



**Impervious Cover Assessment
And Reduction Action Plan
Prepared For**

Hightstown Borough, Mercer 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 Hightstown 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 of 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 40.21 percent of Hightstown Borough's land area. This is well above the 10% threshold above which a subwatershed is considered to be impaired for water quality.
2. The municipality has three subwatersheds which have impervious cover (IC) ranging from 32.6-63.2 % IC; the recommendation of this report is that restorations efforts should be focused throughout all three of the subwatersheds, with a particular focus on the Rocky Brook subwatershed since this covers the greatest area within the Borough; We recommend limitations on development and incorporation of Green Infrastructure throughout the municipality to limit both the extent and the impact of IC.
3. Stormwater runoff volume from the municipality IC is over 400 million gallons of stormwater annually.
4. Using Geographical Information Systems, we identified 22 sites where actions could be taken to mitigate stormwater runoff. For 12 of those sites, we conducted more detailed on-site stormwater assessments and prepared Green Infrastructure conceptual designs. Those 11 projects have a total stormwater mitigation potential of more than 16.5 million gallons of runoff.
5. While Hightstown 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

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,

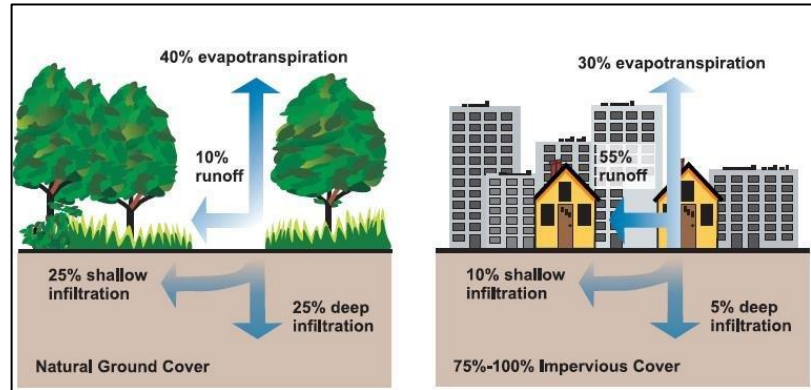


Figure 1: Relationship between impervious surfaces and stormwater runoff.¹

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.

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.

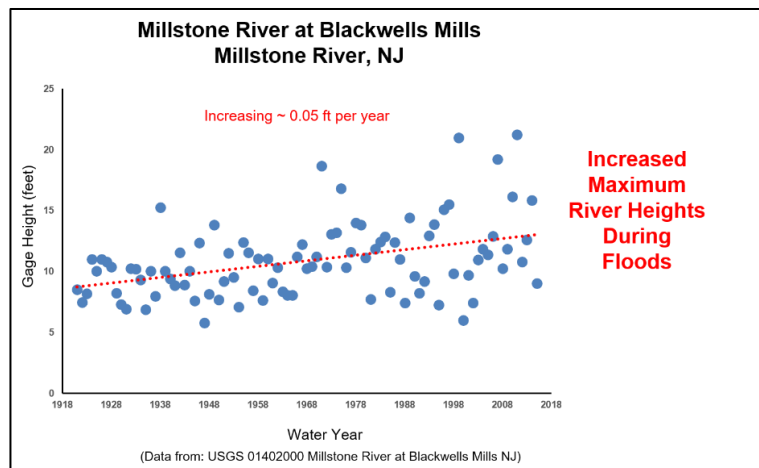


Figure 2: Annual Maximum River Height at Blackwells Mills Dam, Franklin Twp, NJ

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

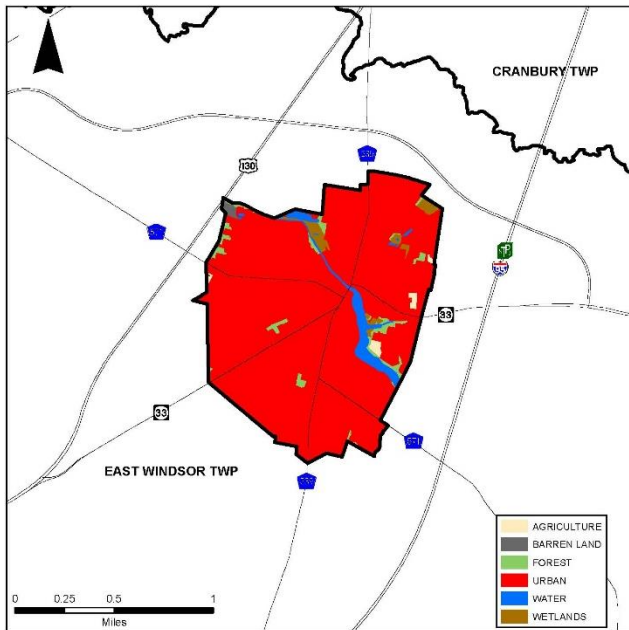


Figure 3: Land-use aerial of Hightstown

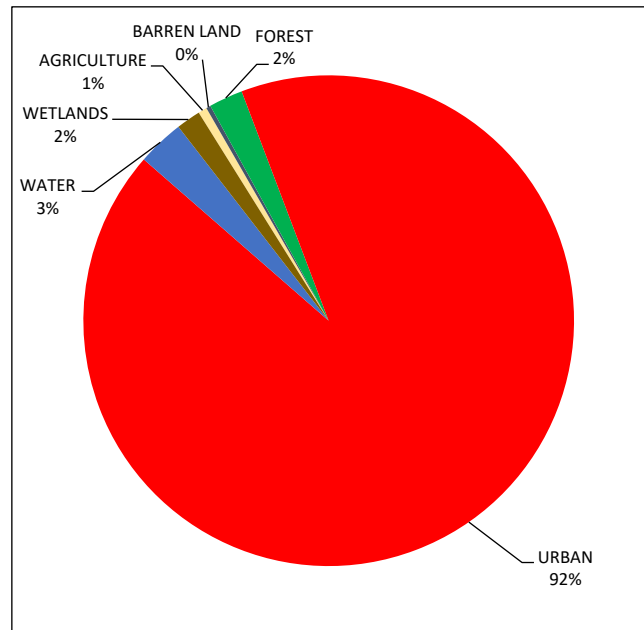


Figure 4: Land-use composition (%) in Hightstown

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 Hightstown 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: Hightstown Borough

Municipal Subwatershed Assessment

Located in Mercer County in central New Jersey, Hightstown Borough covers Just over one square mile. The primary land-use type was determined to be urban at 92% of the total town (Figures 3 & 4), with medium density residential as the dominant type of urban land at 45% (Figure 5). Impervious surfaces were estimated to cover 40.21% of Hightstown Borough’s land area (Figure 6). The municipality is divided into three individual subwatershed units (Figure 7, colored areas), all of which drain to the Millstone River.

