Impervious Cover Assessment
And Reduction Action Plan
Prepared For

Roosevelt Borough, Monmouth County, New Jersey

by the
Watershed Institute

December 30, 2020

Acknowledgements

Designed as a blueprint for municipalities to take action to reduce impacts of stormwater runoff from impervious surfaces to New Jersey's Waterways, this document was created by The Watershed Institute staff with Water Quality Restoration Grant funding from the New Jersey Department of Environmental Protection under the Federal Clean Water Act, Section 319(h). This study was created with guidance from, and in supplement to, similar work performed by the Rutgers Cooperative Extension Water Resources Program, and we would like to thank them for their input and support.

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Executive Summary

Stormwater runoff occurs when precipitation falls on hard surfaces like roofs, parking lots, and roadways that are impervious to water. Stormwater runoff can cause flooding and pollute waters, and these concerns have grown more pronounced with increasing development and larger storm events that scientists attribute to climate change. The Watershed Institute created this Impervious Cover Assessment (ICA) and Reduction Action Plan (RAP) to 1) assess the extent of impervious cover in Roosevelt Borough, as well as the amount of the resultant stormwater runoff and associated pollutant loading (i.e. perform an ICA), 2) perform a more detailed ICA and stormwater assessment for a select number of commercial properties within the municipality, 3) provide a select number of preliminary designs that act as examples of possible actions that can be taken to reduce or mitigate the amount or stormwater runoff and associated pollutants (i.e. create an RAP), and 4) review any policies and ordinances that the municipality may have that are relevant to stormwater management and make recommendations for changes in policy that will reduce stormwater runoff and its impacts in the future.

In Summary:

1. Impervious surfaces cover approximately 4.69 percent of Roosevelt Borough's land area. This is below the 10% threshold above which a subwatershed is considered to be impaired for water quality.
2. The municipality has two subwatersheds which have impervious cover (IC) ranging from 0.28-5.53 % IC; the recommendation of this report is that any restorations efforts should be focused in the subwatershed with the highest percentages of IC: the Upper Assunpink Creek subwatershed; We recommend limitations on development and incorporation of Green Infrastructure throughout the municipality to limit future increases in IC.
3. Stormwater runoff volume from the municipality IC is over 74 million gallons of stormwater annually.
4. Using Geographical Information Systems, we identified 6 sites where actions could be taken to mitigate stormwater runoff. For 4 of those sites, we conducted more detailed on-site stormwater assessments and prepared Green Infrastructure conceptual designs. Those 4 projects have a total stormwater mitigation potential of over 993 thousand gallons of runoff.
5. While Roosevelt Borough has some regulations in place for Tree Protection, Stream Corridor Protection, and Stormwater Management Rules, the creation of new and updating / strengthening of current ordinances for all three of these categories are recommended to help with mitigation and resiliency for both surface water pollution, flooding events, and habitat degradation (See Policy Review).

Introduction

Pervious and impervious are terms that are used to describe the ability or inability of water to flow through a surface. Pervious surfaces are those which allow stormwater to readily soak into the soil and recharge groundwater. When rainfall drains from a surface, it is called "stormwater runoff". Impervious cover (IC) is any material that has been placed over soil that prevents water from soaking into the ground. Impervious surfaces include paved roadways, parking lots, sidewalks, rooftops, and most aspects of development. As impervious areas increase, so does the volume of stormwater runoff. Impervious surfaces alter the natural hydrologic cycle, causing runoff to increase dramatically from ~ 10% of annual rainfall in an undeveloped watershed to > 50% in a highly urbanized watershed (Figure 1).[2]

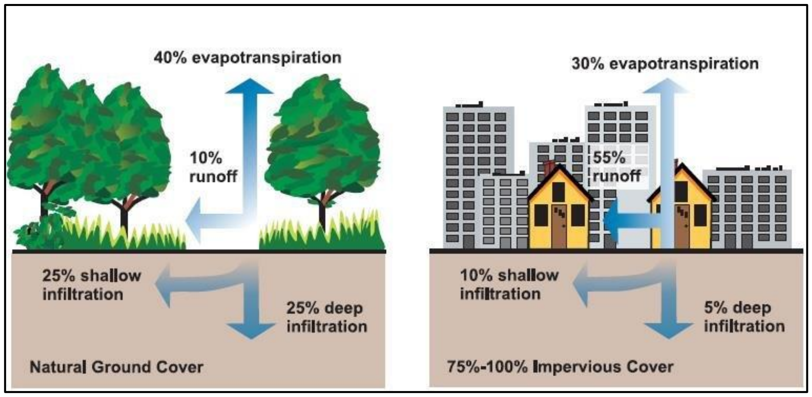


Figure 1: Relationship between impervious surfaces and stormwater runoff.[1]

As stormwater flows over the ground, it picks up pollutants, including salts, animal waste, sediment, excess fertilizers, pesticides, motor oil, and other toxic substances. It is no surprise then, that impervious cover can be linked to the quality of water in lakes, reservoirs, estuaries, and aquifers, and the amount of impervious cover in a watershed can be used to project the current and future quality of streams.[3] However, there are many other consequences associated with high amounts of runoff.

Problems in New Jersey due to stormwater runoff include:

- Pollution: According to the 2010 New Jersey Water Quality Assessment Report, 90% of the assessed waters in New Jersey are impaired, with urban-related stormwater runoff listed as the most probable source of impairment.[4]
- Flooding: Over the past century, the state has seen an increase in flooding (Figure 2). Communities around the state have been affected by these floods. The amount of damage caused also has increased greatly with this trend, costing billions of dollars over this time span.
- Erosion: Increased stormwater runoff causes an increase in the velocity of flows in our waterways. The increased velocity after storm events erodes stream banks and shorelines,

1 Figure and caption recreated from United States Environmental Protection Agency (USEPA). 2003 Protecting Water Quality from Urban Runoff. National Service Center for Environmental Publications - EPA-841-F-03-003

2 Paul MJ & Meyer JL. 2001. The ecology of urban streams. Annual Review of Ecology & Systematics 32:333-365

3 Caraco, D., et. al. 1998. Rapid Watershed Planning Handbook. A Comprehensive Guide for Managing Urbanizing Watersheds. Prepared by Center For Watershed Protection, Ellicott City, MD. Prepared for U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds and Region V. October 1998.

4 United States Environmental Protection Agency (USEPA). 2013. Watershed Assessment, Tracking, and Environmental Results, New Jersey Water Quality Assessment Report. http://ofmpub.epa.gov/waters10/attains_state.control?p_state=NJ

degrading water quality. This erosion can damage local roads and bridges and cause harm to wildlife.

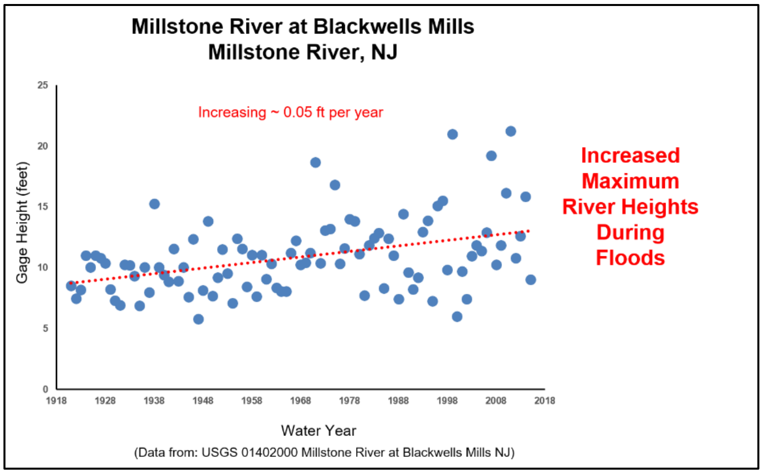


Figure 2: Annual Maximum River Height at Blackwells Mills Dam, Franklin Twp, NJ

The primary cause of the pollution, flooding, and erosion problems is the quantity of impervious surfaces draining directly to local waterways. New Jersey is one of the most developed states in the country, and has the highest percent of impervious cover in the country at 12.1% of its total area.[5] Most of these surfaces are directly connected to local waterways (i.e., every drop of rain that lands on these impervious surfaces and does not evaporate ends up in a local river, lake, or bay without any chance of being treated to remove pollutants or opportunity for it to recharge ground water). To repair our waterways, reduce flooding, recharge groundwater and reduce erosion of streambanks, stormwater runoff from IC has to be better managed. Surfaces need to be disconnected with green infrastructure or other Best Management Practices (BMPs) to restore the natural hydrological cycle by preventing stormwater runoff from flowing directly into New Jersey's waterways.

The first step to reducing the impacts from impervious surfaces is to conduct an impervious cover and stormwater management assessment to determine the sources and volumes of runoff water. Once impervious surface have been delineated, there are three primary actions that can be designed to restore an area's proper hydrology:

1. **Eliminate impervious cover that is not necessary.** For example, a paved courtyard at a public school could be converted to a garden or grassy area.
2. **Reduce or convert impervious surfaces.** There may be surfaces that are required to be hardened, such as roadways or parking lots, but could be reduced in size and/or converted to pervious surface. This can be achieved by reducing car-lanes sizes or replacing hardscaping with permeable paving materials such as porous asphalt, pervious concrete, or permeable paving stones that could be substituted for impermeable paving materials.

