RUTGERS
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Final Report

Regional Stormwater Management Planning for the Highlands Portion of Watershed Management Area 8 - North and South Branch Raritan

Prepared for the New Jersey Highlands Water Protection and Planning Council
by the
Rutgers Cooperative Extension Water Resources Program

July 23, 2021

Highlands Council
New Jersey

ACKNOWLEDGEMENTS:

This document has been prepared by the Rutgers Cooperative Extension Water Resources Program, with funding and direction from the New Jersey Highlands Water Protection and Planning Council and the New Jersey Agricultural Experiment Station, to highlight green infrastructure opportunities within the Highlands Portion of Watershed Management Area 8 - North and South Branch Raritan. We would like to thank the New Jersey Highlands Water Protection and Planning Council, the New Jersey Agricultural Experiment Station, and the 27 municipalities within the project area for their input and support in creating this document.

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Introduction

The New Jersey Highlands Region covers less than 15% of the state but provides drinking water for 70% of its residents. New Jersey recognized the significance of this region and passed the Highlands Act in 2004 to protect the valuable resources in this region. The Highlands Act advocated for a regional planning approach to protect and restore the waterways of the New Jersey Highlands. This project embraces the regional planning concept and focuses on identifying opportunities in the watersheds of the Highlands for green infrastructure to manage uncontrolled sources of stormwater runoff. The focus of this project is on the portion of the North and South Branch of the Raritan River watershed that are in the New Jersey Highlands.

Figure 1 shows the extent of the New Jersey Highlands. The New Jersey Department of Environmental Protection (NJDEP) has divided New Jersey into 20 watershed management areas (WMAs). Portions of eight of these WMAs are in the New Jersey Highlands including WMA 1 – Upper Delaware, WMA 2 – Wallkill, WMA 3 - Pompton, Wanaque, Ramapo, WMA 4 – Lower Passaic and Saddle, WMA 6 - Upper Passaic, Whippany, and Rockaway, WMA 8 - North and South Branch Raritan, WMA 9 - Lower Raritan, South River, and Lawrence, and WMA 11 – Central Delaware (See Figure 2). This study focuses on WMA 8 – North and South Branch Raritan, which contains portions of 27 municipalities (See Figures 3 and 4).

According to Schueler (1994), Arnold and Gibbons (1996) and May et al. (1997), there is a link between impervious cover and stream ecosystem impairment. Impervious cover is directly linked to the quality of lakes, reservoirs, estuaries, and aquifers (Caraco et al., 1998), and the amount of impervious cover in a watershed can be used to project the current and future quality of streams.

Urbanizing streams can be classified into three categories (Schueler, 1994 and 2004):

- Sensitive — Sensitive streams typically have a watershed impervious surface cover from 0-10%.
- Impacted — Impacted streams have a watershed impervious cover ranging from 11-25% and typically show clear signs of degradation from urbanization.