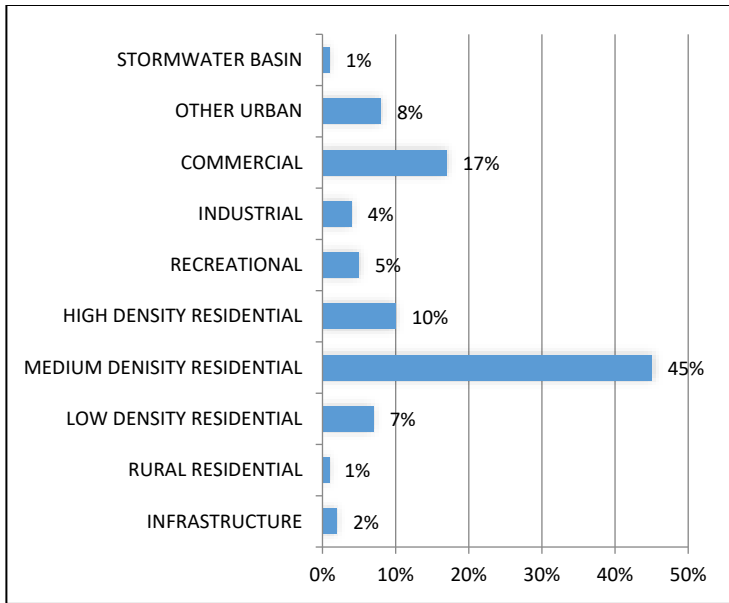


Figure 5 : Urban land-use composition in Hightstown

Analysis of the sections of those drainage areas that fall within the municipality’s boundaries showed a variable amount of IC, ranging from 32.60% in the Upper Millstone subwatershed to 63.20% in the Bear Brook 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 (3.31 inches in

24 hours), 3) the 10-year design storm (5.07 inches in 24 hours), 4) the 100-year design storm (8.57 inches in 24 hours), and 5) New Jersey’s total average annual rainfall of 46.94 inches (Table 2).^{6,7} Impervious surfaces in Hightstown Borough result in over 400 million gallons of annual stormwater runoff. The Water Quality Design storm would produce 10.7 million gallons in just a two hour period, while the 2, 10, and 100 year storms would generate 28.4, 43.4, and 73.4 million gallons within a 24 hour period respectively.

The 3 main subwatersheds within Hightstown Borough are part of 3 greater 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

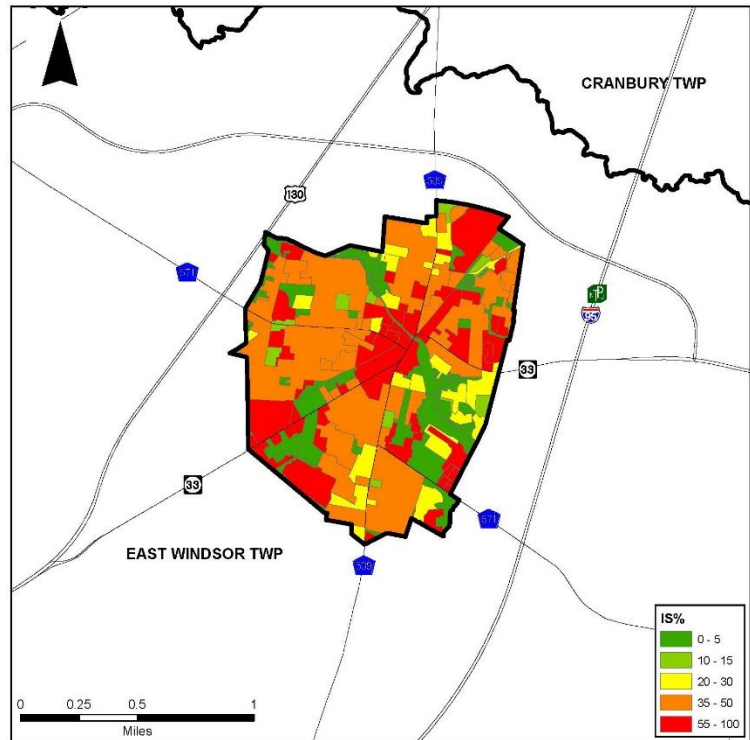


Figure 6: Amount of Impervious Surfaces (% IS) by parcel in Hightstown

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 Hightstown

Subwatershed	Total Area		Land Use Area		Water Area		Impervious Cover		
	(ac)	(mi ²)	(ac)	(mi ²)	(ac)	(mi ²)	(ac)	(mi ²)	(%)
Bear Brook	52.07	0.08	52.07	0.08	0	0.00	32.91	0.05	63.20%
Rocky Brook	734.35	1.15	709.33	1.11	25.02	0.04	275.01	0.43	38.77%
Upper Millstone River	23.31	0.04	23.31	0.04	0	0.00	7.6	0.01	32.60%
Total	809.73	1.27	784.71	1.23	25.02	0.04	315.52	0.49	40.21%

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

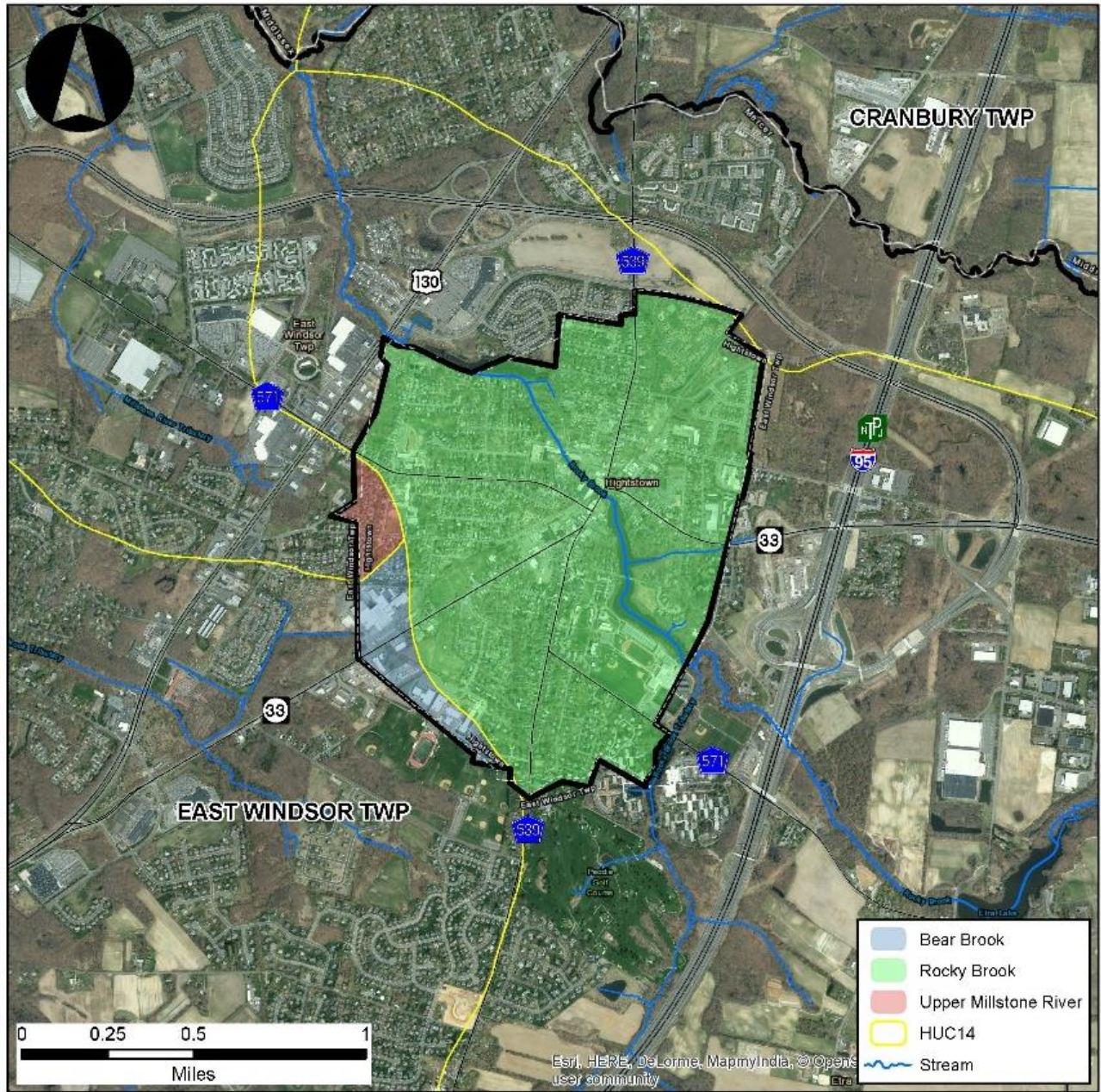
Subwatershed	Total Runoff Volume for the 1.25" NJ Water Quality Storm (MGal)	Total Runoff Volume for the NJ Annual Rainfall (46.94") (MGal)	Total Runoff Volume for the 2-Year Design Storm (3.31") (MGal)	Total Runoff Volume for the 10-Year Design Storm (5.07") (MGal)	Total Runoff Volume for the 100-Year Design Storm (8.57") (MGal)
Bear Brook	1.1	41.9	3.0	4.5	7.7
Rocky Brook	9.3	350.5	24.7	37.9	64.0
Upper Millstone River	0.3	9.7	0.7	1.0	1.8
Total	10.7	402.1	28.4	43.4	73.4