[5] Nowak, D. J., and E. J. Greenfield, 2012. Trees and Impervious Cover in the United States. *Landscape and Urban Planning* 107 (2012): 21-30. http://www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_nowak_002.pdf

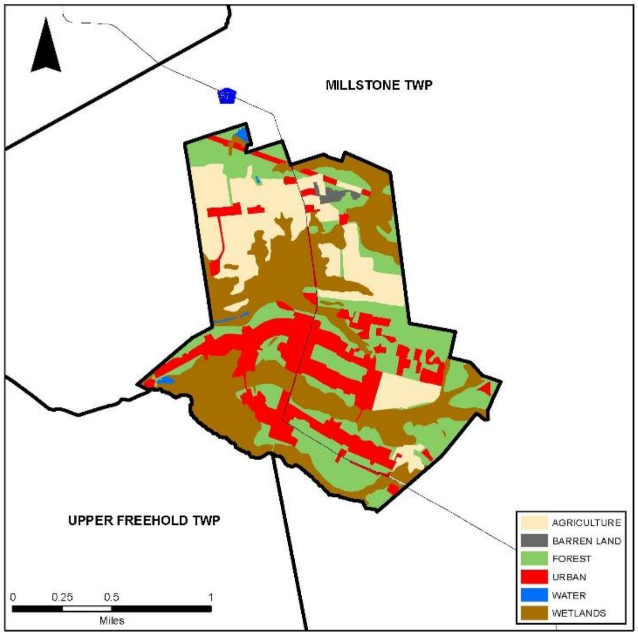


Figure 3: Land-use aerial of Roosevelt Borough

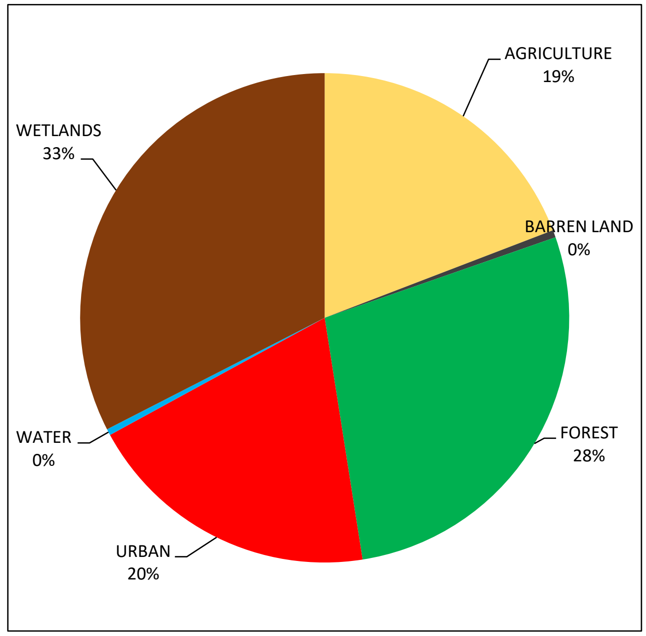


Figure 4: Land-use composition (%) in Roosevelt Borough

3. **Disconnect impervious surfaces from flowing directly to local waterways.** There are many ways to capture and treat stormwater runoff from impervious surfaces and subsequently either reuse the water or allow the water to infiltrate into the ground restoring aquifers (See Green Infrastructure & Best Management Practices).

This report details the results of an Impervious Cover Assessment (ICA) performed during 2016/2017 for Roosevelt Borough at several different scales: by municipality, subwatershed, and individual lots. In addition, a concept design to reduce or mitigate stormwater runoff, here called a Reduction Action Plan or RAP, was created for a subset of the individual lots that were assessed. Finally, a review of the municipality's ordinances and/or Master Plan sections that are relevant to the control of stormwater runoff was completed, with suggestions for making changes towards resiliency for flooding and improved water quality.

Impervious Cover Analysis: Roosevelt Borough

Municipal Subwatershed Assessment

Located in Monmouth County in central New Jersey, Roosevelt Borough covers just under 2 square miles. The Borough is dominated by forest and wetland land types, with urban land-use composing around 20% of the total town (Figures 3 & 4). The dominant types of urban land are low and medium density residential (Figure 5). Impervious surfaces were estimated to cover 4.69% of the Borough's land area (Figure 6). The municipality is divided into two individual subwatershed units (Figure 7, colored areas), one of which drains to the Delaware River and the other to the Millstone River.

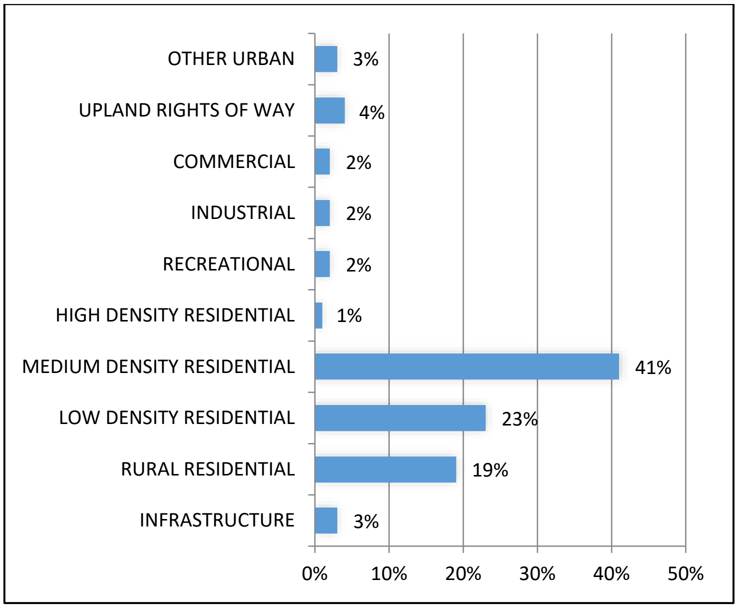


Figure 5: Urban land-use composition in Roosevelt Borough

Analysis of the sections of those drainage areas that fall within the municipality's boundaries showed a variable amount of IC, ranging from 0.28% in the Rocky Brook subwatershed to 5.53% in the Upper Assunpink Creek subwatershed (Table 1).

Runoff volumes caused by impervious surfaces was modeled for the entire municipality as well as for each of the subwatersheds for the following categories of rainfall events: 1) The New Jersey's water quality design storm (the storm event used to analyze and design stormwater management systems (equal to 1.25 inches of rain over a 2 hour period), 2) the 2-year design storm (3.32 inches in 24 hours), 3) the 10-year design storm (5.07 inches in 24 hours), 4) the 100-year design storm (8.54 inches in 24 hours), and 5) New Jersey's total average annual rainfall of 46.94 inches (Table 2).[6,7] Impervious surfaces in Roosevelt Borough result in over 74.2 million gallons of annual stormwater runoff. The Water Quality Design storm would produce 2.0 million gallons in just a two hour period, while the 2, 10, and 100 year storms would generate 5.3, 8.0, and 13.5 million gallons within a 24 hour period respectively.

The 2 main subwatersheds within Roosevelt Borough are part of 3 larger tributary subwatershed units, or HUC 14 basins (delineated by yellow perimeters, Figure 7). Existing conditions for impervious cover and runoff calculations for the entirety of each HUC 14 (which includes the areas outside of the municipal boundaries) were also calculated.

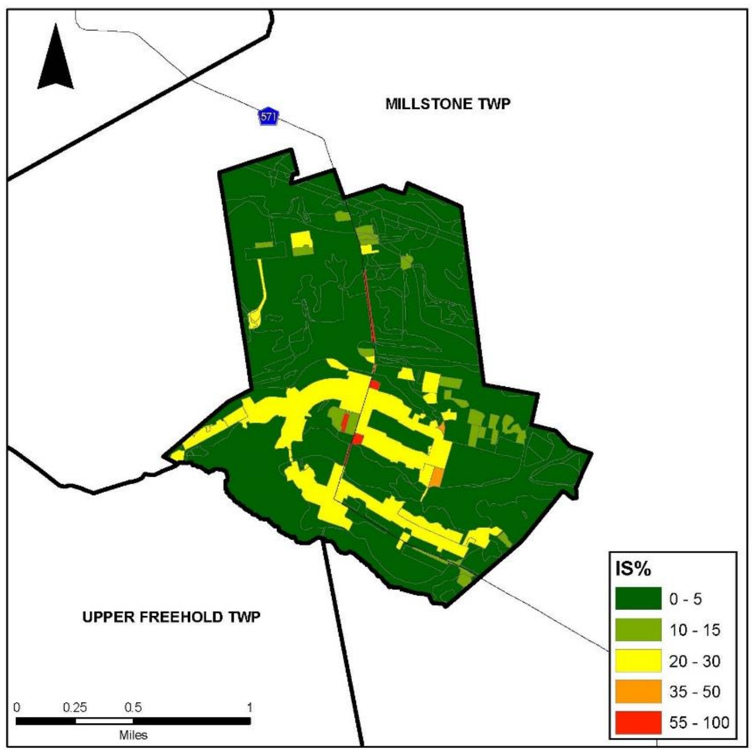


Figure 6: Amount of Impervious Surfaces (% IS) by parcel in Roosevelt Borough

[6] NJ Stormwater Best Management Practices Manual – see https://www.njstormwater.org/bmp_manual2.htm
[7] Based on New Jersey's average annual rainfall as of 2017 – Office of the NJ State Climatologist, Rutgers University

Table 1: Impervious cover analysis by subwatershed for Roosevelt Borough

Subwatershed	Total Area		Land Use Area		Water Area		Impervious Cover		
	(ac)	(mi²)	(ac)	(mi²)	(ac)	(mi²)	(ac)	(mi²)	(%)
Rocky Brook	199.81	0.31	197.35	0.31	2.46	0.00	0.56	0.00	0.28%
Upper Assunpink Creek	1046.69	1.64	1,043.95	1.63	2.74	0.00	57.69	0.09	5.53%
Total	1,246.50	1.95	1,241.30	1.94	5.2	0.01	58.25	0.09	4.69%

Table 2: Stormwater runoff volumes (million gallons) from impervious surfaces by subwatershed in Roosevelt Borough

Subwatershed	Total Runoff Volume for the 1.25" NJ Water Quality Storm (MGal)	Total Runoff Volume for the NJ Annual Rainfall of 46.94" (MGal)	Total Runoff Volume for the 2-Year Design Storm (3.32") (MGal)	Total Runoff Volume for the 10-Year Design Storm (5.07") (MGal)	Total Runoff Volume for the 100-Year Design Storm (8.54") (MGal)
Rocky Brook	0.0	0.7	0.1	0.1	0.1
Upper Assunpink Creek	2.0	73.5	5.2	7.9	13.4
Total	2.0	74.2	5.3	8.0	13.5