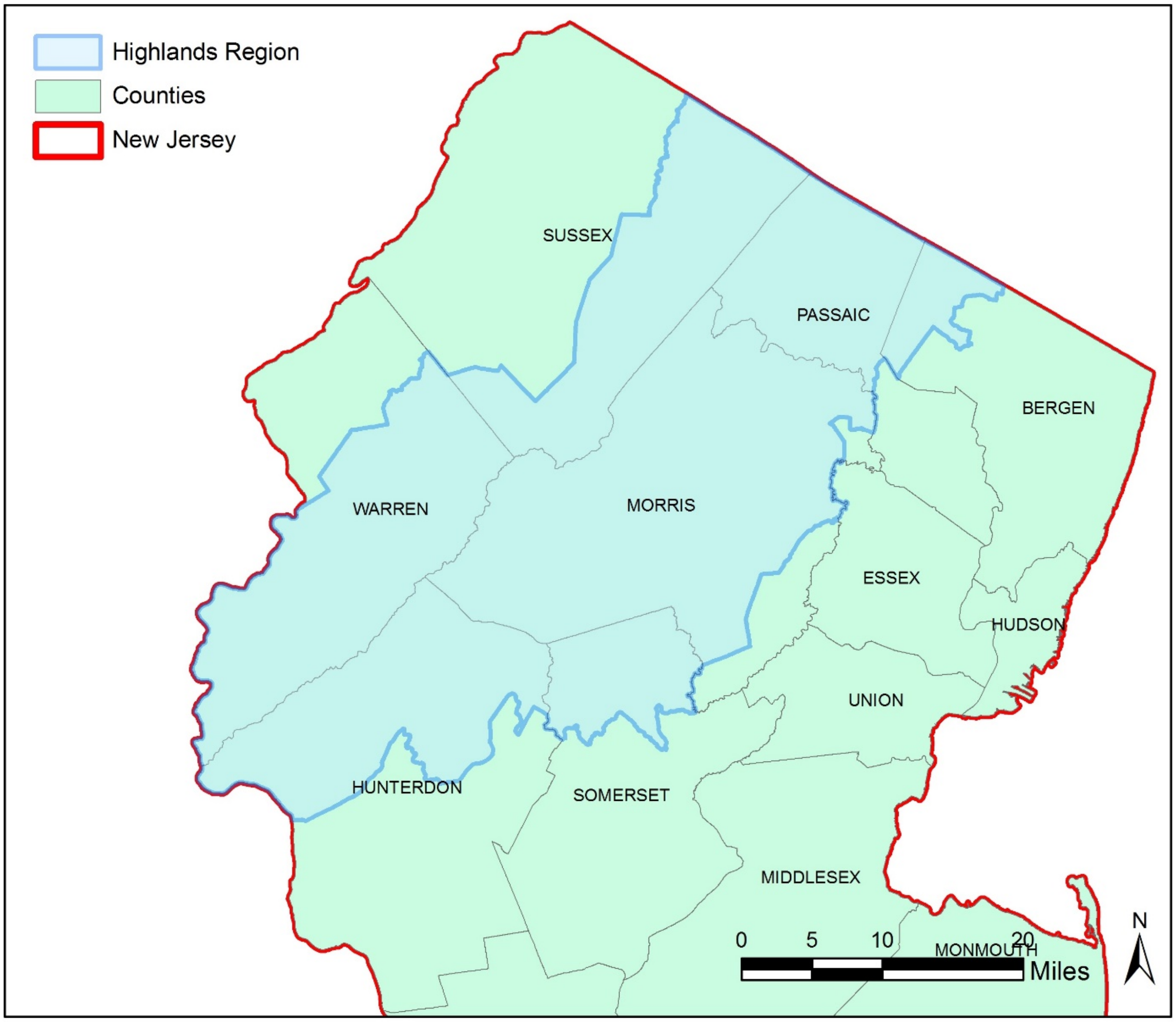


Figure 1: New Jersey Highlands

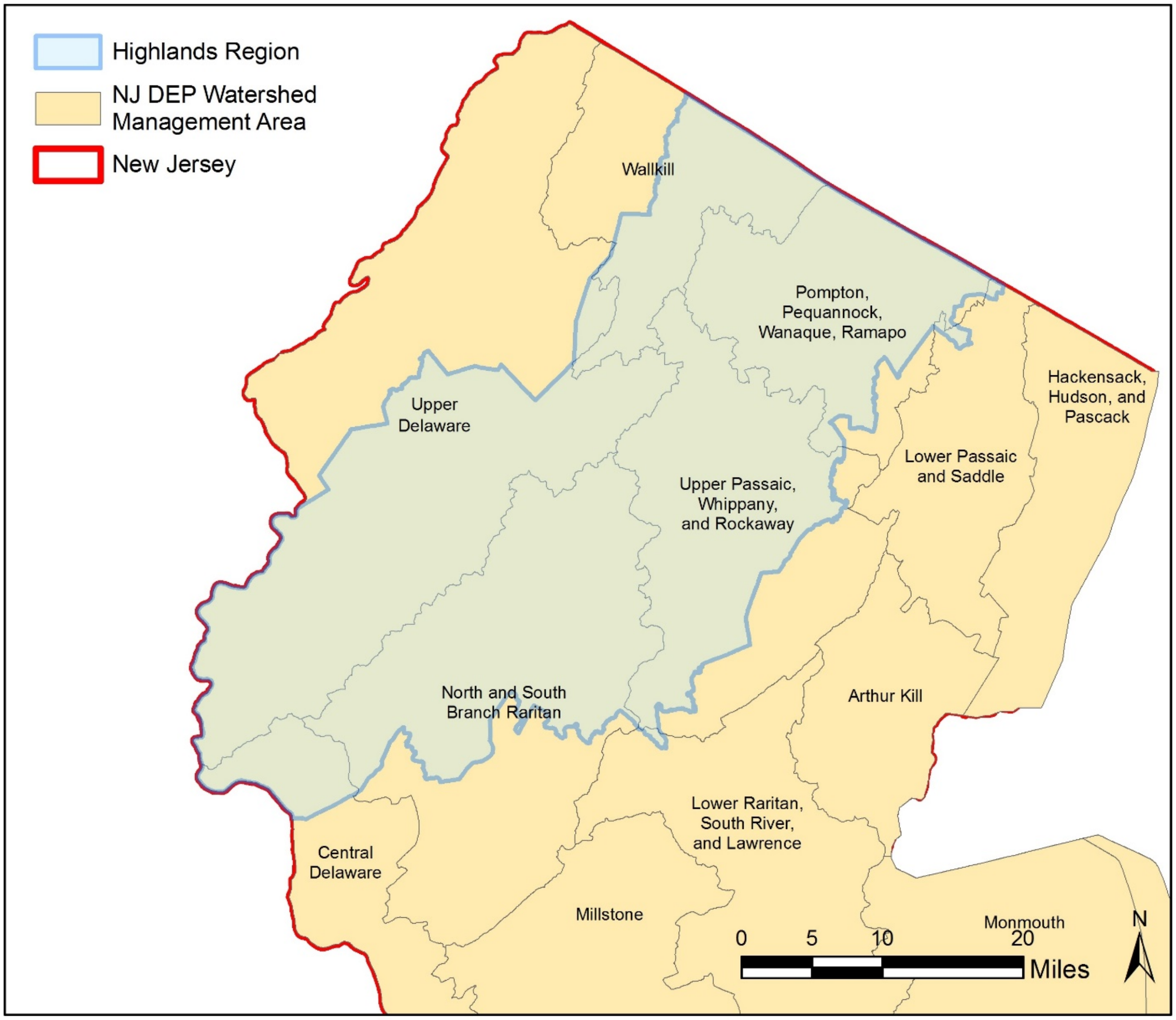


Figure 2: Watershed management areas (WMAs) in the New Jersey Highlands

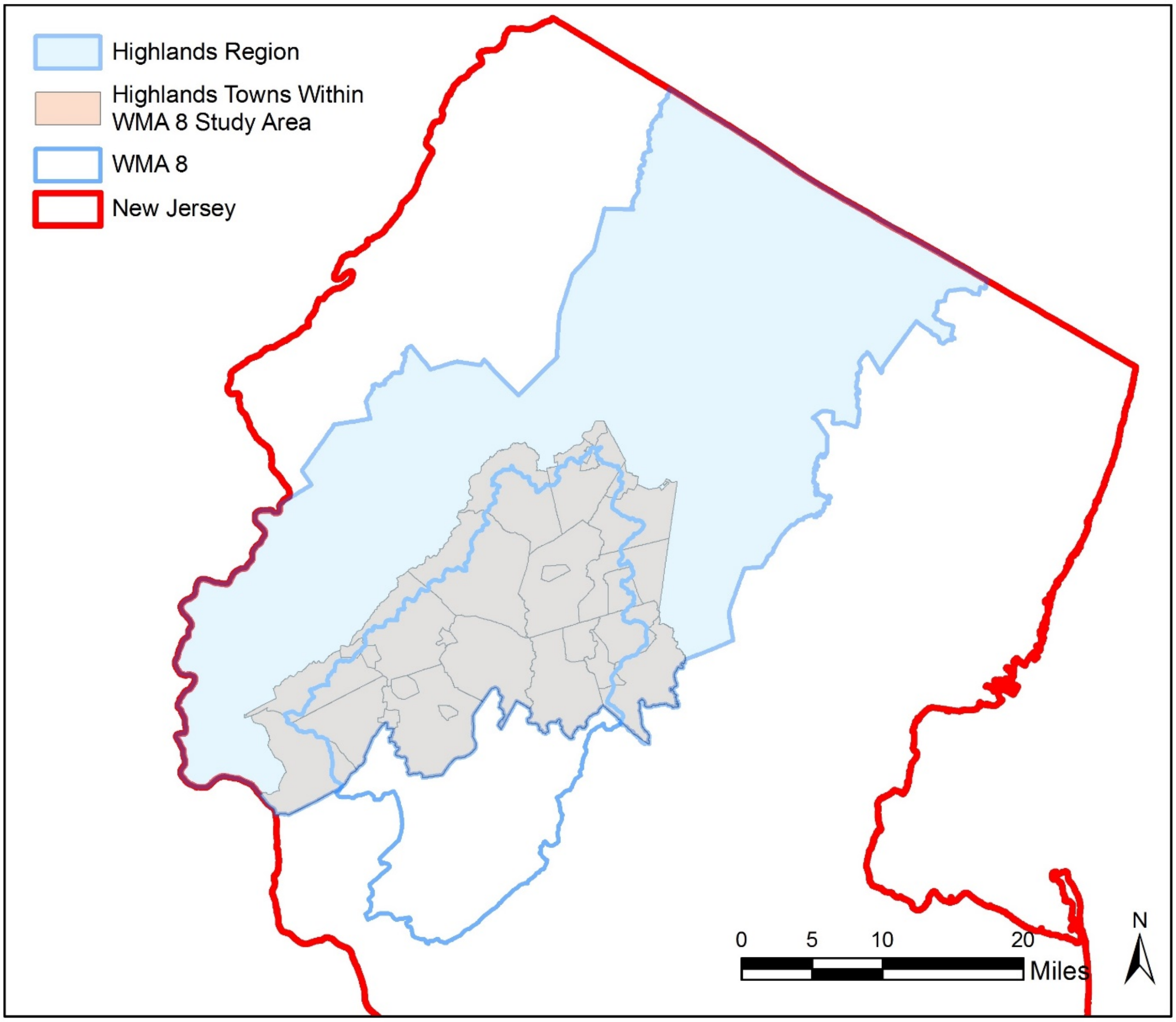


Figure 3: North and South Branch Raritan River WMA 8 municipalties in the New Jersey Highlands