municipal boundaries) were also calculated. 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 22 individual lots in Hightstown 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

Figure 7: Map of subwatersheds in Hightstown



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 22 properties alone accounted for over 98 acres of impervious cover and greater than 125 million gallons of the town’s annual stormwater runoff. This volume of runoff from impervious surfaces carries an estimated 165 lb of total phosphorous, 1,718 lb of total nitrogen, and 15,559 lb of total suspended solids into the streams of Hightstown Borough, and downstream to the Millstone River. The summary of existing individual lot conditions can be found in Appendix C or online at <https://thewatershed.org/impervious-cover-assessments/>.

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 Hightstown RAPs by subwatershed is found in Appendix F. Combined the RAP designs are estimated to have a Maximum Volume Reduction Potential of over 1.2 million gallons/storm, and a Recharge Potential greater than 16.5 million gallons/year. This will mitigate over 45% of a 2 Year Storm event, and infiltrate slightly under 43% of the annual rainfall that runs off of the IC from these 12 sites combined. The potential for pollution removals was also estimated, and the RAPs for these sites will collectively intercept more than 4 lb of TP, 27 lb of TN, and 762 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: Hightstown Borough

Hightstown has long recognized the importance of its environmental resources. In the town’s Master Plan, goal number five is to “protect the natural resources and improve recreational opportunities within the Borough”. The first objective of that goal is to “improve and maintain the natural resources of Peddie Lake and the Rocky Brook corridor.” In order to help Hightstown accomplish this task and reduce the negative impacts of stormwater on the municipality, we offer the following suggestions.

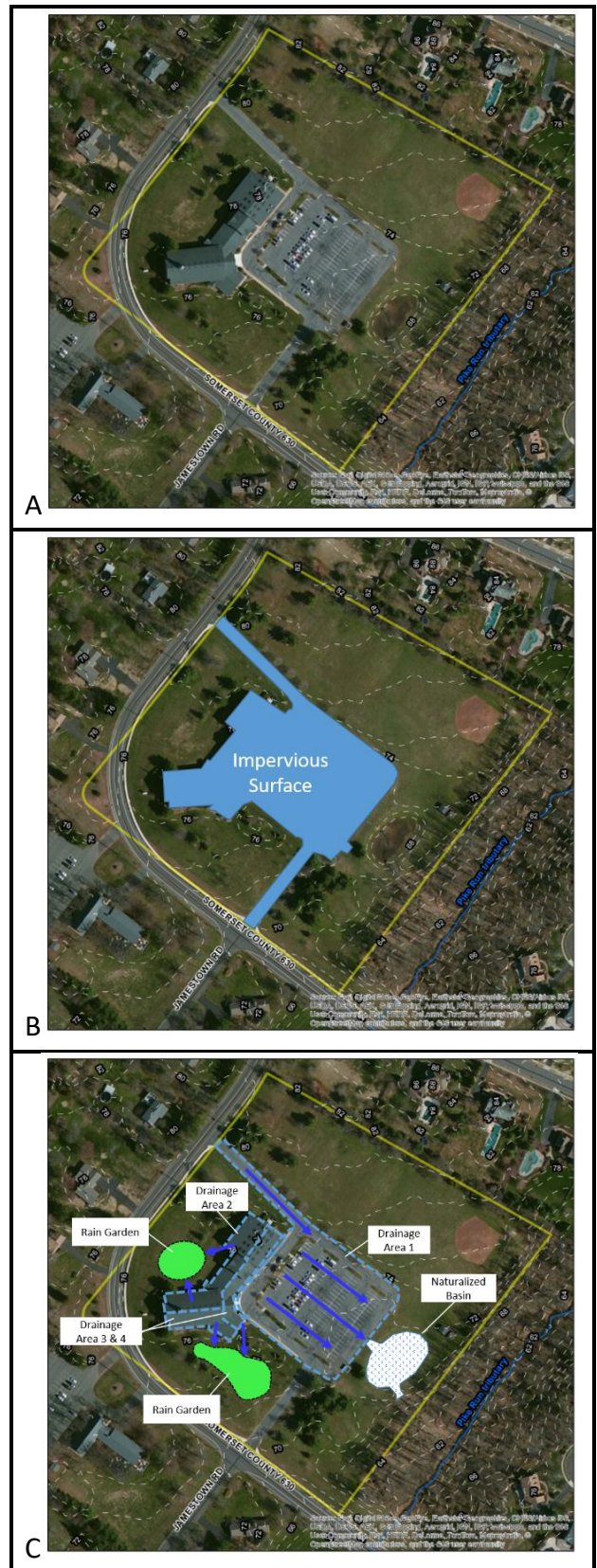


Figure 9: Example site-specific ICA & RAP process

Tree Protection

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

Current Policy: Hightstown’s current ordinances on tree protection can be found in Chapter 20 - Protection of Trees in the municipal code. These ordinances protect all trees on public land in the municipality. Permits are required to “plant, spray, fertilize, preserve, prune, remove, cut above or below ground or otherwise disturb any tree on any public street or Borough-owned property”. Permit applications are reviewed by the Environmental Commission. A Shade Tree Official is appointed in order to provide oversight and ensure compliance with the tree protection ordinances.