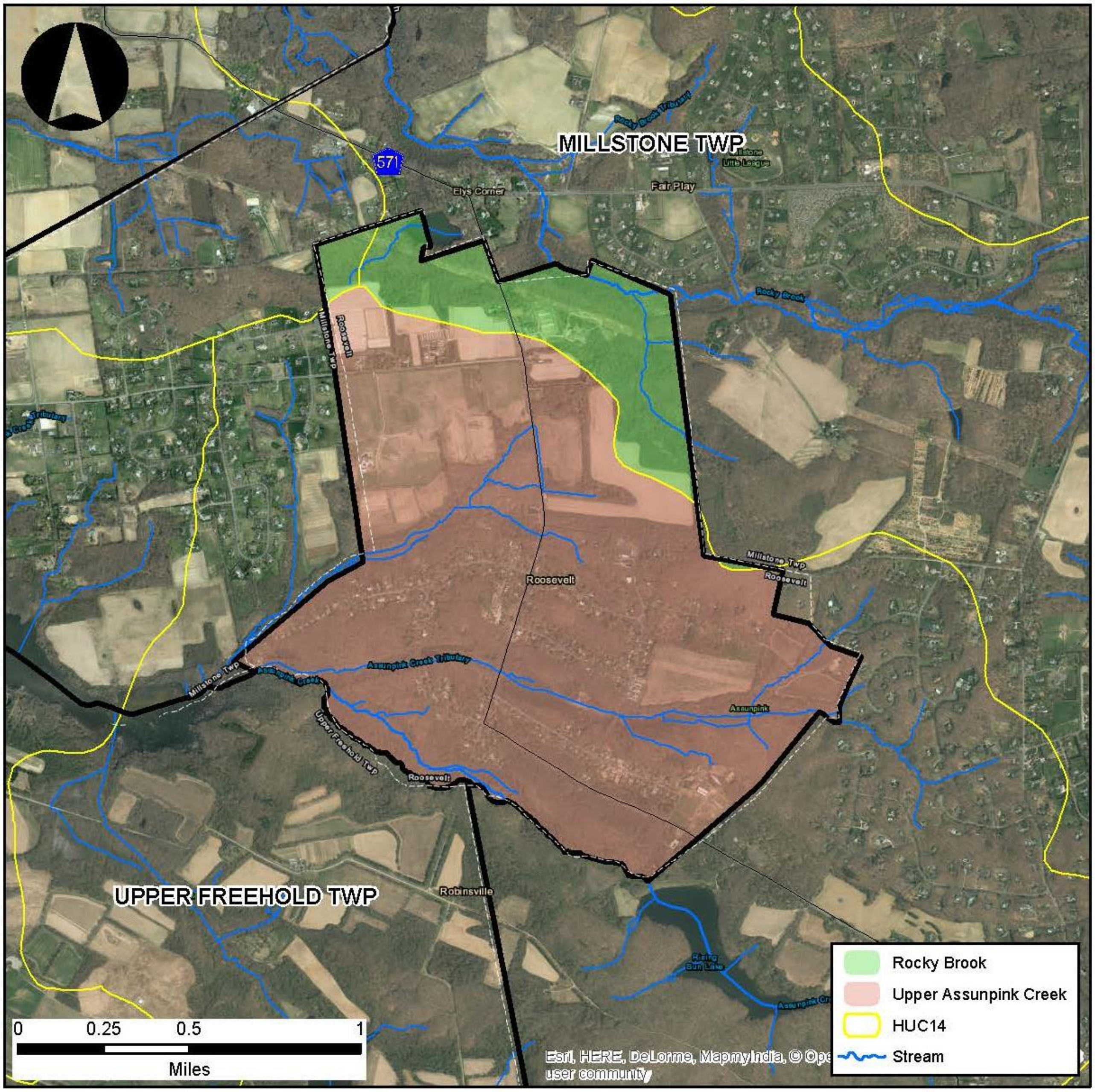
Results for land and water area as well as impervious cover can be found in Appendix A. Runoff values for the different rain event categories were also modeled for each HUC 14 basin and can be found in Appendix B.

Individual Lot Assessment

More specific impacts of runoff due to impervious surfaces can be modeled on a lot by lot basis once priorities have been identified through municipal and subwatershed scale assessments. An ICA was performed for 6 individual lots in Roosevelt Borough that contained particularly high levels of impervious cover (see colored lots, Figure 8 or visit https://thewatershed.org/**impervious-cover-assessments**/). Existing runoff volumes caused only by the sites' IC were modeled for the Water Quality Design Storm, the 2 year storm, and for the state's total annual rainfall (See Appendix C). Estimates for the annual amount of select pollutants (lb/year) that will runoff with the stormwater into waterways were also generated, including total nitrogen (TN), total phosphorous (TP), and total suspended solids (TSS).

Those 6 properties alone accounted for over 3 acres of impervious cover and over 4.1 million gallons of the town's annual stormwater runoff. This volume of runoff from impervious surfaces carries an estimated 4.3 lb of total phosphorous, 44.4 lb of total nitrogen, and 468 lb of total suspended solids into the streams of Roosevelt Borough, and downstream to the Millstone and Delaware Rivers. The summary of existing individual lot conditions can be found in Appendix C or online at https://thewatershed.org/**impervious-cover-assessments**/.

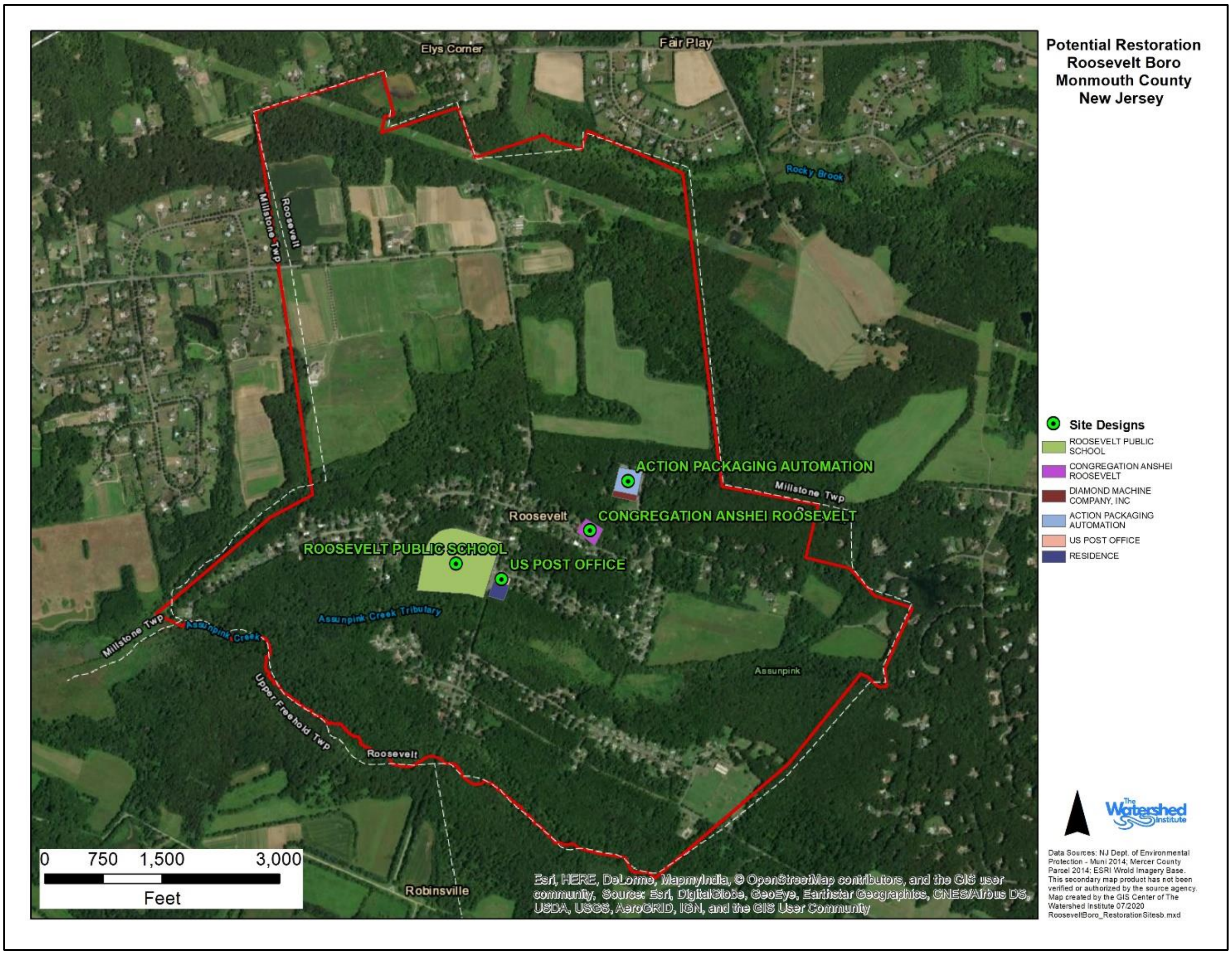
Figure 7: Map of subwatersheds in Roosevelt Borough



Reduction Action Plans: Roosevelt Borough

Of the 6 individual ICAs performed at the single lot scale, 4 were selected for RAP designs (see Fig 8, green labels). For each RAP, we analyzed close up maps of the sites (Figure 9a) with ArcGIS to calculate the total impervious cover (Figure 9b). Site visits were then conducted to survey for precise slope, drainage and existing stormwater management features, and to determine the sites' potential to host a stormwater management project (see Appendix D for example Site Assessment Template). Drainage areas, defined as any area that drains to a similar point on-site, were then delineated, and non-structural stormwater management features were then designed to capture select drainage areas

Figure 8: Map of individual lots that received an ICA in Roosevelt Borough



(Figure 9c). These stormwater features were designed to either remove and/or convert impervious surfaces to pervious surfaces, or otherwise disconnect drainage areas from the local waterways by creating bioretention systems or other Green Infrastructure/Best Management Practices (BMPs) (See Green Infrastructure and Best Management Practices section below).

A summary of BMP designs, the impacts of the proposed BMPs for the site, along with an overview map of each RAP can be found in Appendix E. Wherever possible BMPs were designed with the intent to capture the volume of runoff equivalent to that of the 2 Year Storm for the intended drainage area, however this was not always possible. The modeled runoff reduction for individual and combined BMPs for each site is expressed here in two ways. First, the Maximum Volume Reduction Potential of the green infrastructure expressed as gallons per storm, i.e. the instantaneous capacity of all BMPs installed. The second value is the total annual Recharge Potential (gallons / year), or the total amount of average annual rainfall that is estimated to be infiltrated into the ground to recharge groundwater and is therefore intercepted before reaching local waterways.