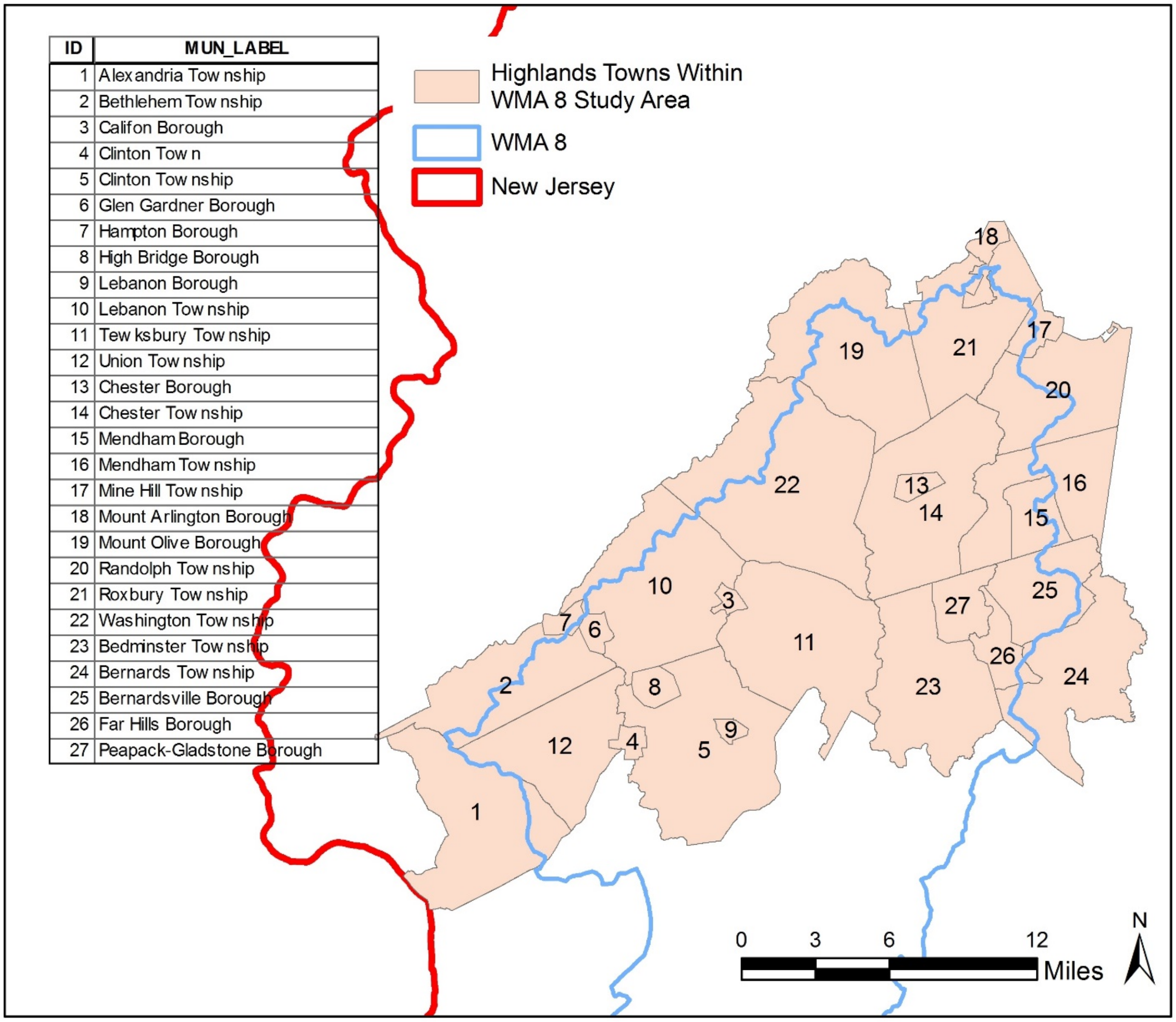


Figure 4: Close up of the North and South Branch Raritan River WMA 8 municipalities in the New Jersey Highlands

- Non-supporting — Non-supporting streams have a watershed impervious cover of greater than 25%; at this high level of impervious cover, streams are simply conduits for stormwater flow and no longer support a diverse stream community.

Schueler et al. (2009) reformulated the impervious cover model, and this new analysis determined that stream degradation was first detected between 2 to 15% impervious cover. The updated impervious cover model recognizes the wide variability of stream degradation at impervious cover below 10%. The updated model also moves away from having a fixed line between stream quality classifications. For example, 5 to 10% impervious cover is included for the transition from sensitive to impacted, 20 to 25% impervious cover for the transition from impacted to non-supporting, and 60 to 70% impervious cover for the transition from non-supporting to urban drainage.

Impervious Cover Assessments

For each of the 27 municipalities, an impervious cover assessment (ICA) was performed. Using available land use/land cover geographic information system (GIS) data, the RCE Water Resources Program determined the acres of impervious cover in the municipality by subwatershed and for the entire municipality. Rutgers calculated stormwater runoff volumes for the impervious surfaces for the one-inch storm, the 2-year design storm, the 10-year design storm, the 100-year design storm, and an annual rainfall of 44 inches.

For the purposes of this report, the Town of Clinton ("Clinton") will be used to illustrate the components of an ICA. Clinton is located in Hunterdon County, New Jersey and covers approximately 1.43 square miles. Figures 5 and 6 illustrate that Clinton is dominated by urban land uses. A total of 53.7% of the municipality's land use is classified as urban. Of the urban land in Clinton, medium density residential is the dominant land use (Figure 7).