Trees on public land are to be protected during construction and trees on the tree lawn are to be replaced if removed for construction or other reasons.

Further, in Hightstown, it is illegal to deny nutrients to public trees. According to the code, “No person shall deposit, place, store or maintain upon any public place of the municipality any stone, brick, sand; concrete or other materials which may impede the free passage of water, air and fertilizer to the roots of any tree growing therein, except by written permit of the Environmental Commission.”

Recommendation: While the protections for trees on public land in Hightstown are excellent, we suggest extending protection to all trees:

1. **Enhance the tree protection ordinance** to require a permit for removal of any tree in the municipality, whether it is on public land or not. Such an ordinance should prohibit the removal of healthy trees over 3 inches in diameter, limit the number and size of trees (measured by cumulative diameter) that can be removed on any lot per year (outside of an approved development application), and specify a replacement plan that does not result in significant canopy loss. Additionally, the tree protection ordinance should mandate that all replacement trees be of a native species.

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: There are currently no protections for stream corridors in Hightstown.

Recommendation: 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 mowing or placement of accessory structures.

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: Hightstown requires stormwater management under two distinct criteria as explained in Chapter 25, Section 2 of the municipal code. Development before the planning board which disturbs $\frac{1}{4}$ acre of soil or results in $\frac{1}{4}$ acre of new impervious cover is required to create a stormwater management plan. Applications that do not require planning board approval but which disrupt at least 1,000 sq ft of soil or involve the construction or redevelopment of 250 sq ft of impervious cover are subject to review by the Hightstown Environmental Commission, which will make recommendations on stormwater management using green infrastructure. In 2019 Hightstown adopted ordinance 2019-02 which sets out requirements for the maintenance of stormwater management BMPs. Each BMP is inspected annually at the cost of \$100 to the property owner.

Recommendation: Considering the positive involvement of the Environmental Commission in managing stormwater management in non-major development projects, our recommendation for Hightstown is primarily to establish a more standard performance metric for the amount of stormwater that is required to be captured from smaller developments and redevelopments. We suggest the following specific changes:

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. **Convert the current minor development recommendations into mandatory requirements.** Specifically, require stormwater mitigation for 250 sq. ft. or greater of any new development or new impervious cover. 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.
8. **Require stormwater management for the replacement of existing impervious cover that was constructed without stormwater management features.** Although the ordinance indicates that stormwater requirements apply to redevelopment projects, this is only true for such projects that add ¼ acre or more of impervious surface or disturb one acre or more of vegetation, soil and/or bedrock. Many older buildings, parking lots, driveways, and other developments were constructed with little or no attention or mitigation of the stormwater runoff that they generate. Stormwater mitigation measures should be required when such developments are **replaced** with new impervious surfaces during redevelopment.

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 over 40% suggests that streams in Hightstown are likely impaired due to impacts associated with stormwater runoff. Evaluating impervious cover on a subwatershed basis reveals that all areas are above the 10 % criteria for impaired watersheds (see Table 1). This suggests that mitigation efforts to be focused throughout the town. However, this also shows that the Borough's land area lies primarily within two subwatersheds, and so by concentrating efforts in the Rocky Brook (734 acres at

⁸ Schueler, T. 1994. The Importance of Imperviousness. *Watershed Protection Techniques* 1 (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.

38.77% IC) and Bear Brook (52 acres at 63.2% IC) subwatersheds would have the greatest effect at lowering the municipality's overall impact to watershed health.

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 73% of the 2 Year Storm, they do account for 192% 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 Hightstown was harvested and purified, it could supply water to more than 97 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 Hightstown 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 Hightstown 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, Hightstown can quickly convert this impervious cover reduction action plan into a stormwater mitigation plan and incorporate it into the municipal stormwater control ordinance.

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:

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

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 Servers: 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

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 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

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:

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

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:

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

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:

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

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

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 evapotranspire 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.



Figure 10: Figure 10: Rapid Infiltration of water through pervious pavement

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

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

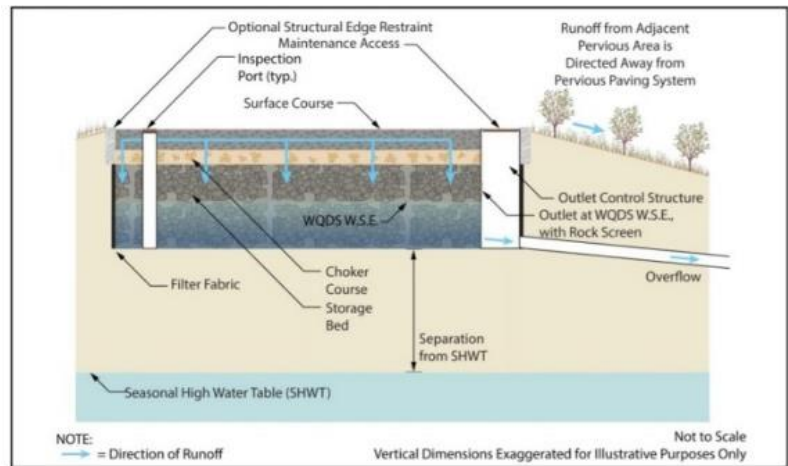


Figure 12: Basic components diagram common to a variety of pervious pavement systems.

Image Credit – NJ-BMP Manual

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.

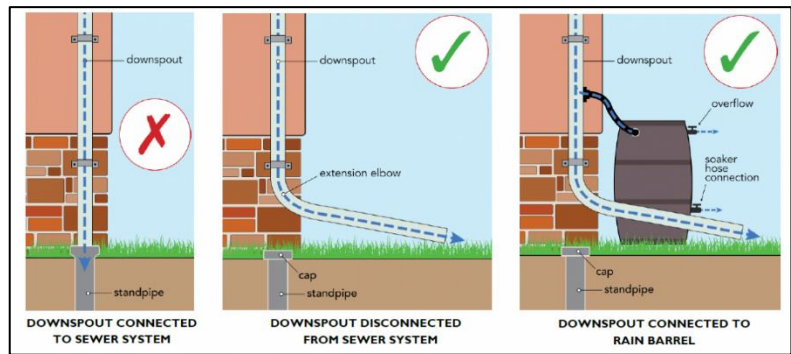


Figure 13: Downspout disconnection
Image credit: DC-Water

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.