A summary of individual and combined BMPs for all Roosevelt's RAPs by subwatershed is found in Appendix F. Combined the RAP designs are estimated to have a Maximum Volume Reduction Potential of over 73.9 thousand gallons/storm, and a Recharge Potential greater than 993.4 thousand gallons/year. This will mitigate over 32% of a 2 Year Storm event, and infiltrate just over 30% of the annual rainfall that runs off of the IC from these 4 sites combined. The potential for pollution removals was also estimated, and the RAPs for these sites will collectively intercept more than 0.25 lb of TP, 1.37 lb of TN, and 36 lb of TSS, preventing these pollutants from entering local waterways. Finally, we provide a robust cost estimate for each feature based on previous experience and professional conversations.

Policy Review: Roosevelt Borough

Roosevelt Borough has taken many steps to preserve and protect both the historic nature of the town, as well as to protect its rich environmental resources. In its 2001 Master Plan, Roosevelt Borough laid out the need to preserve open space and protect "environmentally sensitive lands from development or misuse". As such, the municipality has already enacted many ordinances and policies that limit development and the spread of impervious cover. The small geographic size of the municipality, which is slightly under two square miles, further limits the amount of potential future development. However, there are stretches of critical Category One waters located within the municipality. Extra care needs to be taken to ensure that these waters remain protected under local ordinances that complement or exceed state standards.

Tree Protection

Trees and forestlands play an important part in reducing flooding and soil erosion. Having fewer trees compounds the effects of impervious cover on flooding and pollution, especially when trees are replaced with impervious cover. Strengthening protections for trees is important in limiting the spread of impervious cover as well as reducing its impacts.

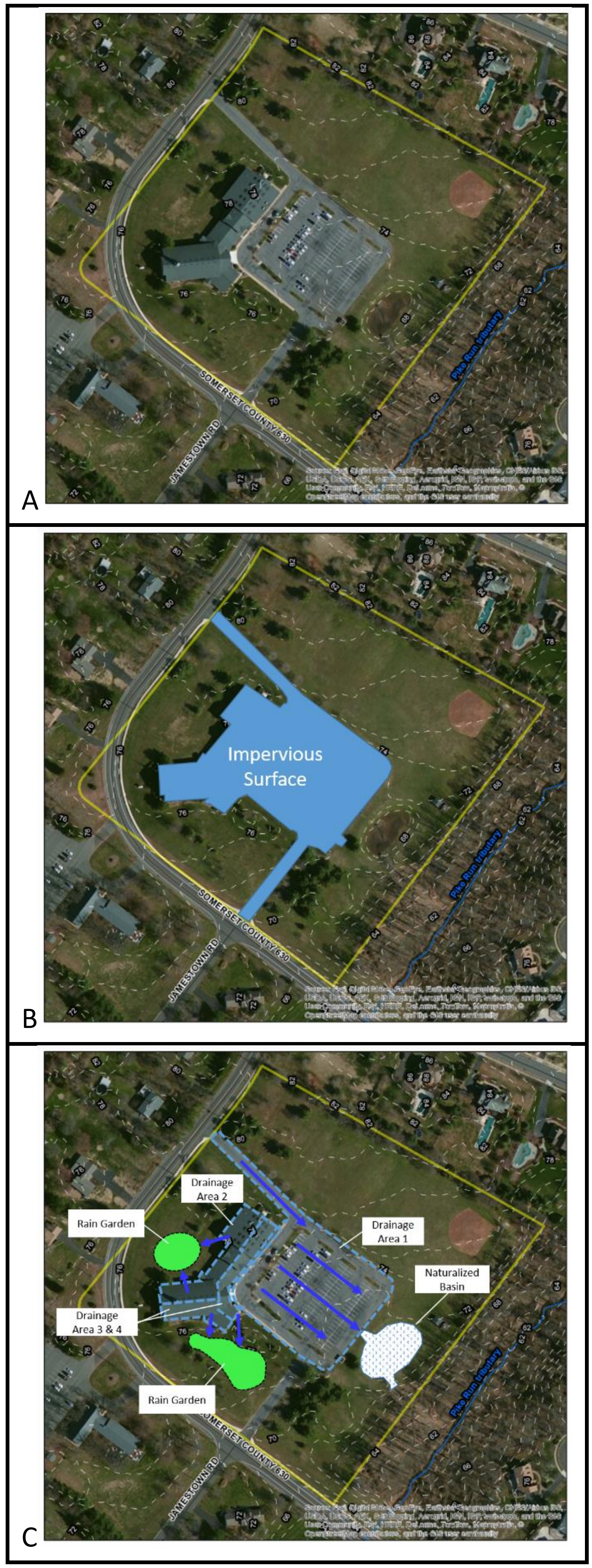


Figure 9: Example site-specific ICA & RAP process

Current Policy: In June of 2020 Roosevelt Borough adopted ordinance 20-08 which significantly improved the protection of trees in the municipality. The ordinance prohibits the following activities:

- Removing, causing or permitting the removal of any significant specimen tree without seeking variance relief.
- Removing, causing or permitting the removal of any tree having a trunk diameter of 6 inches DBH or larger without first obtaining a tree removal permit.
- Removing, causing or permitting the removal of any ornamental tree having a size of 3 inches DBH or higher for any Dogwood or American Holly or any other ornamental tree with a DBH of 4 inches or higher.

A permit is required for the removal of any tree of 6 inches DBH or greater.

Tree mitigation requirements were also put in place. Tree mitigation triggers are established for individual zoning districts and trees must be replaced with specimens that are at least 30% of the total DBH of the trees removed.

Roosevelt also has a Community Forestry Management Plan approved through 2021.

Recommendation: The Watershed Institute commends Roosevelt Borough for putting strong protections in place for its trees. It may want to consider reducing the threshold for a permit to trees of 3 inches DBH or greater from the current 6 inches.

Stream Corridors

A stream corridor is composed of several essential elements including the stream channel itself, floodplains, and forests. Where stream corridors are maintained in their natural condition with minimum disturbance, they are instrumental in removing sediment, nutrients, and pollutants by providing opportunities for filtration, absorption and decomposition by slowing stormwater velocity, which aids in allowing stormwater to be absorbed in the soil and taken up by vegetation. They also reduce stream bank erosion, displace potential sources of non-point source pollution from the water's edge, and prevent flood-related damage and associated costs to surrounding communities. Impervious cover does the opposite of these things, so prohibiting the placement of impervious cover near streams is an important goal.

Current Policy: While Roosevelt Borough's Municipal and Zoning codes mention stream corridors as environmentally constrained areas, there is no specific section dealing with the activities that are permitted or not permitted therein. The current definition given for a stream buffer in Chapter 22, Landscape Requirements, of the Municipal Code provides for only a 50 ft buffer from each side of the stream bank. The buffer must be increased to include any wetlands, wetlands transition areas, and floodplains as defined by the New Jersey Department of Environmental Protection. In the municipal zoning ordinance, Article VI, Section 1.164, Stormwater for Major Development, a “special water resource protection area” has been established for those waters defined as Category One by the state. This protection area is 300 ft on both sides of the waterway “measured perpendicular to the waterway from the top of the bank outwards or from the centerline of the waterway where the bank is not defined, consisting of existing vegetation or vegetation allowed to follow natural successions provided”.

Recommendation: The ambiguity and lack of specific actions that are or are not permitted within the buffer areas is a concern. **We strongly suggest adopting a Stream Corridor Protection Ordinance** that not only includes the 300 ft protection on all Category One waters and their tributaries, but adds a 150 ft buffer to all other streams and rivers within the municipality. The ordinance should recognize the importance of headwaters and provide similar protections to this segment of a waterway as the remainder of the waterway. This ordinance should also specify what actions can and cannot be taken by a property owner within the buffer area, such as prohibiting mowing or placement of accessory structures. If possible, any redevelopment application should be required to site impervious cover further away from the stream beds, if the site allows.

Stormwater Management

Impervious cover creates more stormwater run-off as the rain is unable to infiltrate into the ground. Impervious cover also speeds the runoff of rain water from the property, which carries with it whatever litter and chemicals are on the surface. Proper stormwater management can mitigate the worst impacts of impervious cover on the environment.

Current Policy: Currently, stormwater management is only required of any new major developments in Roosevelt Borough, as described in Article VI, Section 6.164, Stormwater for Major Development. Major development is defined as any development that disturbs one or more acres of land. The zoning ordinance calls for non-structural stormwater management practices to be implemented “to the maximum extent practicable”, and suggests using a number of best practices to reduce run-off, including limiting the area of disturbance and reducing soil compaction.

Article VIII, Section 8.460, Drainage of the zoning ordinance specifically identifies “natural vegetated swales” as not only allowable, but preferable to pipes and inlets for addressing drainage issues.

Recommendation: Roosevelt Borough’s historic nature and layout make the trigger for stormwater management plans of one acre inadequate to address the situations where development or expansion of impervious surfaces falls below the trigger, but still results in significant collective impact. Other small boroughs in the region have faced similar challenges and addressed them by significantly lowering the trigger for a stormwater plan.

Our recommendations are to:

1. **Decrease the threshold for a development to be considered "major"** to half an acre of soil disturbance or 5,000 sq ft. of new or replacement impervious cover. Disturbance should also include repaving activities that do not necessarily disturb bare soil as well as other redevelopment activities.
2. Require the retention and treatment of the 95th percentile storm on site.
3. **Amend the definition of "minor development" and require stormwater management for all such developments**. Specifically, require stormwater mitigation for 250 sq. ft. or greater of any new development or new impervious cover. Along with the change in definition, minor development should require stormwater management that would treat on site 2 gallons of stormwater per square foot of impervious cover predominantly through the use of green infrastructure and non-structural stormwater management best practices. Of the 2 gallons per square foot, the 95th percentile storm should be retained onsite.
4. **The regulatory thresholds for major and minor development should be evaluated** for the total cumulative earth disturbance and/or additional impervious cover.
5. **The stormwater management design must recognize the existence of a TMDL** or impaired waters in the watershed and enhance the stormwater management requirements to meet the reductions set out in the TMDL or to reduce pollution in impaired waters.
6. **Porous pavement should be required** in any reconstruction project, except where heavy sediment loading, traffic, or truck weight is expected.
7. **A strict adherence to the non-structural requirements** should be met and enforced..