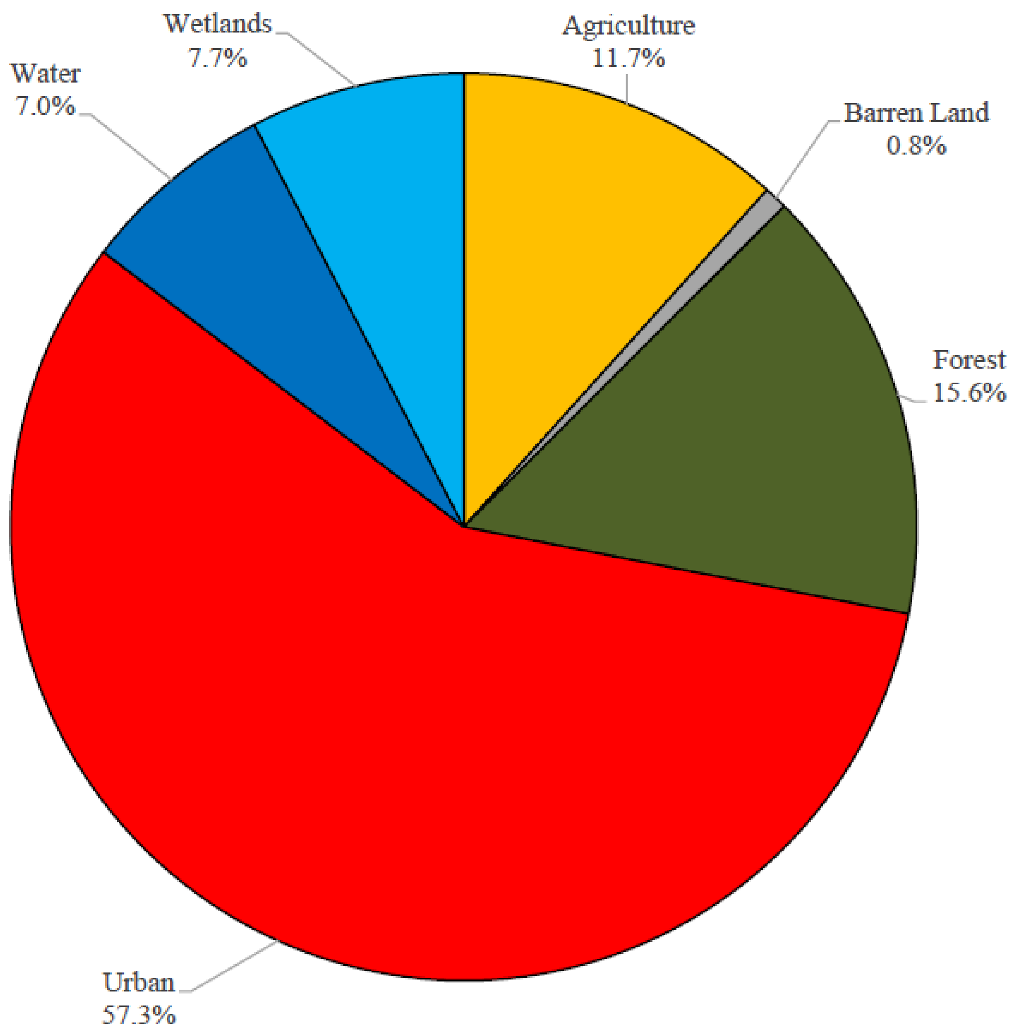


Figure 5: Land use for Clinton

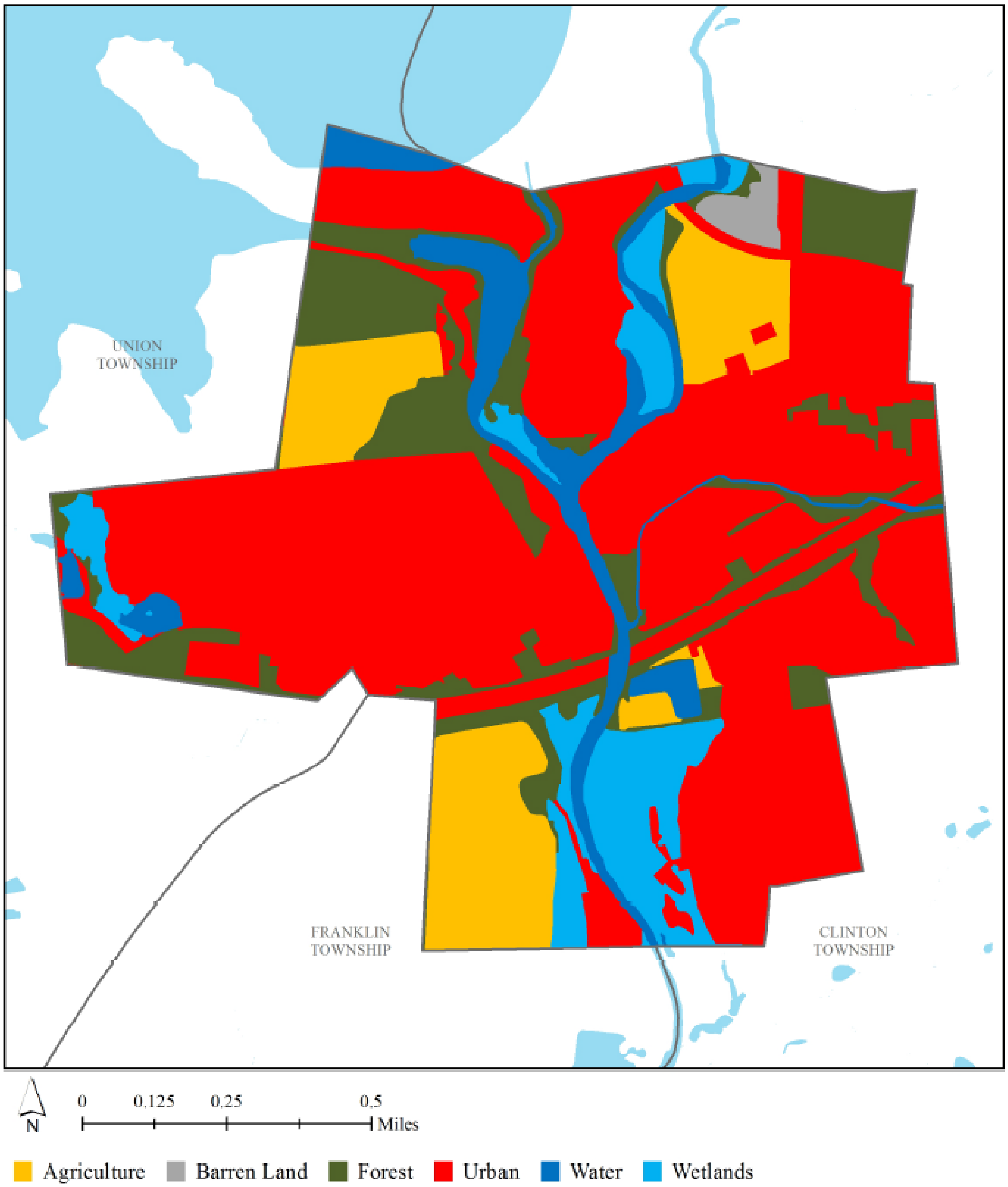


Figure 6: Map illustrating the land use in Clinton

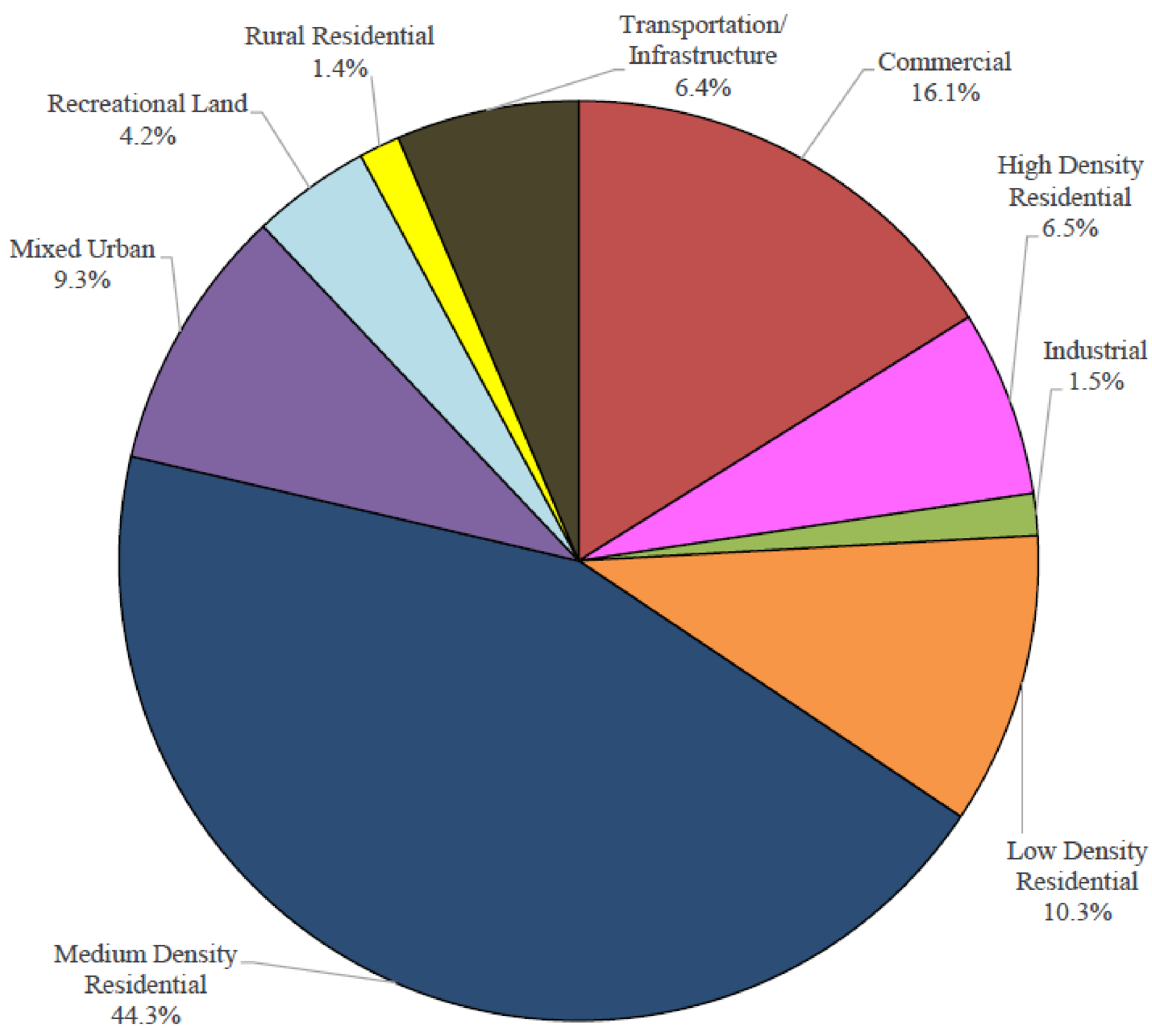


Figure 7: Pie chart illustrating the various types of urban land use in Clinton

The New Jersey Department of Environmental Protection's (NJDEP) 2015 land use/land cover GIS data layer categorizes Clinton into many unique land use areas, assigning a percent impervious cover for each delineated area. These impervious cover values were used to estimate the impervious coverage for Clinton. Based upon the 2015 NJDEP land use/land cover data, approximately 24.6% of Clinton is impervious cover. This level of impervious cover suggests that the streams in Clinton likely range from being impacted to non-supporting streams.

Water resources are typically managed on a watershed/subwatershed basis; therefore, an impervious cover analysis was performed for each subwatershed within Clinton (Table 1 and Figure 8). On a subwatershed basis, impervious cover ranges from 18.5% in the Spruce Run Reservoir subwatershed to 47.4% in the Beaver Brook subwatershed. Evaluating impervious cover on a subwatershed basis allows the municipality to focus impervious cover reduction or disconnection efforts in the subwatersheds where impervious cover is high.

In developed landscapes, stormwater runoff from parking lots, driveways, sidewalks, and rooftops flows to drainage pipes that feed the sewer system. The cumulative effect of these impervious surfaces and thousands of connected downspouts reduces the amount of water that can infiltrate into soils and greatly increases the volume and rate of runoff that flows to waterways. Stormwater runoff volumes (specific to Clinton, Hunterdon County) associated with impervious surfaces were calculated for the following storms: the New Jersey water quality design storm of 1.25 inches of rain, an annual rainfall of 44 inches, the 2-year design storm (3.38 inches of rain), the 10-year design storm (5.00 inches of rain), and the 100-year design storm (8.03 inches of rain). These runoff volumes are summarized in Table 2.

This same analysis was completed for all 27 municipalities. Table 3 summaries the impervious cover for each of the 27 municipalities. It is important to note that the ICAs were completed for the entire municipality even though portions of these municipalities may be outside WMA8 and outside the New Jersey Highlands Area.