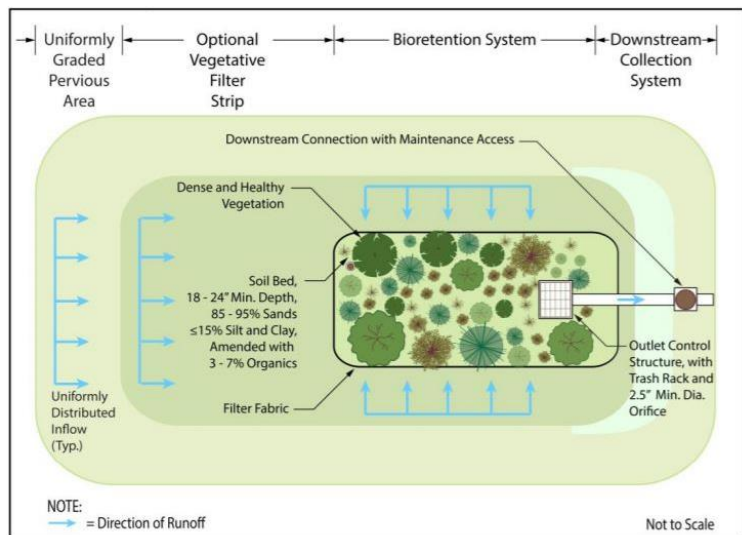
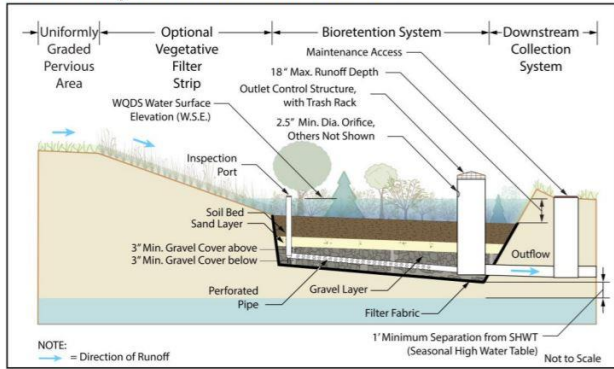


Figure 14: Basic bioretention system design.
Image credit: NJ-BMP Manual

Bioretention System with Underdrain - Profile View



Bioretention System Basics - Profile View

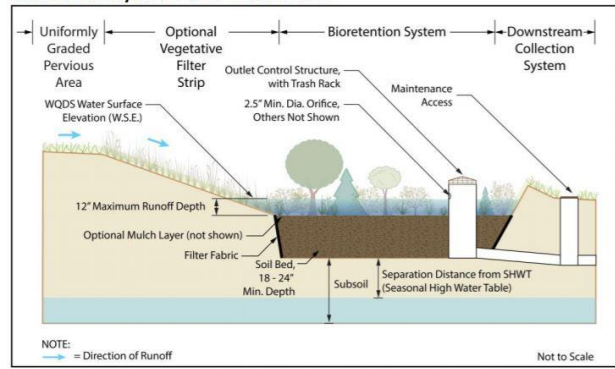


Figure 15: Bioretention facility cross section with underdrains.

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.

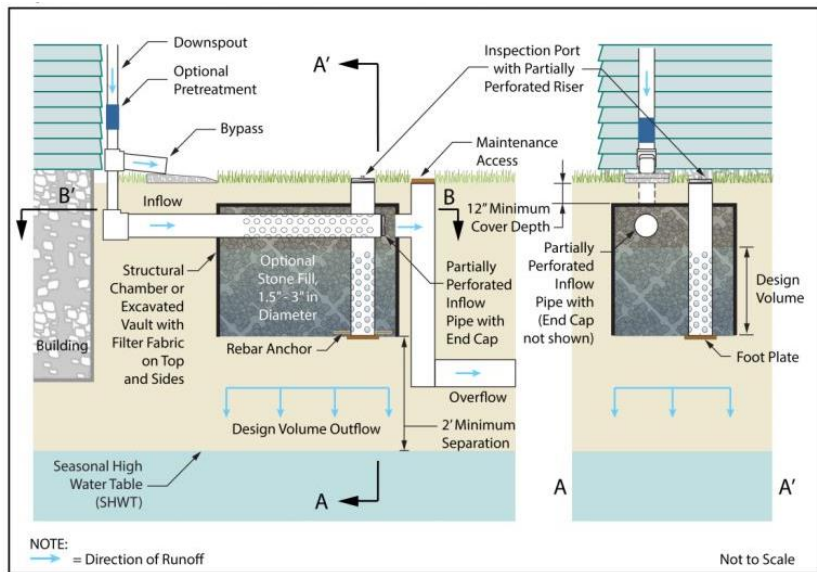


Figure 16: Dry well basics diagram.

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

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

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 and sizes. Cisterns must be sized based upon

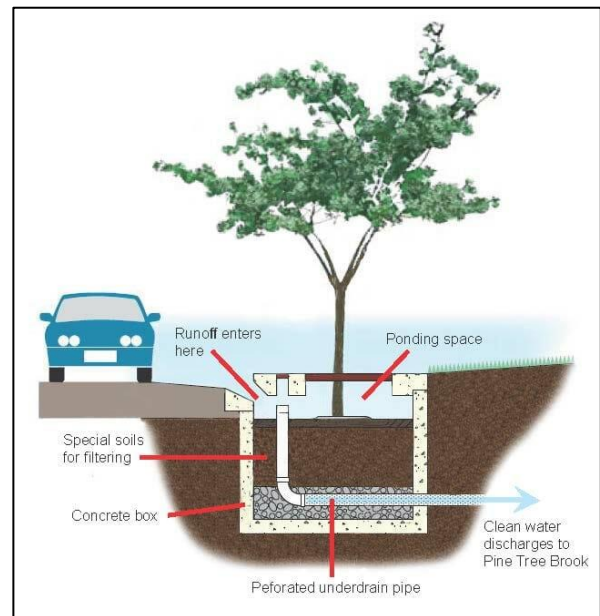


Figure 17: Basic tree filter box diagram

Image credit: Town of Milton, MA Dept. of public works stormwater



Figure 18: Street-side stormwater planter diagram

Image credit: Philly Water

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

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.

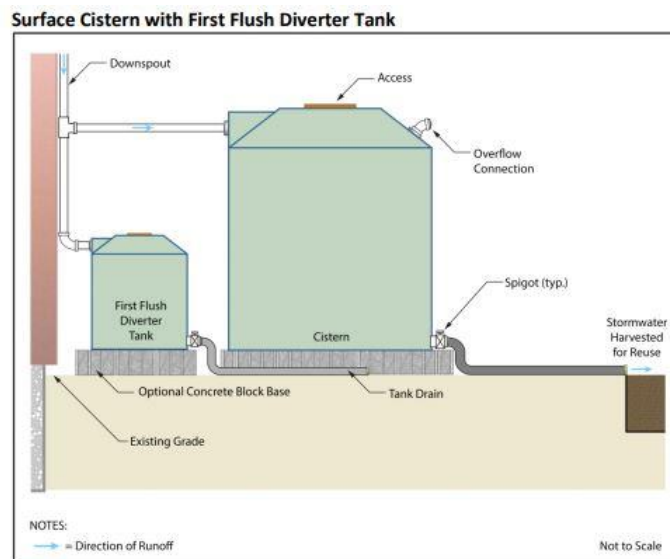


Figure 19: Example of above ground cistern including first flush diverter. Image credit: NJ BMP Manual

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 (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%
Millstone R (Cranbury Bk to Rocky Bk)	Upper Millstone River	02030105100060	4,327.65	6.76	4,280.97	6.69	46.68	0.07	464.94	0.73	10.86%
Bear Brook (above Trenton Road)	Bear Brook	02030105100120	4,157.42	6.50	4,138.88	6.47	18.54	0.03	702.38	1.10	16.97%
Total			13,659.57	21.34	13,489.40	21.08	170.17	0.27	2,089.14	3.26	15.49%