Discussion and Conclusions

The literature suggests a link between impervious cover and stream ecosystem impairment starting at approximately 10% impervious cover, but has also been seen to impact water quality at 5% or lower depending on the parameter and conditions being studied.[8,9,10] Having a collective level of impervious cover of less than 5% suggests that streams in Montgomery Township are not likely impaired due to impacts associated with stormwater runoff. Evaluating impervious cover on a subwatershed basis reveals that both major subwatersheds are below the 10 % criteria for impaired watersheds (see Table 1), but allows mitigation efforts to be focused in areas with the highest amounts of runoff, flooding, and likelihood of impairment (see Table 2). For instance, concentrating efforts in the Upper Assunpink Creek

[8] Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques1(3): 100-111.

[9] Arnold, C.L. Jr. and C.J. Gibbons. 1996. Impervious Surface Coverage The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62(2): 243-258.

[10] Walsh CJ, Roy AH, Feminella JW, Cottingham PD, Groffman PM, Morgan RP II (2005) The urban stream syndrome: Current knowledge and the search for a cure. Journal of the North American Benthological Society 24(3):706-723.

(5.53 % IC) would have the greatest effect at lowering the municipality's overall impact to watershed health. As the Borough is currently dominated by forests and wetlands, limitations on further development is strongly recommended to keep the town's % IC low.

The recommended green infrastructure practice and the drainage area that the practice will treat are identified for each site in Appendix E. While the designs reported here account for approximately 32% of the 2 Year Storm, they do account for 85% of a Water Quality Design Storm, for which precipitation rate is much higher and flooding much more likely. For context, if the stormwater runoff from one Water Quality Design Storm (1.25 inches of rain) in Roosevelt was harvested and purified, it could supply water to more than 18 homes for one year.[11] Additionally, the calculations herein consider instantaneous capacity which does not account for infiltration into the ground, when in reality each BMP will infiltrate water at rates that are geology-dependent. This can be interpreted as providing a robust *underestimate* of feature capability. Consequently, capacity of each BMP should be higher than estimated in this report, and will increase with higher soil infiltration rates.

This report contains information on specific *potential* project sites where *potential* green infrastructure practices could be installed to provide examples of steps that can be taken towards stormwater runoff mitigation. They do not represent the only possibilities on each site. Variations, subsets, or alternatives to each design exist and this report is not exhaustive. There are also many other projects not considered by this report that may be implemented at public/commercial organizations, schools, faith-based and nonprofit organizations, and other community locations not included in this report. Robust cost estimates have also been included which may not be representative of actual project costs, and likely will be lower depending on the contractor, materials, and methods.

Here we report on the state of impervious cover and resultant runoff impacts for Roosevelt Borough, and provide examples of how the municipality can reduce flooding and improve its waterways by better managing stormwater runoff from impervious surfaces. Assessing impervious cover is the first step toward better managing stormwater runoff. The impervious cover reduction action plans are meant to provide the Borough with a blueprint for implementing green infrastructure practices that will reduce the impact of stormwater runoff. These practices can be implemented in other public spaces including along roadways and throughout the entire community. Furthermore, development projects that cannot satisfy the New Jersey stormwater management requirements for major development can also use these plans or others like them to provide off-site compensation from stormwater impacts to offset a stormwater management deficit.[12] Finally, Roosevelt can quickly convert this impervious cover reduction action plan into a stormwater mitigation plan and incorporate it into the municipal stormwater control ordinance.

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[11] Assuming 300 gallons per day per home

[12] New Jersey Administrative Code, N.J.A.C. 7:8, Stormwater Management, Statutory Authority: N.J.S.A. 12:5-3,13:1D-1 et seq., 13:9A-1 et seq., 13:19-1 et seq., 40:55D-93 to 99, 58:4-1 et seq., 58:10A-1 et seq., 58:11A-1 et seq. and 58:16A-50 et seq., *Date last amended: April 19, 2010*.

Methodology

Municipal Impervious Cover Assessments:

Watersheds were delineated, and land-use types, composition, and impervious cover percentages for the entire municipality and for each of the subwatersheds was determined using ArcGIS.[13] Runoff volume caused by impervious cover was modeled for the entire municipality as well as for each subwatershed for the following categories of rainfall events: 1) The New Jersey's water quality design storm (the storm event used to analyze and design stormwater management systems: equal to 1.25 inches of rain over a 2 hour period), 2) the 2-year design storm, 3) the 10-year design storm, 4) the 100-year design storm, and 5) New Jersey's total average annual rainfall of 46.94 inches.[14,15]

Runoff volume was modeled using equation 1:

$$Eq\ 1: Runoff\ Volume\ \ (gal) = \left[IC\ Area\ (ft^2) \times \left(Rainfall\ (in) \times \frac{1\ (ft)}{12\ (in)}\right)\right] \times \frac{7.48052\ (gal)}{1\ (ft^3)}$$

Where IC is impervious cover. Rain volumes for each storm event used for each municipality can be found in Table 3. These values were determined by the precipitation values for a municipality's dominant subwatershed, and were taken from NOAA's Atlas 14 Point Precipitation Frequency Estimates for New Jersey.[16]

Individual Lot Impervious Cover Assessments:

Public or commercial sites were selected based on the following primary criteria: amount of impervious cover; proximity to and/or potential impact to a stream; and where practicable, the nature of the commercial or public property (e.g. ease of access, potential for partnerships or project implementation, etc.). Percent area of impervious cover for lots was taken from NJ-GeoWeb's 2012 aerial imagery. Total impervious cover for each site was estimated as the percent IC (as determined in the Land Use/Land Cover 2012 data layer) times the lot size.

Existing runoff volumes caused only by the sites' impervious cover were modeled for the Water Quality Design Storm, the 2 year storm, and for the state's total annual rainfall as described above. Annual loading estimates for the associated select pollutants (lb/year), including total nitrogen (TN), total phosphorous (TP), and total suspended solids (TSS) were calculated for each site after the NJDEP method for calculating Total Maximum Daily Loads. The specific aerial loading coefficients were taken

[13] Land Use/Land Cover 2012 [New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS)]; HUC14 2011 [Department of Environmental Protection (NJDEP), New Jersey Geological Survey (NJGS)]; Municipality 2014 [New Jersey Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS)]
[14] NJ Stormwater Best Management Practices Manual – see https://www.njstormwater.org/bmp_manual2.htm
[15] Based on New Jersey's average annual rainfall as of 2017 – Office of the NJ State Climatologist, Rutgers University
[16] NOAA Precipitation Frequency Data Severs: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nj

from the NJ Stormwater Best Management Practices Manual, are determined by Land Cover and can be found in Table 4.[17]

Table 3: Stormwater volumes by storm event

HUC-13 Watershed	2-Year Storm *(in/24 hrs)*	10-Year Storm *(in/24 hrs)*	100-Year Storm *(in/24 hrs)*
Cranbury Twp	3.31	5.07	8.57
East Windsor Twp	3.31	5.07	8.57
Hightstown Bor	3.31	5.07	8.57
Hopewell Bor	3.30	4.96	8.12
Hopewell Twp	3.32	4.98	8.14
Lawrence Twp	3.32	4.98	8.14
Millstone Bor	3.32	5.07	8.54
Montgomery Twp	3.30	4.96	8.12
Pennington Bor	3.32	4.98	8.14
Plainsboro Twp	3.30	5.01	8.32
Princeton	3.30	5.01	8.32
Robbinsville Twp	3.32	5.07	8.54
Rocky Hill Bor	3.30	5.01	8.32
Roosevelt Bor	3.32	5.07	8.54
West Amwell Twp	3.33	4.94	7.92
West Windsor Twp	3.30	5.01	8.32

Reduction Action Plans (RAPs):

A select number of lots were chosen for RAPs from the individual ICA list using the criteria described above. For each RAP, we analyzed close up maps of the sites and performed hand-drawn calculations for total impervious cover using ArcGIS measurement tools. Preliminary soil assessments were conducted for each potential project site identified using the U.S. Department of Agriculture Natural Resources Conservation Service GIS soil layer, which utilizes regional soil data to predict soil types in an area. Several key soil parameters were examined (e.g., hydrologic soil group, drainage class, depth to water table) to evaluate the suitability of each site's soil for type of green infrastructure practices. Site visits were then conducted to survey for precise slope, drainage and existing stormwater management features, and to determine the sites' potential to host, and placement of, stormwater management features (see Appendix D for example Site Assessment Template).

Table 4: Nutrient loading coefficients by Land Cover type

Land Cover	TP load (lbs/acre/yr)	TN load (lbs/acre/yr)	TSS load (lbs/acre/yr)
High, Medium Density residential	1.4	15	140
Low Density, Rural Residential	0.6	5	100
Commercial	2.1	22	200
Industrial	1.5	16	200
Urban, Mixed Urban, Other Urban	1	10	120
Agriculture	1.3	10	300
Forest, Water, Wetlands	0.1	3	40
Barrenland/Transitional Area	0.5	5	60

[17] NJ Stormwater Best Management Practices Manual – see https://www.njstormwater.org/bmp_manual2.htm

Non-structural stormwater Green Infrastructure, or Best Management Practice (BMP), features were then designed to capture select drainage areas based on the above assessments and with respect to the two year storm event.