Table 1: Impervious cover analysis by subwatershed for Clinton

Watershed	**Total Area (ac)**	**Impervious Cover (ac)**	**Impervious Cover %**
Beaver Brook	152.3	70.8	47.4%
Raritan River South Branch	408.5	78.6	20.9%
Spruce Run Reservoir	357.1	60.7	18.5%
Total	917.9	210.2	24.6%

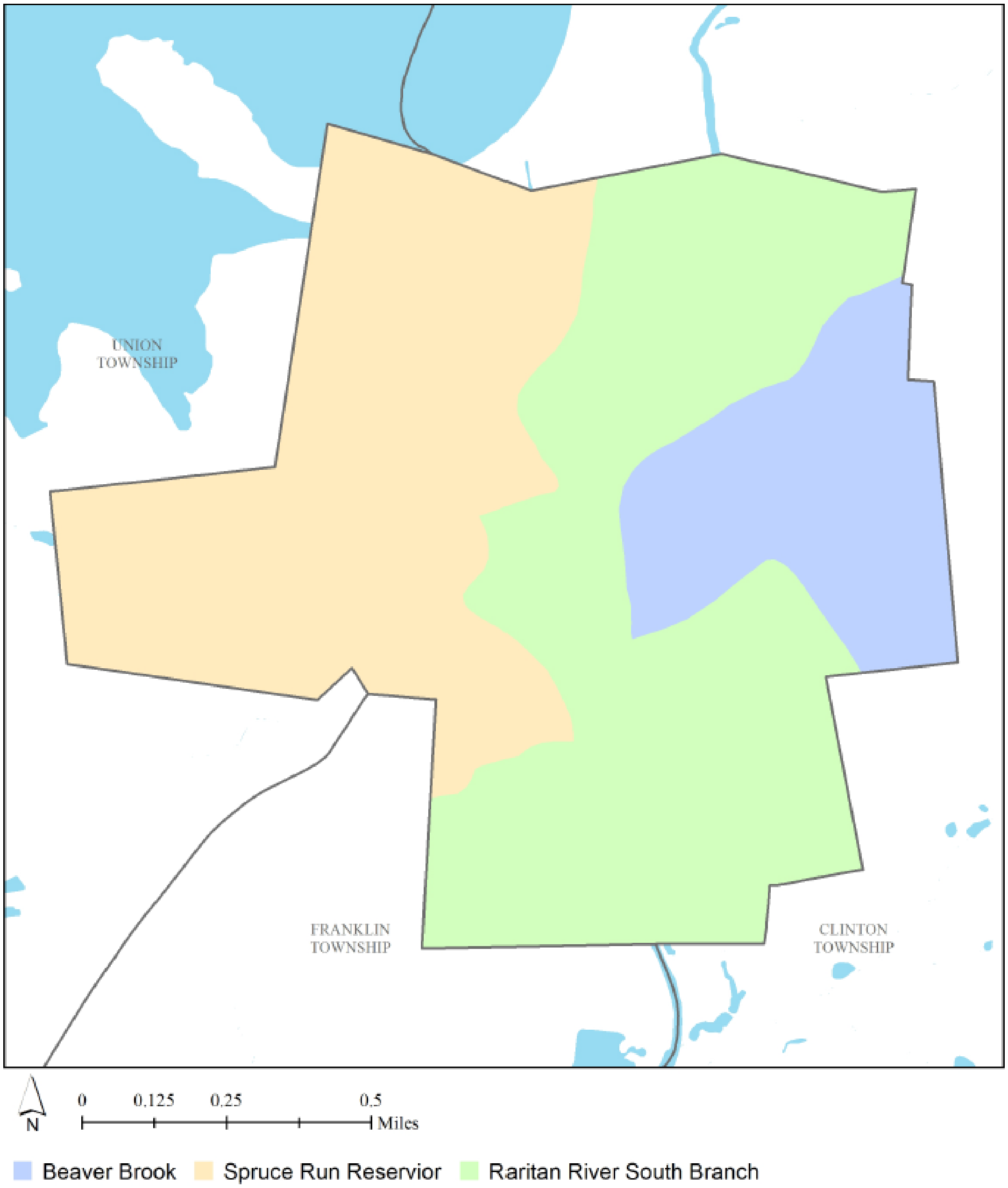


Figure 8: Map of the subwatersheds in Clinton

Table 2: Impervious cover analysis by subwatershed for Clinton

Subwatershed	NJ Water Quality Storm (MGal)	Annual Rainfall of 44″ (MGal)	2-Year Design Storm (3.38″) (MGal)	10-Year Design Storm (5.00″) (MGal)	100-Year Design Storm (8.03″) (MGal)
Beaver Brook	2.4	84.6	6.5	9.6	15.4
Raritan River South Branch	2.7	93.9	7.2	10.7	17.1
Spruce Run Reservoir	2.1	72.5	5.6	8.2	13.2
Total	7.1	251.1	19.3	28.5	45.8

Table 3: Percent impervious cover for the 27 municipalities in the New Jersey Highlands portion of the North and South Branch Raritan River watershed management area

Municipality	County	Total Area (acres)	Impervious Cover	% Impervious
Lebanon Boro	Hunterdon	576.9	175.4	30.5%
Califon Boro	Hunterdon	636.6	70.9	11.6%
High Bridge Boro	Hunterdon	1,555.4	215.2	14.1%
Tewksbury Twp	Hunterdon	20,333.7	636.9	3.2%
Clinton	Hunterdon	917.9	210.2	24.6%
Glen Gardner Boro	Hunterdon	990.6	99.3	10.1%
Clinton Twp	Hunterdon	21,706.3	1,300.8	6.8%
Union Twp	Hunterdon	13,168.6	655.6	5.5%
Lebanon Boro	Hunterdon	20,249.7	583.6	2.9%
Bethlehem Twp	Hunterdon	13,288.0	412.7	3.1%
Alexandria Twp	Hunterdon	17,768.1	480.1	2.7%
Hampton Boro	Hunterdon	971.5	86.3	8.9%
Chester Boro	Morris	1,020.2	235.5	23.1%
Chester Twp	Morris	18,655.2	724.47	3.9%
Mendham Twp	Morris	3,826.4	407.4	10.7%
Washington Twp	Morris	12,939.3	692.0	5.4%
Roxbury Twp	Morris	14,039.8	1,819.10	13.6%
Mount Olive Twp	Morris	19,992.0	1,910.4	10.0%
Mendham Twp	Morris	11,526.7	529.6	4.7%
Randolph Twp	Morris	13,541.7	1,945.1	14.5%
Mine Hill Twp	Morris	1,917.7	226.4	12.0%
Mount Arlington	Morris	1,794.7	314.2	22.7%
Peapack-Gladstone	Somerset	3,696.4	257.3	7.1%
Bedminster Twp	Somerset	16,875.5	879	5.3%
Far Hills Boro	Somerset	3,149.3	122.8	4.0%
Bernardsville Boro	Somerset	8,264.6	658.7	8.0%
Bernards Twp	Somerset	15,567.7	2,056.3	13.3%
Municipal Average Impervious Cover =				**10.5%**

Impervious Cover Reduction Action Plans

An impervious cover reduction action plan (RAP) was completed for each of the 27 municipalities. For each RAP, sites where green infrastructure projects could be installed were identified. Green infrastructure is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure projects capture, filter, absorb, and reuse stormwater to maintain or mimic natural systems and to treat runoff as a resource. As a general principle, green infrastructure practices use soil and vegetation to recycle stormwater runoff through infiltration and evapotranspiration. When used as components of a stormwater management system, green infrastructure practices such as bioretention, green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.

These green infrastructure projects would manage stormwater runoff from the site to help mitigate the impact of runoff from impervious surfaces. Initially, aerial imagery was used to identify potential project sites that contain extensive impervious cover. Field visits were then conducted at each of these potential project sites to determine if a viable option exists to reduce impervious cover or to disconnect impervious surfaces from draining directly to the local waterway or storm sewer system. During the site visit, appropriate green infrastructure practices for the site were determined.