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 (below Monmouth Co line)	Rocky Brook	02030105100050	31.3	1,174.9	82.8	126.9	214.5
Millstone R (Cranbury Bk to Rocky Bk)	Upper Millstone River	02030105100060	15.8	592.6	41.8	64.0	108.2
Bear Brook (above Trenton Road)	Bear Brook	02030105100120	23.8	895.2	62.9	95.5	158.7
		Total	70.9	2,662.7	187.6	286.5	481.4

Appendix C – Summary of Existing Conditions for Individual Lot ICAs

SITE NAME	LOCATION				EVALUATED AREA		IMPERVIOUS 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
BEAR BROOK SUBWATERSHED															
* Hightstown High School	25 Leshin Lane	62.01	7	Bear Brook (above Trenton Road)	28.56	1,243,952	13.80	601,191	48.3%	13.80	138.01	1,656.17	468,461	1,240,484	17,591,647
		61.01	47	Bear Brook (above Trenton Road)											
		48	7	Bear Brook (above Trenton Road)											
Hightstown Police Department	415A Mercer Street	61.01	44, 45	Bear Brook (above Trenton Road)	7.59	330,435	5.59	243,501	73.7%	11.74	122.98	1,118.00	189,741	502,434	7,125,164
Mercer Street Warehouse	500 Mercer Street	48	26,27,32,33,34	Bear Brook (above Trenton Road)	16.29	709,601	15.89	691,916	97.5%	33.36	349.45	3,176.84	539,156	1,427,684	20,246,386
Bear Brook Subwatershed Total					52.44	2,283,988	35.28	1,536,608	67.3%	58.90	610.45	5,951.02	1,197,357	3,170,602	44,963,198
ROCKY BROOK SUBWATERSHED															
* 1st Constitution Bank	140 Mercer Street	39	28	Rocky Brook (below Monmouth Co line)	1.20	52,148	0.97	42,393	81.3%	0.97	9.73	116.79	33,034	87,473	1,240,485
* CCL Label	118 Stockton Street	21.01	11.01	Rocky Brook (below Monmouth Co line)	2.23	100,135	1.87	81,597	81.5%	1.87	18.73	224.79	63,582	168,366	2,387,651
Comisky's Greenhouse	115 Manlove Avenue	24	6	Rocky Brook (below Monmouth Co line)	2.24	97,682	2.03	88,451	90.5%	2.03	20.31	243.67	68,923	182,507	2,588,181
* Empire Antiques	278 Monmouth Street	24	9	Rocky Brook (below Monmouth Co line)	4.26	185,577	3.06	133,072	71.7%	3.05	30.55	366.59	103,693	274,578	3,893,874
* First Baptist Church	125 South Main Street	28	50,49	Rocky Brook (below Monmouth Co line)	2.40	104,367	0.87	37,762	36.2%	0.87	8.67	104.03	29,425	77,918	1,104,980
* First United Methodist Church	187 Stockton Street	36	3,4,5,6	Rocky Brook (below Monmouth Co line)	1.09	47,326	0.73	31,818	67.2%	0.73	7.30	87.65	24,794	65,653	931,049
Grace N. Rogers Elementary School	380 Stockton Street	9	26,27,28,29,30,31	Rocky Brook (below Monmouth Co line)	11.31	492,558	4.81	209,641	42.6%	4.26	44.67	406.11	163,357	432,569	6,134,385
* Hightstown Fire Department	140 North Main Street	30	13	Rocky Brook (below Monmouth Co line)	0.68	29,803	0.43	18,893	63.4%	0.43	4.34	52.05	14,722	38,983	552,831
Hightstown Housing Authority	131 Rogers Avenue	37, 32	8	Rocky Brook (below Monmouth Co line)	3.91	170,371	2.26	98,532	57.8%	4.75	49.76	452.40	76,778	203,308	2,883,167
* Hightstown Library - Memorial Branch	114 Franklin Street	28	1	Rocky Brook (below Monmouth Co line)	0.69	30,187	0.22	9,392	31.1%	0.22	2.16	25.87	7,319	19,380	274,830
Mount Olivet Baptist Church	21 Reverend William L Powell Road	4.01	2,3,4,5	Rocky Brook (below Monmouth Co line)	1.08	47,167	0.57	24,908	52.8%	1.20	12.58	114.36	19,409	51,395	728,853
Peddie School	201 South Main Street	53	1.02	Rocky Brook (below Monmouth Co line)	57.52	2,505,323	19.25	838,400	33.5%	40.42	423.43	3,849.41	653,299	1,729,936	24,532,708
* Rocky Brook Park	170 Bank Street	4.01	6	Rocky Brook (below Monmouth Co line)	4.79	208,747	1.06	46,011	22.0%	1.06	10.56	126.75	35,853	94,938	1,346,341
Sieck-Wright Floral Products	231 Monmouth Street	11	6.01	Rocky Brook (below Monmouth Co line)	2.43	106,038	2.10	91,337	86.1%	4.40	46.13	419.36	71,171	188,462	2,672,629
* Saint Anthony of Padua Church	251 Franklin Street	27	37,36,35,34,33,32,31,47,48,12.01	Rocky Brook (below Monmouth Co line)	5.66	246,689	4.20	182,819	74.1%	4.20	41.97	503.63	142,457	377,225	5,349,537
* United States Post Office	150 Mercer Street	39	29	Rocky Brook (below Monmouth Co line)	2.95	128,338	2.06	89,901	70.1%	2.06	20.64	247.66	70,053	185,500	2,630,628
Walter C. Black Elementary School	371 Stockton Street	47.01	2,3,4	SPLIT: Millstone R (Cranbury Bk to Rocky Bk) & Rocky Brook (below Monmouth Co line)	8.30	361,671	3.57	155,593	43.0%	7.50	78.58	714.38	121,241	321,047	4,552,855
* Wells Fargo	105 Main Street	28	51,52	Rocky Brook (below Monmouth Co line)	1.12	48,757	1.00	43,600	89.4%	1.00	10.01	120.11	33,974	89,963	1,275,797
WycKoff's Mills Association	100 Clubhouse Drive	2.01	1	Rocky Brook (below Monmouth Co line)	31.11	1,355,008	12.16	529,763	39.1%	25.54	267.56	2,432.34	412,803	1,093,102	15,501,580
Rocky Brook Subwatershed Total					144.98	6,317,892	63.23	2,753,886	43.6%	106.58	1,107.68	10,607.94	2,145,885	5,682,305	80,582,360
HIGHTSTOWN BOROUGH TOTAL					197.42	8,601,879	98.51	4,290,495	49.9%	165.48	1,718.13	16,558.96	3,343,243	8,852,907	125,545,557

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



**IMPERVIOUS COVER ASSESSMENT AND REDUCTION
SITE ASSESSMENT FORM**

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

Assessment date:

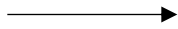

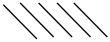




SITE INFORMATION

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)	