The BMP area required for each identified drainage area was calculated using equation 2:

$$Eq\ 2{:}\ BMP\ Area\ (ft^2) = \left[Drainage\ Area\ (ft^2) \times \left(2\ year\ storm\ (in) \times \frac{1\ (ft)}{12\ (in)}\right)\right] \div BMP\ Capacity\ (ft)$$

The Maximum Volume Reduction Potential for each individual BMP, or the volume of runoff captured per storm event (gal), was then calculated using equation 3:

$$Eq\ 3{:}\ Maximum\ Volume\ Reduction\ Potential\ (gal) = \left(Drainage\ Area\ (ft^2) \times 2\ Year\ Storm(ft)\right) \times \frac{7.48052\ (gal)}{1\ (ft^3)}$$

Annual Recharge Potential (gallons / year), or the total amount of average annual rainfall that is estimated to be captured by individual BMPs was calculated using equation 4:

$$Eq\ 4{:}\ Recharge\ Potential\ (gal) = \left\{\left[Drainage\ Area\ (ft^2) \times \left(Annual\ Rainfall\ (in) \times \frac{1\ (ft)}{12\ (in)}\right) \times\right] 0.95\right\} \times \frac{7.48052\ (gal)}{1\ (ft^3)}$$

Finally, the potential for each BMP to remove TSS, TP, and TN was estimated using BMP-dependent removal coefficients (Table 5), and calculated using equation 5:

$$Eq\ 5{:}\ Removal\ Potential\ \left({}^{lb}/{}_{yr}\right) = \left(Area\ of\ BMP\ (ft^2) \times \frac{1\ (acre)}{43560\ (ft^2)}\right) \times Loading\ Coefficent\ \left(\frac{{}^{lb}/{}_{acre}}{year}\right) \times Removal\ Coefficient$$

Table 5: BMP-specific nutrient removal potential coefficients.

BMP Practice	TSS Removal Potential	TP Removal Potential	TN Removal Potential
Pervious Pavement	0.8	0.6	0.5
Bioretention system	0.9	0.6	0.3
Downspout planter boxes	ND*	ND*	ND*
Rainwater harvesting system	ND*	ND*	ND*
Curb Cuts	ND*	ND*	ND*
Dry well	ND*	ND*	ND*
Extended Detention Basin	0.5	0.2	0.2
Infiltration Structure	0.8	0.6	0.5
Sand Filter	0.8	0.5	0.35
Vegetative Filter	0.7	0.3	0.3
Wet Pond	0.7	0.5	0.3

*No Data

Green Infrastructure & Best Management Practices


Figure 10: Rapid Infiltration of water through pervious pavement

Section 502 of the Clean Water Act defines green infrastructure as "...the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters." Whereas gray infrastructure is a conventional piped drainage system that quickly moves urban stormwater downstream and away from the built environment.

Stormwater runoff is a major cause of water pollution in urban areas. The concern with the conventional system is that it does not allow water to soak into the ground and instead sends it flowing off hardscaped surfaces such as parking lots, roads and roofs, to gutters and storm sewers and other engineered collection systems where it is discharged into local streams. These stormwater flows carry with it nutrients, bacteria, trash, and other contaminants. Larger storms result in higher stormwater volumes, which cause erosion and flooding in streams, damaging property, infrastructure and habitat. However when rain falls in natural, undeveloped areas, water is absorbed and filtered by soil and plants.

Green infrastructure mimics these natural systems and treats runoff as a resource by capturing, filtering, and absorbing stormwater. As a general principal, 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, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these practices can simultaneously help filter


Figure 11: Example of Depaving project
Image credit: Habitat Network, yardmap.org

air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.[18]

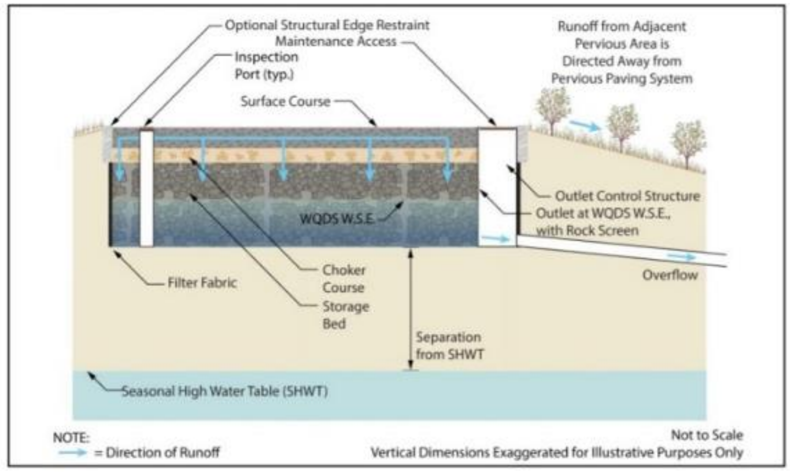

Figure 12: Basic components diagram common to a variety of pervious pavement systems.
Image Credit – NJ-BMP Manual

Elimination of Impervious Surfaces (De-paving)

One method to reduce impervious cover is to "depave" (Figure 11). Depaving is the act of removing paved impervious surfaces and replacing them with pervious soil and vegetation that will allow for the infiltration of rainwater. Depaving leads to the re-creation of natural space that will help reduce flooding, increase wildlife habitat, and positively enhance water quality as well as beautify neighborhoods. Depaving can also bring communities together around a shared vision to work together to reconnect their neighborhood to the natural environment.

Pervious Pavements

A pervious paving system (Figure 10 & 12) is a stormwater management facility that filters stormwater runoff as it moves vertically through the system by either infiltrating through the void spaces in the hardscaped surface course or infiltrating through the joints in paver units. The system consists of a surface course, a transition layer and a storage bed of open-graded aggregate, where runoff is temporarily stored. Discharge of runoff from pervious paving systems is either through an underdrain or through infiltration into the subsoil. In order to receive a TSS removal rate for Water Quality, these systems must be designed to treat the entire Water Quality Design Storm volume without overflow; the adopted total suspended solids (TSS) removal rate is 80%. [19]

[18] United States Environmental Protection Agency (USEPA), 2013. Watershed Assessment, Tracking, and Environmental Results, New Jersey Water Quality Assessment Report. http://ofmpub.epa.gov/waters10/attains_state.control?p_state=NJ
[19] New Jersey Stormwater Best Management Practices Manual, Chapter 9.7 Pervious Paving Systems, p. 2, https://www.njstormwater.org/pdf/2016-11-07-pervious-paving-final.pdf

Disconnected Downspouts

Often referred to simply as disconnection, this is the easiest and least costly method to reduce stormwater runoff for smaller storm events. Rather than flowing out toward the street, and then into the sewer system, a downspout is redirected over a grassed area to allow the water to be filtered by the grass and soaked into the ground (Figure 13). A healthy lawn can typically absorb the first inch of stormwater runoff from a rooftop in a slow rain event. Alternatively, downspouts can also be diverted to a vessel such as a rainbarrel in order to harvest and reuse the rainwater.

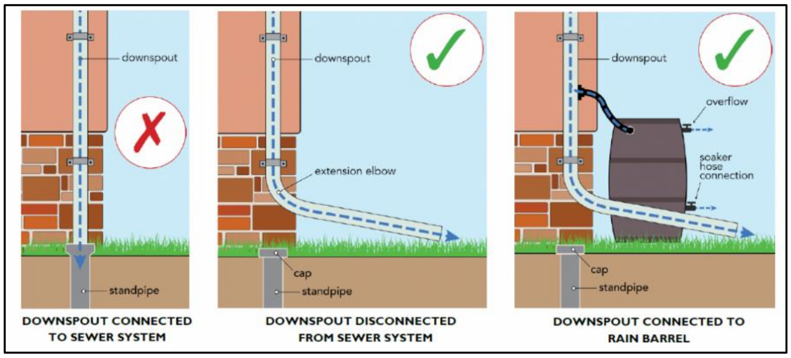

Figure 13: Downspout disconnection
Image credit: DC-Water

Bioretention Systems

Bioretention systems are vegetated stormwater management facilities that are used to address the stormwater quality and quantity impacts of land development. They filter a wide range of pollutants from land development sites through both the native vegetation and the soil bed, including suspended solids, nutrients, metals, hydrocarbons and bacteria. Vegetation provides uptake of pollutants and runoff, and the root system helps maintain the infiltration rate in the soil bed before discharging excess downstream through an underdrain or infiltrating into the subsoil.

The total suspended solids (TSS) removal rate is 80 - 90%; this rate will depend on the depth of the soil bed and the type of vegetation selected. These systems provide an opportunity to intercept and slow stormwater, as well as filter and cool the water that has flowed off of a hot, polluted surface before it enters the sewer system.

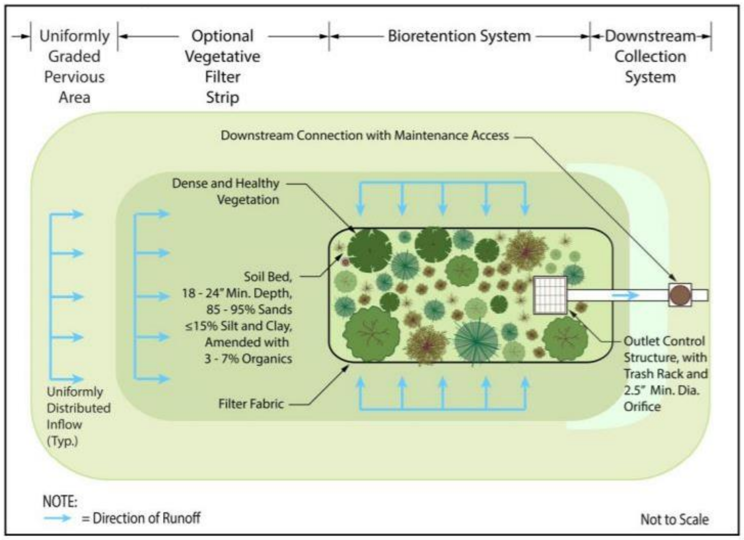

Figure 14: Basic bioretention system design.
Image credit: NJ-BMP Manual

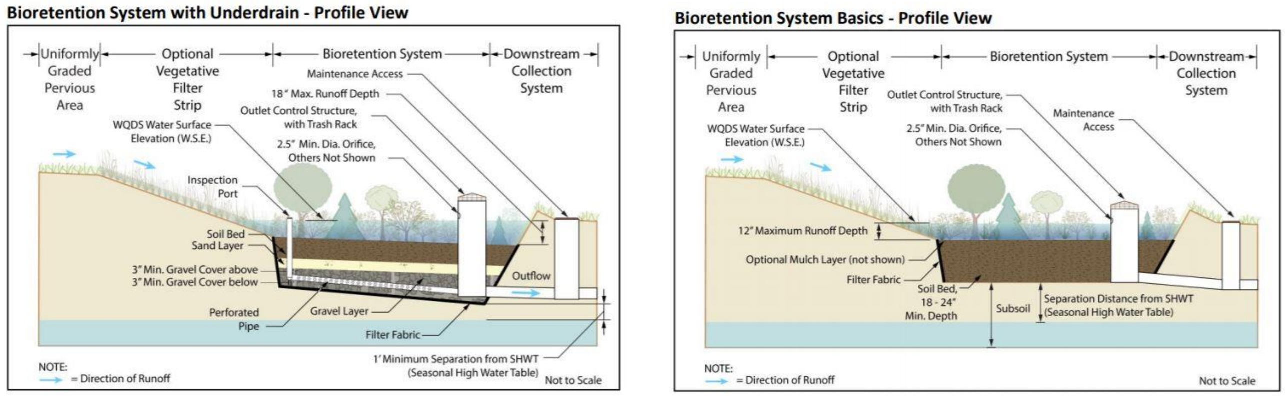

Figure 15: Bioretention facility cross section with underdrains. Image credit: NJ-BMP Manua

Dry Wells

A dry well is an underground chamber that is used to collect and store stormwater runoff from rooftops while allowing it to infiltrate into the soil. Dry wells are limited to the collection of roof runoff and is prohibited in areas where there is high pollution or sediments are anticipated. Treatment from all other surfaces is not allowed. Dry wells are mainly used in areas where stormwater quality is not a concern, as this type of structure will not remove pollutants from stormwater.