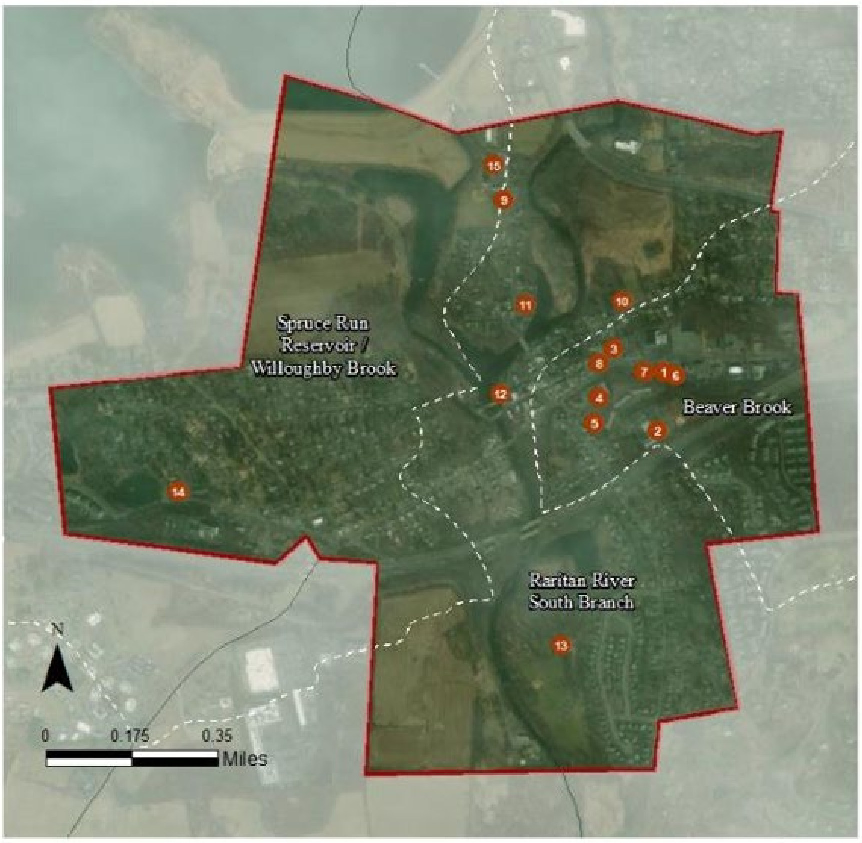
For each potential project site, specific aerial loading coefficients for commercial land use were used to determine the annual runoff loads for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) from impervious surfaces. These aerial loading coefficients were 2.1 lbs/acre/year, 22 lbs/acre/year, and 200 lbs/acre/year for TP, TN, and TSS. These are the same aerial loading coefficients NJDEP uses to develop total maximum daily loads (TMDLs) for impaired waterways of the state. The percentage of impervious cover for each site was extracted from the 2015 NJDEP land use/land cover database. For impervious areas, runoff volumes were determined for the water quality design storm (1.25 inches of rain over two hours) and for the annual rainfall total of 44 inches.

Preliminary soil assessments were conducted for each potential project site using the United States Department of Agriculture Natural Resources Conservation Service Web Soil Survey, which utilizes regional and statewide soil data to predict soil types in an area. Several key soil parameters were examined (e.g., natural drainage class, saturated hydraulic conductivity of the most limiting soil layer (Ksat), depth to water table, and hydrologic soil group) to evaluate the suitability of each site's soil for green infrastructure practices. In cases where multiple soil types were encountered, the key soil parameters were examined for each soil type expected at a site.

For each potential project site, drainage areas were determined for each of the green infrastructure practices proposed at the site. These green infrastructure practices were designed to manage the 2-year design storm, enabling these practices to capture 95% of the annual rainfall. Runoff volumes were calculated for each proposed green infrastructure practice. The reduction in TSS loading was calculated for each drainage area for each proposed green infrastructure practice using the aerial loading coefficients. The maximum volume reduction in stormwater runoff for each green infrastructure practice for a storm was determined by calculating the volume of runoff captured from the 2-year design storm. For each green infrastructure practice, peak discharge reduction potential was determined through hydrologic modeling in HydroCAD. For each green infrastructure practice, a cost estimate is provided. These costs are based upon the square footage of the green infrastructure practice and the real cost of green infrastructure practice implementation in New Jersey. Ten to 20 project sites were identified in each of the 27 municipalities.

Using Clinton as an example, Figure 9 shows the 15 potential green infrastructure sites that were identified in Clinton. These certainly are not all the sites where green infrastructure could be installed in town, but they are a foundation for Clinton to begin implementing green infrastructure to address stormwater issues. For each project site, there is an information sheet (See Figure 10) and a map showing the proposed locations of the green infrastructure projects on that site (See Figure 11).

RAPs were completed for all 27 municipalities. In total, 358 potential project sites were identified across these 27 municipalities, with 271 of these sites occurring within the New Jersey Highlands portion of the North and South Branch Raritan River watershed management area. The sites from



SITES WITHIN THE BEAVER BROOK SUBWATERSHED

1. Basil Bandwagon
2. Clinton Elementary School
3. Clinton Fire Department
4. Clinton Municipal Offices
5. Evangel Chapel
6. Neo Sushi
7. Tirpok Cleaners
8. United States Postal Service

SITES WITHIN THE RARITAN RIVER SOUTH BRANCH SUBWATERSHED

9. Clinton Community Center
10. Clinton Presbyterian Church
11. Clinton United Methodist Church
12. Hunterdon Art Museum
13. Hunts Mills Park

SITES WITHIN THE SPRUCE RUN RESERVOIR /WILLOUGHBY BROOK SUBWATERSHED

14. Pediatric Surgical Associates
15. North County Library

Figure 9: Potential green infrastructure sties in Clinton

PEDIATRIC SURGICAL ASSOCIATES

Subwatershed: Spruce Run Reservoir/Willoughby Brook

Site Area: 27,148 sq. ft.

Address: 122 West Main Street
Clinton, NJ 08809

Block and Lot: Block 1, Lot 1

A proposed rain garden can be installed in the front of the building to aid in infiltration of stormwater from the roof top. A downspout planter box can be installed at the northwestern corner of the building to prevent rooftop stormwater from flowing across the pavement. A preliminary soil assessment suggests that more soil testing would be required before determining the soil's suitability for green infrastructure.

Impervious Cover		Existing Loads from Impervious Cover (lbs/yr)			Runoff Volume from Impervious Cover (Mgal)	
%	sq. ft.	TP	TN	TSS	For the 1.25" Water Quality Storm	For an Annual Rainfall of 44"
69	18,661	0.9	9.4	85.7	0.015	0.51

Recommended Green Infrastructure Practices	Recharge Potential (Mgal/yr)	TSS Removal Potential (lbs/yr)	Maximum Volume Reduction Potential (gal/storm)	Peak Discharge Reduction Potential (cu. ft./second)	Estimated Size (sq. ft.)	Estimated Cost
Bioretention system	0.016	3	1,200	0.05	155	$775
Planter box	n/a	1	n/a	n/a	1 (box)	$1,000

Figure 10: Typical information sheet for potential green infrastructure site

Figure 11: Typical aerial map showing the location of potential green infrastructure projects

the RAPs were incorporated into a web-based interface (i.e., RAP web map) for each municipality so the general public can easily access the recommendations.

Green Infrastructure Feasibility Studies

For each of the 27 municipalities, a green infrastructure feasibility study was prepared. This combines all the information from the ICA and RAP and provides more information on why managing stormwater runoff is important. The green infrastructure feasibility study also includes more detailed information on the various types of green infrastructure practices. These studies also include artistic renderings of three of the potential green infrastructure sites (See Figure 12). This document was created in an easy-to-read format and can be a stand-alone document to provide to stakeholders.

Regional Stormwater Management

The ICAs, RAPs, and green infrastructure feasibility studies were created to help municipalities advocate for green infrastructure and begin implementing some highly visible projects throughout their communities. These studies were designed so information from adjacent towns could be combined to make recommendations on a watershed-scale and begin thinking about stormwater management from a regional perspective. Regional watershed management is often pursued on the HUC 11 scale. HUC stands for Hydrologic Unit Code, and the "11" means it is an 11-digit code. This is a system created by the United State Geological Survey (USGS). There are four HUC 11s that comprise almost all of the 27 municipalities in the New Jersey Highlands portion of the North and South Branch Raritan River watershed management area (See Figure 13). Only small portions of Bernardsville and Bernards Township are left out of the four HUC 11s.