Appendix D – Example Site assessment Form – Page 2 of 5

AERIAL MAP KEY (Write in additional symbols as needed)
installations

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?	<input type="checkbox"/> Rooftop <input type="checkbox"/> Parking lot <input type="checkbox"/> Sidewalk <input type="checkbox"/> Compacted grass	
Is the site sloped? (Indicate stormwater flow direction on aerial map with arrows)	<input type="checkbox"/> Yes, there is a defined slope <input type="checkbox"/> Yes, somewhat <input type="checkbox"/> No, the site is flat	
Are there areas of pronounced erosion? (Indicate stormwater erosion on aerial map with hatched lines)	<input type="checkbox"/> Yes, there is serious erosion <input type="checkbox"/> Yes, there is mild erosion <input type="checkbox"/> There is evidence of healed erosion <input type="checkbox"/> No	
Are there areas of pronounced sedimentation? (Indicate sedimentation on aerial map with dots)	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Appendix D – Example Site assessment Form – Page 3 of 5

<p>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)</p>	<p><input type="checkbox"/> Yes, ponding visible on grassy area <input type="checkbox"/> Yes, ponding visible on asphalt/concrete <input type="checkbox"/> No</p>	
<p>Does stormwater runoff flow directly into sewer system? (Indicate storm sewers on aerial map with hatched boxes)</p>	<p><input type="checkbox"/> Yes, downspouts connected to sewer <input type="checkbox"/> Yes, downspouts directed toward sewers <input type="checkbox"/> Yes, stormwater flows toward sewers <input type="checkbox"/> No, stormwater flows away from sewers OR there are no sewers nearby</p>	
<p>Are there existing curb cuts to direct stormwater flow? (Indicate curb cuts on aerial map with ovals)</p>	<p><input type="checkbox"/> Yes, there are existing curb cuts <input type="checkbox"/> No, there are no curb cuts <input type="checkbox"/> N/A</p>	
<p>Are there existing stormwater BMPs on site? (Write in BMP types on aerial map)</p>	<p><input type="checkbox"/> Yes, indicate type and number in comments <input type="checkbox"/> No</p>	

DEPAVING/DISCONTINUOUS PAVING/GRAVEL FILTER	OBSERVATIONS	COMMENTS
<p>Is there a potential to remove existing paved areas?</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> Portions of pavement can be removed <input type="checkbox"/> No</p>	

PERVIOUS PAVEMENT	OBSERVATIONS	COMMENTS
<p>Is any asphalt or other paved area in disrepair?</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A, there is no paved area</p>	

Appendix D – Example Site assessment Form – Page 4 of 5

<p>Are there areas of asphalt that are lightly used, like parking spaces or fire lanes?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No	
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RAINWATER HARVESTING/STORAGE	OBSERVATIONS	COMMENTS
<p>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)</p>	<input type="checkbox"/> Yes, external downspouts <input type="checkbox"/> Yes, internal downspouts <input type="checkbox"/> No <input type="checkbox"/> N/A, there is no building on-site	
<p>Is there a garden or athletic field nearby that may use collected rainwater?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No	
<p>Is there space next to the downspout for a BMP placement?</p>	<input type="checkbox"/> Yes, enough space for a cistern <input type="checkbox"/> Yes, enough space for a rain barrel or downspout planter <input type="checkbox"/> No <input type="checkbox"/> N/A, there are no downspouts	

STORMWATER BASIN NATURALIZATION	OBSERVATIONS	COMMENTS
<p>Is there an existing stormwater detention basin?</p>	<input type="checkbox"/> Yes, with short mowed grass <input type="checkbox"/> Yes, with concrete low-flow channel <input type="checkbox"/> No	

RAIN GARDEN	OBSERVATIONS	COMMENTS
<p>Are there unpaved areas on-site suitable and large enough for landscaping?</p>	<input type="checkbox"/> Yes, grassy areas can be landscaped <input type="checkbox"/> No, grassy areas cannot be landscaped <input type="checkbox"/> No, no grassy areas on-site	

Appendix D – Example Site assessment Form – Page 5 of 5

<p>What type(s) of plants would be appropriate in these areas?</p>	<input type="checkbox"/> Full sun <input type="checkbox"/> Shade <input type="checkbox"/> Mix of sun and shade	
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TREE FILTER BOX (recommended for more urban areas)	OBSERVATIONS	COMMENTS
<p>Does stormwater flow across sidewalks, curbs, or along the street?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No	
<p>Is there a sufficient amount of space to install a tree filter box along the sidewalk or road?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No	
<p>Are there existing trees along the sidewalk or road that could be used in a filter box design?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No	

BIOSWALE	OBSERVATIONS	COMMENTS
<p>Does stormwater need to travel from its source to the selected BMP?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No	

GI RECOMMENDATIONS			
<p>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)</p>	<input type="checkbox"/> Rooftop disconnection <input type="checkbox"/> Pervious pavement <input type="checkbox"/> Rain barrel <input type="checkbox"/> Rain garden <input type="checkbox"/> Basin naturalization <input type="checkbox"/> OTHER _____	<input type="checkbox"/> Depaving <input type="checkbox"/> Cistern <input type="checkbox"/> Downspout planter <input type="checkbox"/> Bioswale <input type="checkbox"/> Tree filter box	<input type="checkbox"/> Sand/Gravel Filter Pit/Strip <input type="checkbox"/> Discontinuous pavement (partial depaving)