Tree Filter Boxes

Tree box filters are in-ground containers typically containing street trees in urban areas. Runoff is directed to the tree box, where it is filtered by vegetation and soil before entering a catch basin. Tree box filters adapt bioretention principles used in rain gardens to enhance pollutant removal, improve reliability, standardize and increase ease of construction, and reduce maintenance costs. Individual tree box filters hold a relatively small volume of stormwater (100 - 300 gallons), but concerted use throughout a stormwater drainage area will decrease the total volume of discharged stormwater.

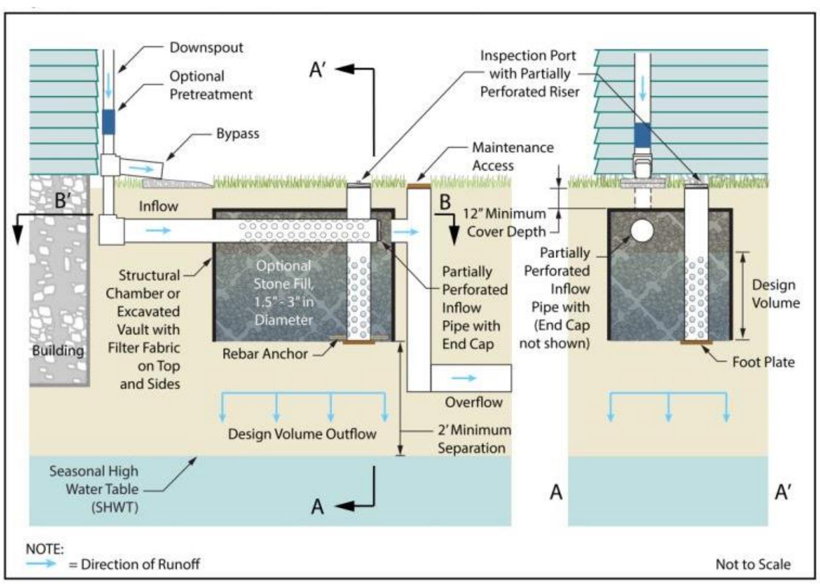

Figure 16: Dry well basics diagram. Image credit: NJ-BMP Manual

Tree box filters decrease peak discharge by detaining stormwater volume and by increasing discharge duration. Use of numerous tree box filters in a stormwater drainage area can have an impact on total discharge energy and flow rates. Tree box filters have a high removal rate of pollutants in stormwater, as they have similar mechanisms and pollutant removal capabilities as rain gardens and vegetated roofs. They also provide the added value of aesthetics while making efficient use of available land for stormwater management.[20]

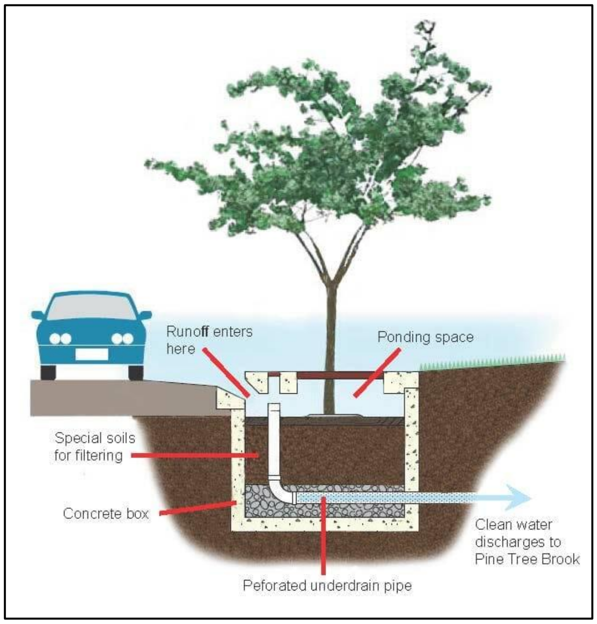

Figure 17: Basic tree filter box diagram
Image credit: Town of Milton, MA Dept. of public works stormwater

Stormwater Planters

A stormwater planter is a specialized planter installed in the sidewalk area that is designed to manage street and sidewalk runoff. It is normally rectangular, with four concrete sides providing structure and curbs for the planter. The planter is lined with a permeable fabric, filled with gravel or stone, and topped off with soil, plants, and sometimes trees. The top of the soil in the planter is lower in elevation than the sidewalk, allowing for runoff to flow into the planter through an inlet at street level. These planters manage stormwater by providing storage, infiltration and evapotranspiration of runoff. Excess runoff is directed into an overflow pipe connected to the existing combined sewer pipe.[21]

Figure 18: Street-side stormwater planter diagram
Image credit: Philly Water

Rainwater Harvesting Systems

Cisterns are stormwater management practices used to capture similar to rain barrels, but collect and reuse roof runoff on a much larger scale. Cisterns are ideal for harvesting rainwater for non-potable uses including vehicle washing or toilet flushing. Cisterns are extremely versatile and may be used on a variety of sites ranging from small-scale residential sites to large-scale industrial or commercial sites; they may be placed either indoors or outdoors and above, at, or below grade. They can also be found in various shapes

[20] Water Environment Research Foundation, Tree Box Filters, 12/2019 https://www.werf.org/liveablecommunities/toolbox/treebox.htm
[21] Phillywatershed.org, Stormwater Planter, 12/2019, http://archive.phillywatersheds.org/what_were_doing/green_infrastructure/tools/stormwater-planter

and sizes. Cisterns must be sized based upon on-site water needs; an under-sized cistern may not store sufficient water for site demands, and an over-sized cistern may remain full or near-full most of the time, and thus be unable to provide storage during rain events.

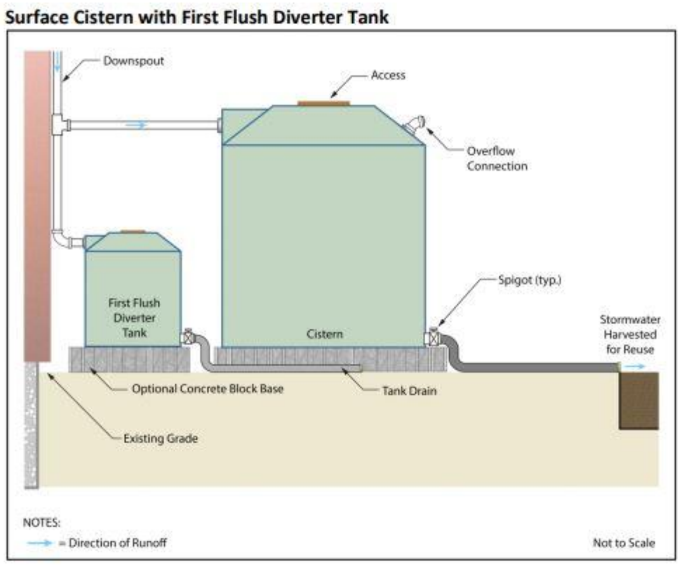

Figure 19: Example of above ground cistern including first flush diverter. Image credit: NJ BMP Manual

Appendix A

Municipality's HUC 14 Existing Impervious Surface Conditions

HUC 14 NAME	HUC13 NAME	HUC14 CODE	Total Area		Land Use Area		Water Area		Impervious Cover		
			(ac)	(mi^2)	(ac)	(mi^2)	(ac)	(mi^2)	(ac)	(mi^2)	(%)
Rocky Brook (above Monmouth Co line)	Rocky Brook	02030105100040	4,429.22	6.92	4,377.43	6.84	51.79	0.08	185.59	0.29	4.24%
Rocky Brook (below Monmouth Co line)	Rocky Brook	02030105100050	5,174.50	8.09	5,069.55	7.92	104.95	0.16	921.82	1.44	18.18%
Assunpink Ck (above Assunpink Lake)	Upper Assunpink Creek	02040105230010	4,379.17	6.84	4,276.95	6.68	102.22	0.16	132.43	0.21	3.10%
		Total	13,982.89	21.85	13,723.93	21.44	258.96	0.40	1,239.84	1.94	9.03%

Appendix B

Municipality's HUC 14 Existing Runoff Conditions

HUC 14 NAME	HUC13 NAME	HUC14 CODE	Total Runoff Volume for the 1.25" NJ Water Quality Storm (MGal)	Total Runoff Volume for the NJ Annual Rainfall of 46.94" (MGal)	Total Runoff Volume for the 2-Year Design Storm (3.30-3.33") (MGal)	Total Runoff Volume for the 10-Year Design Storm (4.94-5.07") (MGal)	Total Runoff Volume for the 100-Year Design Storm (7.92-8.57") (MGal)
Rocky Brook (above Monmouth Co line)	Rocky Brook	02030105100040	6.3	236.5	16.7	25.5	43.2
Rocky Brook (below Monmouth Co line)	Rocky Brook	02030105100050	31.3	1,174.9	82.8	126.9	214.5
Assunpink Ck (above Assunpink Lake)	Upper Assunpink Creek	02040105230010	4.5	168.8	11.9	18.0	29.9
		Total	42.1	1,580.2	111.4	170.5	287.6