The next step in the regional analysis was to determine the percent impervious cover for each HUC 11. As in the ICAs for each HUC 11, a land use analysis was performed using GIS data from the NJDEP. Unlike the ICAs, the impervious cover percentages were calculated for 2002, 2007, 2012, and 2015 (See Table 4). In general, the impervious cover percentage increases over time, particularly from 2012 to 2015.

Before installation of green infrastructure

After installation of the green infrastructure practice (i.e., a rain garden)

Figure 12: Example of rendering of proposed green infrastructure practice

Figure 13: Four HUC 11s that comprise almost all of the 27 municipalities in the New Jersey Highlands portion of the North and South Branch River watershed management area

Table 4: Imervious cover percentage for HUC 11 from 2002 to 2015

HUC 11	Impervious Cover (%)			
	2002	**2007**	**2012**	**2015**
2030105010	7.68	8.06	7.73	11.34
2030105020	4.85	5.11	4.93	7.86
2030105050	4.95	5.28	5.76	8.93
2030105060	6.34	6.63	6.58	10.55

Using the 2015 impervious cover data, runoff volumes from the impervious surfaces were calculated for various land uses for each HUC 11. These results are presented in Tables 5, 6, 7, and 8. It is important to note that from a water quality perspective, the water quality design storm of 1.25 inches of rain over two hours is the best storm to target for stormwater management. Ninety percent of the rain events in New Jersey come in storms that are less than 1.25 inches of rain. If we can manage stormwater runoff from these smaller events, we can protect and restore the health of our waterways. During these smaller events, most of the stormwater runoff is generated from the impervious surfaces. Although the compaction level, soil type, groundcover, and slope greatly determine how much rainfall a pervious surface can absorb, many can absorb up to 1.25 inches of rain. Therefore, implementing green infrastructure to capture runoff from impervious surfaces for the water quality storm should be one of the main goals in the New Jersey Highlands.

As climate continues to change, the rainfall in New Jersey occurs as more intense storms. In the near future, the majority of rainfall events may be greater than 1.25 inches. To address this issue, all green infrastructure practices that have been identified in the 27 ICAs, RAPs, and green infrastructure feasibility studies use the two-year design storm (3.38 inches of rain over 24 hours) for the preliminary design calculations. This will allow the green infrastructure practice to be slightly larger so it can manage more intense storms that may result from climate change. Equally important, these systems will capture, treat, and infiltrate stormwater runoff from the two-year design storm, which will help reduce localized flooding.

Results

A total of 271 potential green infrastructure sites were identified in the ICAs, RAPs, and green infrastructure feasibility studies in the New Jersey Highlands portion of the North and South Branch Raritan River watershed management area (See Figure 14). These sites represent five different NJDEP land use categories: 1) High, Medium Density Residential, 2) Low Density, Rural Residential, 3) Commercial/Services, 4) Industrial, and 5) Urban, Mixed Urban, Other Urban. Of the 271 sites identified, 172 were classified as Commercial/Services, which includes schools, churches, libraries, municipal buildings, banks, restaurants, businesses, etc. When these sites were selected and site visits were conducted, the goal was to identify one or more green infrastructure practices for each site that would be highly visible as well as capture, treat, and

Table 5: Runoff volumes for various land uses for HUC 02030105010

Land Use Type	HUC 02030105010				
	% Land Use Type	% Impervious Cover	Runoff Volumes From Impervious Cover		
			Water Quality Storm (1.25" over 2 hours) (Mgal)	2-Year Storm (Mgal)	Annual (Mgal)
High, Medium Density Residential	5.5%	21.5%	37.4	98.6	1,314.8
Low Density, Rural Residential	21.2%	41.8%	72.5	191.5	2,553.6
Commercial	2.1%	12.7%	22.1	58.3	777.4
Industrial	1.1%	7.4%	12.8	33.8	451.1
Urban, Mixed Urban, Other Urban	4.9%	5.0%	8.7	22.9	305.9
Agriculture	10.9%	3.3%	5.7	15.1	200.7
Forest, Water, Wetlands	53.8%	7.4%	12.8	33.8	451.3
Barrenland/ Transitional Area	0.6%	0.9%	1.6	4.3	57.5
TOTALS			173.6	458.3	6,112

Table 6: Runoff volumes for various land uses for HUC 02030105020

Land Use Type	HUC 02030105020				
	% Land Use Type	% Impervious Cover	Runoff Volumes From Impervious Cover		
			Water Quality Storm (1.25" over 2 hours) (Mgal)	2-Year Storm (Mgal)	Annual (Mgal)
High, Medium Density Residential	1.4%	8.2%	10.6	27.9	371.7
Low Density, Rural Residential	17.1%	44.2%	56.8	149.8	1,997.7
Commercial	1.6%	12.7%	16.4	43.2	576.3
Industrial	1.3%	11.4%	14.7	38.8	516.9
Urban, Mixed Urban, Other Urban	4.4%	6.9%	8.8	23.3	311.2
Agriculture	19.2%	7.1%	9.1	24.1	321.4
Forest, Water, Wetlands	54.7%	8.9%	11.4	30.0	400.4
Barrenland/ Transitional Area	0.4%	0.6%	0.8	2.1	27.5
TOTALS			128.6	339.2	4,523

Table 7: Runoff volumes for various land uses for HUC 02030105050

Land Use Type	HUC 02030105050				
	% Land Use Type	% Impervious Cover	Runoff Volumes From Impervious Cover		
			Water Quality Storm (1.25" over 2 hours) (Mgal)	2-Year Storm (Mgal)	Annual (Mgal)
High, Medium Density Residential	2.8%	14.1%	23.6	62.3	830.7
Low Density, Rural Residential	17.3%	39.6%	66.5	175.7	2,342.1
Commercial	1.7%	12.8%	21.5	56.7	756.4
Industrial	1.4%	11.6%	19.5	51.4	684.7
Urban, Mixed Urban, Other Urban	4.6%	5.3%	8.9	23.6	314.1
Agriculture	20.4%	7.5%	12.6	33.2	442.4
Forest, Water, Wetlands	50.9%	8.6%	14.5	38.2	509.4
Barrenland/ Transitional Area	0.9%	0.5%	0.8	2.2	29.6
TOTALS			167.9	443.3	5,909

Table 8: Runoff volumes for various land uses for HUC 02030105060

Land Use Type	HUC 02030105060				
	% Land Use Type	% Impervious Cover	Runoff Volumes From Impervious Cover		
			Water Quality Storm (1.25" over 2 hours) (Mgal)	2-Year Storm (Mgal)	Annual (Mgal)
High, Medium Density Residential	2.4%	11.2%	16.4	43.2	575.7
Low Density, Rural Residential	25.3%	50.2%	73.6	194.2	2,589.2
Commercial	1.8%	11.8%	17.2	45.5	606.4
Industrial	0.8%	6.0%	8.8	23.2	309.9
Urban, Mixed Urban, Other Urban	6.3%	6.4%	9.4	24.8	330.9
Agriculture	15.6%	5.1%	7.5	19.9	264.8
Forest, Water, Wetlands	47.7%	9.2%	13.5	35.8	477.0
Barrenland/ Transitional Area	0.1%	0.1%	0.1	0.3	4.1
TOTALS			146.5	386.9	5,158

