, sewer trunk mains, pump stations and destination wastewater treatment plant.

Stream Daylighting: Brings buried waterways back to life by physically uncovering and restoring them. An effort to assist communities in reducing polluted runoff, addressing flash flooding concerns, and improving the livability of the built environment

Topographic Map: A map that portrays the shape and elevation of the land surface through the use of contour lines that connect points of equal elevation. Topographic maps show natural features such as mountains, valleys, lakes, rivers, and vegetation. They also sometimes identify manmade features, such as roads, boundaries, major powerlines, and buildings.

Resources

1 Daylighting Streams: Breathing Life into Urban Streams and Communities–*americanrivers.org/wp-content/uploads/2016/05/AmericanRivers_daylighting-streams-report.pdf*

2 Green Infrastructure Guidance Manual For New Jersey. Prepared by the Rutgers Cooperative Extension Water Resources Program, August 2016.

3 Jersey Water Works Tools & Resources–*www.jerseywaterworks.org/tools-resources/*

4 Pinkham, R. 2000. Daylighting: new life for buried streams. Rocky Mountain Institute. Old Snowmass, Colorado. *d231jw5ce53gcq.cloudfront.net/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprts_W00-32_Daylighting.pdf*

5 Philadelphia Water Department Green Stormwater Infrastructure Tools– *phillywatersheds.org/what_were_doing/green_infrastructure/tools*

6 National Park Service Daylighting Brochure–*http://npshistory.com/publications/rtca/city-center-streams.pdf*

7 New Jersey Developers' Green Infrastructure Guide–prepared by AKRF for New Jersey Future. April 2017 *www.njfuture.org/wp-content/uploads/2017/03/NJ-Developers-Green-Infrastructure-Guide_FINAL_web.pdf*

8 NJDEP Division of Water Quality Combined Sewer Overflow Topics–*www.nj.gov/dep/dwq/cso.htm*

9 New York City's Wastewater Treatment System - *www.nyc.gov/html/dep/pdf/wwsystem.pdf*

10 U.S. EPA, Office of Water. Green Infrastructure in Parks. June 2017–*www.epa.gov/sites/production/files/2017-05/documents/gi_parksplaybook_2017-05-01_508.pdf*

11 Water Works: Rebuilding Infrastructure, Creating Jobs, Greening the Environment. Prepared by Green For All. 2011. – *http://pacinst.org/app/uploads/2013/02/water_works3.pdf*

5C032020

This publication was made possible through the generous support of
• **Rutgers Water Resources Program** for professional guidance and review
• **Jessica Casale** for writing and editing assistance
• **Victoria Foundation, Environmental Endowment for New Jersey, New Jersey American Water** for funding support

ANJEC is a statewide nonprofit organization that provides leadership, education, and support for environmental commissions and other local boards and public officials, and partners with other organizations for strong state and regional environmental policy.

For further information, contact ANJEC at
P.O. Box 157, Mendham, NJ 07945 • Tel 973-539-7547 • Email: info@anjec.org
Website: www.anjec.org

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