Appendix C – Summary of Existing Conditions for Individual Lot ICAs

	SITE NAME	LOCATION				EVALUATED AREA		IMPERVIOIUS COVER			EXISTING ANNUAL LOADS (lb/yr)			RUNOFF VOLUME (gal)		
		ADDRESS	BLOCK	LOT	HUC-14	(ac)	(sq ft)	(ac)	(sq ft)	Percent	TP	TN	TSS	Water Quality Storm	Two Year Storm	Annual Rainfall
	UPPER ASSUNPINK CREEK SUBWATERSHED															
*	Action Packaging Automation	15 Oscar Drive	6	19	Assunpink Ck (above Assunpink Lake)	2.16	94,194	1.00	43,727	46.4%	2.11	22.08	200.76	34,073	90,497	1,279,497
*	Congregation Anshei Roosevelt	20 Homestead Lane	6	12	Assunpink Ck (above Assunpink Lake)	1.37	59,565	0.12	5,416	9.1%	0.12	1.24	14.92	4,220	11,209	158,486
	Diamond Machine Company	32 North Valley Road	6	18	Assunpink Ck (above Assunpink Lake)	0.51	22,355	0.37	16,193	72.4%	0.37	3.72	44.64	12,618	33,512	473,815
	Residence	1 North Rochdale Avenue	9	21	Assunpink Ck (above Assunpink Lake)	0.95	41,441	0.30	13,120	31.7%	0.30	3.01	36.12	10,223	27,153	383,911
*	Roosevelt Public School	2A School Lane	3	31	Assunpink Ck (above Assunpink Lake)	15.93	693,725	1.18	51,267	7.4%	1.18	11.77	141.23	39,948	106,102	1,500,128
*	United States Post Office	1 Farm Lane	9	20	Assunpink Ck (above Assunpink Lake)	0.45	19,590	0.25	11,068	56.5%	0.25	2.54	30.49	8,624	22,906	323,855
	Upper Assunpink Creek Subwatershed Total					**21.37**	**930,869**	**3.23**	**140,790**	**15.1%**	**4.34**	**44.37**	**468.17**	**109,706**	**291,380**	**4,119,692**

***Denotes a site that a Reduction Action Plan was created for; see Appendix E**

IMPERVIOUS COVER ASSESSMENT AND REDUCTION
SITE ASSESSMENT FORM

Name of person(s) completing assessment: **Assessment date:**

SITE INFORMATION

Site ID:	Site Name:
Site address:	
Block/Lot:	Property owner:
Size of site:	Percent impervious coverage:
Proximity to waterway:	Name of nearest waterway:
Subwatershed (HUC-14):	
Soil type(s) on-site: (Indicate drainage capability)	

AERIAL MAP KEY (Write in additional symbols as needed) Note: Use silver pen for existing infrastructure, other color for potential new installations

Stormwater flow (arrows):	Sedimentation (dots):
Erosion (hatched lines):	Existing curb cuts (oval circling cuts):
Storm drain (box with vertical lines):	Ponding (concentric circles):
Downspouts (small filled-in circle):	

EXISTING STORMWATER FLOW	**OBSERVATIONS**	**COMMENTS**
What is the source of stormwater runoff?	☐ Rooftop ☐ Parking lot ☐ Sidewalk ☐ Compacted grass	
Is the site sloped? (Indicate stormwater flow direction on aerial map with arrows)	☐ Yes, there is a defined slope ☐ Yes, somewhat ☐ No, the site is flat	
Are there areas of pronounced erosion? (Indicate stormwater erosion on aerial map with hatched lines)	☐ Yes, there is serious erosion ☐ Yes, there is mild erosion ☐ There is evidence of healed erosion ☐ No	
Are there areas of pronounced sedimentation? (Indicate sedimentation on aerial map with dots)	☐ Yes ☐ No	

Is there evidence of ponding? Are these low-lying areas on impervious or grassy surfaces? (Indicate areas of ponding on aerial map with concentric circles)	☐ Yes, ponding visible on grassy area ☐ Yes, ponding visible on asphalt/concrete ☐ No	
Does stormwater runoff flow directly into sewer system? (Indicate storm sewers on aerial map with hatched boxes)	☐ Yes, downspouts connected to sewer ☐ Yes, downspouts directed toward sewers ☐ Yes, stormwater flows toward sewers ☐ No, stormwater flows away from sewers OR there are no sewers nearby	
Are there existing curb cuts to direct stormwater flow? (Indicate curb cuts on aerial map with ovals)	☐ Yes, there are existing curb cuts ☐ No, there are no curb cuts ☐ N/A	
Are there existing stormwater BMPs on site? (Write in BMP types on aerial map)	☐ Yes, indicate type and number in comments ☐ No	

DEPAVING/DISCONTINUOUS PAVING/GRAVEL FILTER	OBSERVATIONS	COMMENTS
Is there a potential to remove existing paved areas?	☐ Yes ☐ Portions of pavement can be removed ☐ No	

PERVIOUS PAVEMENT	OBSERVATIONS	COMMENTS
Is any asphalt or other paved area in disrepair?	☐ Yes ☐ No ☐ N/A, there is no paved area	

Are there areas of asphalt that are lightly used, like parking spaces or fire lanes?	☐ Yes ☐ No	

RAINWATER HARVESTING/STORAGE	OBSERVATIONS	COMMENTS
Are there downspouts visible on the building? Do they direct onto the ground or into a pipe underground? (Indicate downspouts on aerial map with circles)	☐ Yes, external downspouts ☐ Yes, internal downspouts ☐ No ☐ N/A, there is no building on-site	
Is there a garden or athletic field nearby that may use collected rainwater?	☐ Yes ☐ No	
Is there space next to the downspout for a BMP placement?	☐ Yes, enough space for a cistern ☐ Yes, enough space for a rain barrel or downspout planter ☐ No ☐ N/A, there are no downspouts	

STORMWATER BASIN NATURALIZATION	OBSERVATIONS	COMMENTS
Is there an existing stormwater detention basin?	☐ Yes, with short mowed grass ☐ Yes, with concrete low-flow channel ☐ No	

RAIN GARDEN	OBSERVATIONS	COMMENTS
Are there unpaved areas on-site suitable and large enough for landscaping?	☐ Yes, grassy areas can be landscaped ☐ No, grassy areas cannot be landscaped ☐ No, no grassy areas on-site	

What type(s) of plants would be appropriate in these areas?	☐ Full sun ☐ Shade ☐ Mix of sun and shade	

TREE FILTER BOX (recommended for more urban areas)	**OBSERVATIONS**	**COMMENTS**
Does stormwater flow across sidewalks, curbs, or along the street?	☐ Yes ☐ No	
Is there a sufficient amount of space to install a tree filter box along the sidewalk or road?	☐ Yes ☐ No	
Are there existing trees along the sidewalk or road that could be used in a filter box design?	☐ Yes ☐ No	

BIOSWALE	**OBSERVATIONS**	**COMMENTS**
Does stormwater need to travel from its source to the selected BMP?	☐ Yes ☐ No	

GI RECOMMENDATIONS			
Based on your observations, what GI practices would you recommend for this site? (Indicate placement of these practices on the aerial map using alternate pen color)	☐ Rooftop disconnection ☐ Pervious pavement ☐ Rain barrel ☐ Rain garden ☐ Basin naturalization ☐ OTHER ______________________	☐ Depaving ☐ Cistern ☐ Downspout planter ☐ Bioswale ☐ Tree filter box	☐ Sand/Gravel Filter Pit/Strip ☐ Discontinuous pavement (partial depaving)

Appendix E – Site-Specific Reduction Action Plans

ATTACHED SEPERATELY

Appendix F – Summary of Reduction Action Plans for Roosevelt Borough

STORMWATER BMP BY SITE	POTENTIAL MANAGEMENT AREA		SIZE OF BMP		PERCENTAGE OF IMPERVIOUS COVER TREATED	REMOVAL POTENTIAL			MAXIMUM VOLUME REDUCTION POTENTIAL (gal/storm)	RECHARGE POTENTIAL (gal/year)	ESTIMATED COST
	(ac)	(sq ft)	(ac)	(sq ft)		TP	TN	TSS			
UPPER ASSUNPINK CREEK SUBWATERSHED											
Action Packaging Automation											
Rain Garden	0.36	15,581	0.15	6,614	35.6%	0.19	1.00	27.33	32,247	433,136	$33,072.40
Site Total	**0.36**	**15,581**	**0.15**	**6,614**	**35.6%**	**0.19**	**1.00**	**27.33**	**32,247**	**433,136**	**$33,072.40**
Congregation Anshei Roosevelt											
Bioswale	0.10	4,140	0.02	695	76.4%	0.01	0.05	1.72	8,569	115,091	$3,476.85
Site Total	**0.10**	**4,140**	**0.02**	**695**	**76.4%**	**0.01**	**0.05**	**1.72**	**8,569**	**115,091**	**$3,476.85**
Roosevelt Public School											
Porous Pavement	0.25	10,696	0.04	1,958	20.9%	0.03	0.22	4.31	22,137	297,337	$23,490.24
Rain Garden	0.04	1,798	0.02	808	3.5%	0.01	0.06	2.00	3,722	49,992	$4,042.45
Site Total	**0.29**	**12,495**	**0.06**	**2,766**	**24.4%**	**0.04**	**0.28**	**6.32**	**25,859**	**347,329**	**$27,532.69**
United States Post Office											
Bioswale	0.08	3,523	0.01	607	31.8%	0.01	0.04	1.50	7,292	97,938	$3,034.85
Site Total	**0.08**	**3,523**	**0.01**	**607**	**31.8%**	**0.01**	**0.04**	**1.50**	**7,292**	**97,938**	**$3,034.85**
Upper Asssunpink Creek Subwatershed Total	**0.82**	**35,739**	**0.25**	**10,683**		**0.25**	**1.37**	**36.88**	**73,967**	**993,494**	**$67,116.79**
ROOSEVELT BOROUGH TOTAL	**0.82**	**35,739**	**0.25**	**10,683**		**0.25**	**1.37**	**36.88**	**73,967**	**993,494**	**$67,116.79**