Appendix E – Site-Specific Reduction Action Plans

ATTACHED SEPERATELY

Appendix F – Summary of Reduction Action Plans for Hightstown Borough

STORMWATER BMP BY SITE	POTENTIAL MANAGEMENT AREA		SIZE OF BMP		PERCENTAGE OF IMPERVIOUS COVER TREATED	REMOVAL POTENTIAL (lb/yr)			MAXIMUM VOLUME REDUCTION POTENTIAL (gal/storm)	RECHARGE POTENTIAL (gal/year)	ESTIMATED COST
	(ac)	(sq ft)	(ac)	(sq ft)		TP	TN	TSS			
BEAR BROOK SUBWATERSHED											
Hightstown High School											
Rain Garden	0.28	12,153	0.11	4,916	2.0%	0.03	0.68	12.19	25,076	337,828	\$24,578.08
Porous Pavement	1.22	53,304	0.18	7,683	8.9%	0.11	0.88	16.93	109,987	1,481,770	\$92,198.52
Stormwater Basin Naturalization	3.81	166,005	0.58	25,229	27.6%	2.29	11.43	411.58	342,530	4,614,632	\$126,145.01
Site Total	5.31	231,462	0.87	37,828	38.5%	2.43	12.99	440.70	477,593	6,434,229	\$242,921.60
BEAR BROOK SUBWATERSHED TOTAL											
	5.31	231,462	0.87	37,828		2.43	12.99	440.70	477,593	6,434,229	\$242,921.60
ROCKY BROOK SUBWATERSHED											
1st Constitution Bank											
Bioswale	0.12	5,303	0.03	1,391	12.5%	0.02	0.10	3.45	10,942	147,411	\$6,957.43
Porous Pavement 1	0.34	14,879	0.08	3,636	35.1%	0.05	0.42	8.01	30,700	413,601	\$43,631.84
Rain Garden	0.04	1,827	0.02	731	4.3%	0.03	0.13	4.53	3,769	50,776	\$3,653.88
Porous Pavement 2	0.30	13,068	0.11	4,631	30.8%	0.06	0.53	10.21	26,964	363,260	\$55,573.96
Site Total	0.81	35,076	0.24	10,389	82.7%	0.16	1.17	26.20	72,375	975,048	\$109,817.11
CCL Label											
Porous Pavement	0.73	31,754	0.20	8,617	38.9%	0.12	0.99	18.99	65,521	882,707	\$103,403.54
Site Total	0.73	31,754	0.20	8,617	38.9%	0.12	0.99	18.99	65,521	882,707	\$103,403.54
Empire Antiques											
Depave	0.40	17,501	0.40	17,501	13.2%	0.00	0.00	0.00	36,111	486,496	\$35,001.22
Bioswale	0.48	20,915	0.10	4,393	15.7%	0.06	0.30	10.89	43,156	581,407	\$21,965.75
Vegetated Filter	0.45	19,585	0.62	26,968	14.7%	0.37	3.10	59.43	40,411	544,429	\$80,905.44
Site Total	1.33	58,001	1.12	48,862	43.6%	0.43	3.40	70.33	119,679	1,612,332	\$137,872.40
First Baptist Church											
Vegetated Filter	0.11	4,838	0.14	6,309	12.8%	0.04	0.43	12.17	9,983	134,490	\$18,927.66
Rain Garden	0.12	5,297	0.05	2,203	14.0%	0.07	0.36	13.13	10,930	147,251	\$4,406.23
Porous Pavement	0.33	14,278	0.05	2,380	37.8%	0.03	0.27	5.24	29,461	396,905	\$28,554.92
Site Total	0.56	24,413	0.25	10,892	64.6%	0.15	1.07	30.54	50,374	678,646	\$51,888.81

Appendix F – Summary of Reduction Action Plans for Hightstown Borough

STORMWATER BMP BY SITE	POTENTIAL MANAGEMENT AREA		SIZE OF BMP		PERCENTAGE OF IMPERVIOUS COVER TREATED	REMOVAL POTENTIAL (lb/yr)			MAXIMUM VOLUME REDUCTION POTENTIAL (gal/storm)	RECHARGE POTENTIAL (gal/year)	ESTIMATED COST
	(ac)	(sq ft)	(ac)	(sq ft)		TP	TN	TSS			
First United Methodist Church											
Rain Garden	0.14	5,907	0.05	2,336	18.6%	0.03	0.16	5.79	12,188	164,194	\$11,682.44
Porous Pavement	0.27	11,607	0.05	2,127	36.5%	0.03	0.24	4.69	23,951	322,667	\$25,518.30
Site Total	0.40	17,514	0.10	4,463	55.0%	0.06	0.41	10.48	36,138	486,861	\$37,200.74
Hightstown Fire Department											
Cistern	0.18	7,824	0.05	2,200	41.4%	0.00	0.00	0.00	16,144	217,498	\$4,400.00
Vegetated Filter	0.08	3,322	0.10	4,410	17.6%	0.03	0.30	8.50	6,855	92,352	\$22,048.14
Site Total	0.26	11,146	0.15	6,610	59.0%	0.03	0.30	8.50	22,999	309,851	\$26,448.14
Hightstown Library-Memorial Branch											
Bioswale	0.07	3,186	0.01	556	33.9%	0.04	0.22	7.90	6,574	88,560	\$2,781.74
Porous Pavement	0.09	3,967	0.01	550	42.2%	0.01	0.06	1.21	8,186	110,289	\$6,597.17
Site Total	0.16	7,153	0.03	1,106	76.2%	0.05	0.28	9.11	14,760	198,849	\$9,378.90
Rocky Brook Park											
Vegetated Filter	0.32	14,070	0.40	17,313	30.6%	0.12	1.19	33.39	29,033	391,134	\$86,567.45
Porous Pavement	0.49	21,215	0.07	2,926	46.1%	0.04	0.34	6.45	43,774	589,738	\$43,888.50
Site Total	0.81	35,285	0.46	20,239	76.7%	0.16	1.53	39.84	72,807	980,873	\$130,455.95
Saint Anthony of Padua Church											
Porous Pavement 1	0.75	32,493	0.15	6,702	17.8%	0.09	0.77	14.77	67,044	903,235	\$80,426.87
Porous Pavement 2	0.77	33,418	0.09	3,702	18.3%	0.05	0.42	8.16	68,953	928,949	\$44,429.03
Porous Pavement 3	0.20	8,742	0.04	1,858	4.8%	0.03	0.21	4.10	18,037	243,001	\$22,298.77
Porous Pavement 4	0.22	9,612	0.04	1,763	5.3%	0.02	0.20	3.89	19,833	267,198	\$21,156.67
Site Total	1.93	84,264	0.32	14,026	46.1%	0.19	1.61	30.91	173,868	2,342,383	\$168,311.34
United States Post Office											
Rain Garden	0.09	3,814	0.03	1,115	4.2%	0.02	0.08	2.77	7,870	106,022	\$5,576.55
Porous Pavement 1	0.38	16,503	0.05	2,284	18.4%	0.23	1.89	36.37	34,052	458,750	\$27,403.98
Porous Pavement 2	0.20	8,777	0.04	1,873	9.8%	0.03	0.21	4.13	18,110	243,977	\$22,473.80
Vegetated Filter	0.16	7,131	0.21	8,991	7.9%	0.06	0.62	17.34	14,713	198,221	\$26,973.39
Site Total	0.83	36,224	0.33	14,263	40.3%	0.33	2.81	60.60	74,744	1,006,970	\$82,427.73

Appendix F – Summary of Reduction Action Plans for Hightstown Borough

STORMWATER BMP BY SITE	POTENTIAL MANAGEMENT AREA		SIZE OF BMP		PERCENTAGE OF IMPERVIOUS COVER TREATED	REMOVAL POTENTIAL (lb/yr)			MAXIMUM VOLUME REDUCTION POTENTIAL (gal/storm)	RECHARGE POTENTIAL (gal/year)	ESTIMATED COST
	(ac)	(sq ft)	(ac)	(sq ft)		TP	TN	TSS			
Wells Fargo											
Porous Pavement 1	0.26	11,142	0.04	1,755	25.6%	0.02	0.20	3.87	22,989	309,714	\$21,059.17
Porous Pavement 2	0.15	6,405	0.02	927	14.7%	0.01	0.11	2.04	13,215	178,039	\$11,129.08
Porous Pavement 3	0.10	4,328	0.15	6,547	9.9%	0.06	0.50	9.54	8,931	120,320	\$78,562.08
Site Total	0.50	21,875	0.21	9,229	50.2%	0.10	0.80	15.45	45,135	608,073	\$110,750.33
ROCKY BROOK SUBWATERSHED TOTAL	8.33	362,706	3.41	148,697		1.78	14.37	320.96	748,400	10,082,592	\$967,954.99
HIGHTSTOWN BOROUGH TOTAL	13.64	594,168	4.28	186,525		4.21	27.36	761.66	1,225,993	16,516,821	\$1,210,876.59