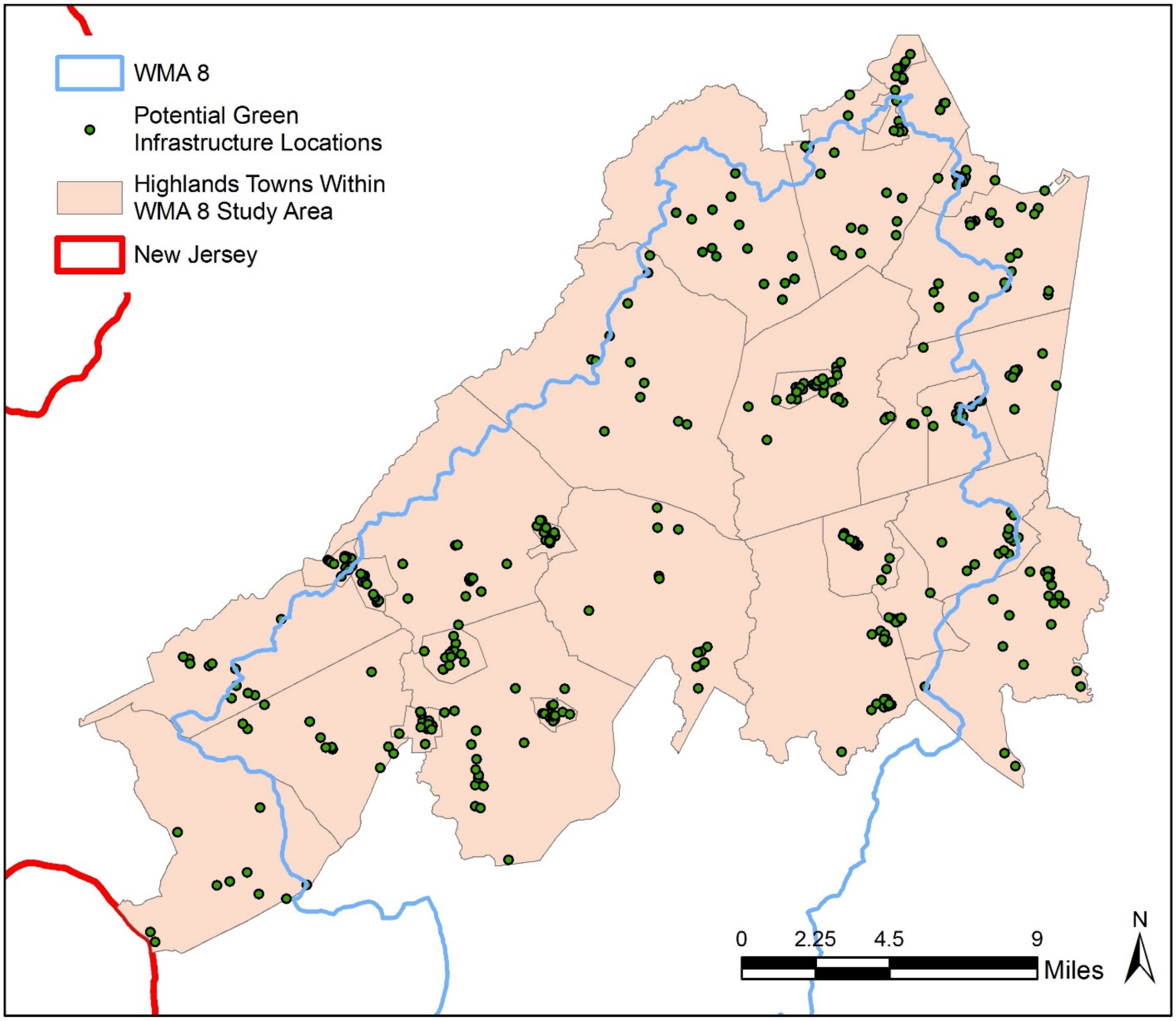


Figure 14: Potential green infrastructure sites in the New Jersey Highlands portion of the North and South Branch Rarian River watershed management area

infiltrate runoff from impervious surfaces. It is important to note that by no means was any attempt made to maximize the amount of impervious surfaces that would be treated with green infrastructure. There was a wide range of impervious percentages that green infrastructure practices were recommended to treat at these 172 commercial land use sites from 100% to less than 1% with the average being 21.4%. For each of the five land use categories, the potential green infrastructure projects that were identified for the 27 municipalities were used to determine an average percent potential reduction in impervious surfaces (See Table 9). These percentages were then applied to the land uses in each of the HUC 11s to determine the reduction in volume of stormwater runoff that could be obtained by installing green infrastructure (See Table 10). When comparing these reductions to existing runoff volumes from impervious surfaces, the installation of green infrastructure at an average rate recommended in the green infrastructure feasibility studies for the 27 municipalities can reduce runoff volumes for the water quality storm and the two-year design storm by 15 to 16%. This should be viewed as a minimum reduction since there are most likely many more opportunities at each potential site to optimize the amount of impervious surfaces being treated.

Costs

Costs for the various green infrastructure practices recommended in the studies for the 27 municipalities are provided. A cost of $5 per square foot is used to estimate the costs associated with bioretention systems such as rain gardens and bioswales. Based on the RCE Water Resources Program experience, these costs can range from $0.50 per square foot to as much as $25 per square foot. Permeable pavement costs are also included in the plans. These costs are based upon the installation of porous asphalt systems throughout New Jersey. The only other cost that is generally provided in the plans are for rainwater harvesting systems, which typically have a cost of $2 per gallon, but this cost has risen in many areas to $3 to $4 per gallon over the last two years.

Ideally, grant funding could be used to design and build some of these projects. There is an ongoing discussion in Washington, D.C. about a federal infrastructure act. In the past, federal pass-through dollars for building projects have prioritized “shovel-ready” projects. While preliminary engineering calculations have been completed for the projects in the plans, they are

Table 9: Potential reduction in impervious cover based upon proposed green infrastructure sites within the 27 municipalities

Land Use (LU) Type	**% Impervious Cover Reduction**
High, Medium Density Residential	17.1%
Low Density, Rural Residential	15.9%
Commercial	21.4%
Industrial	13.2%
Urban, Mixed Urban, Other Urban	38.7%

Table 10: Potential stormwater volume reduction by land use for each HUC 11

Land Use (LU) Type	% Reduct-ion	Volume Reduction							
		HUC 010		HUC 020		HUC 050		HUC 060	
		WQS (Mgal)	2-Year (Mgal)	WQS (Mgal)	2-Year (Mgal)	WQS (Mgal)	2-Year (Mgal)	WQS (Mgal)	2-Year (Mgal)
High, Medium Density Residential	17.1%	6.4	16.9	1.8	4.8	4.0	10.7	2.8	7.4
Low Density, Rural Residential	15.9%	11.5	30.4	9.0	23.8	10.6	27.9	11.7	30.8
Commercial	21.4%	4.7	12.5	3.5	9.2	4.6	12.1	3.7	9.7
Industrial	13.2%	1.7	4.5	1.9	5.1	2.6	6.8	1.2	3.1
Urban, Mixed Urban, Other Urban	38.7%	3.4	8.9	3.4	9.0	3.5	9.1	3.6	9.6
Percent reduction compared to existing runoff volumes		**16.0%**	**16.0%**	**15.2%**	**15.3%**	**15.1%**	**15.0%**	**15.7%**	**15.7%**

WQS = water quality storm

not considered "shovel-ready." Often "shovel-ready" means engineering designs that are at least 30% complete.

The good news is that the New Jersey Highlands Council has funding for municipalities to prepare designs. The RCE Water Resources Program experience is that it is much easier to secure funding for projects that are already designed; municipalities may want to consider reaching out to the New Jersey Highlands Council to inquire about available funding for designs.

Some municipalities have incorporated green infrastructure funding into their annual capital improvement budget. They often either hire a subcontractor to install projects every year or their public works department installs the projects. Over several years, this could lead to significant water quality improvements and a reduction in flooding.

Finally, New Jersey has recently passed a bill to allow for the formation of stormwater utilities. Just like a water utility or a sewerage utility, users pay an annual fee for the utility to manage the stormwater they generate. This fee is based upon the amount of impervious surfaces the property owner has and allows the property owner to install their own green infrastructure (e.g., a rain garden or a rainwater harvesting system) to reduce the fee. The end result is that those who contribute more stormwater runoff pay more, thereby introducing a level of fairness. Municipalities alone or in a regional fashion may want to explore the option of forming a stormwater utility.

Conclusion

It is clear that there are many opportunities in the New Jersey Highlands portion of the North and South Branch Raritan River watershed management area to better manage stormwater runoff from impervious surfaces. Green infrastructure can easily be retrofitted into many sites and can dramatically reduce stormwater runoff volumes for the New Jersey water quality storm and the two-year design storm. This will improve water quality where waterways are impaired, protect water quality in waterways that are pristine, and help reduce localized flooding. This study showed a minimum potential for a 15 to 16% reduction in runoff volumes for the water quality storm and the two-year design storm, which could be much greater with more detailed site analyses.

The next step would be for the municipalities to reach out to the New Jersey Highlands Council and the RCE Water Resources Program to discuss how to begin implementing projects. The sooner we start chipping away at the problem, the quicker the health of the waters of the New Jersey Highlands will be restored and protected.

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