RUTGERS
New Jersey Agricultural
Experiment Station

Hamilton Township (Mercer County)
Hydrologic Model Report

Developed by the Rutgers Cooperative Extension Water Resources Program
Funded by the Hamilton Township, Mercer County, New Jersey

November 2015

Hydrologic Modeling Analysis[1]

Executive Summary

In the spring of 2011, the Rutgers Cooperative Extension (RCE) Water Resources Program partnered with Hamilton Township to evaluate watershed and stormwater management issues and to develop recommendations for improving and protecting water resources in the community.

To better understand the impacts of stormwater runoff on water quality and quantity, the RCE Water Resources Program initially prepared a hydrologic model for five of the major watersheds within the Township: Miry Run, Pond Run, Shady Brook, Back Creek, and Doctors Creek (Rutgers 2013). Modeling was conducted using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), a U.S. Army Corps of Engineers (USACOE) software program designed to simulate precipitation and resulting runoff in larger watershed systems. A hydrologic model provides an understanding of stormwater runoff volumes from individual watersheds that can contribute to flooding. It also allows for the determination of stream and flood responses to stormwater runoff under various storm conditions. The model was simulated using the New Jersey water quality storm of 1.25-inches of rainfall in two hours, as well as the 24-hour, Type III Soil Conservation Service (SCS) storm distribution for the 1-year, 2-year, 10-year, and 100-year storm events. Table 1 contains the associated precipitation values for each storm event in Mercer County.

Table 1: 24 hour, Type III SCS Storm Distribution for Mercer County

Mercer County SCS Type III Total Rainfall Depth			
1-year Storm Event (inches)	2-year Storm Event (inches)	10-year Storm Event (inches)	100-year Storm Event (inches)
2.8	3.3	5.0	8.3

[1] Rutgers Hydrology Report – Miry Run, Pond Run, Shady Brook, Back Creek, and Doctors Creek, 2013

Much of the input data for the model was downloaded directly from the New Jersey Department of Environmental Protection (NJDEP) Bureau of GIS website (http://www.nj.gov/dep/gis/download.htm). The Geospatial Hydrologic Modeling extension for HEC-HMS (HEC-GeoHMS) and Spatial Analyst extension for ArcGIS 9.3 were utilized to combine different layers and extract new attributes from the data to input into the HEC-HMS model.

The initial modeling completed in 2013 identified a series of critical subbasins within each watershed based on normalized runoff volumes. It was recommended that more detailed analysis of these critical subbasins was needed to understand the impacts of impervious cover and the opportunities for disconnecting impervious areas using stormwater best management practices. Figure 1 highlights the critical subbasin delineations for each watershed.

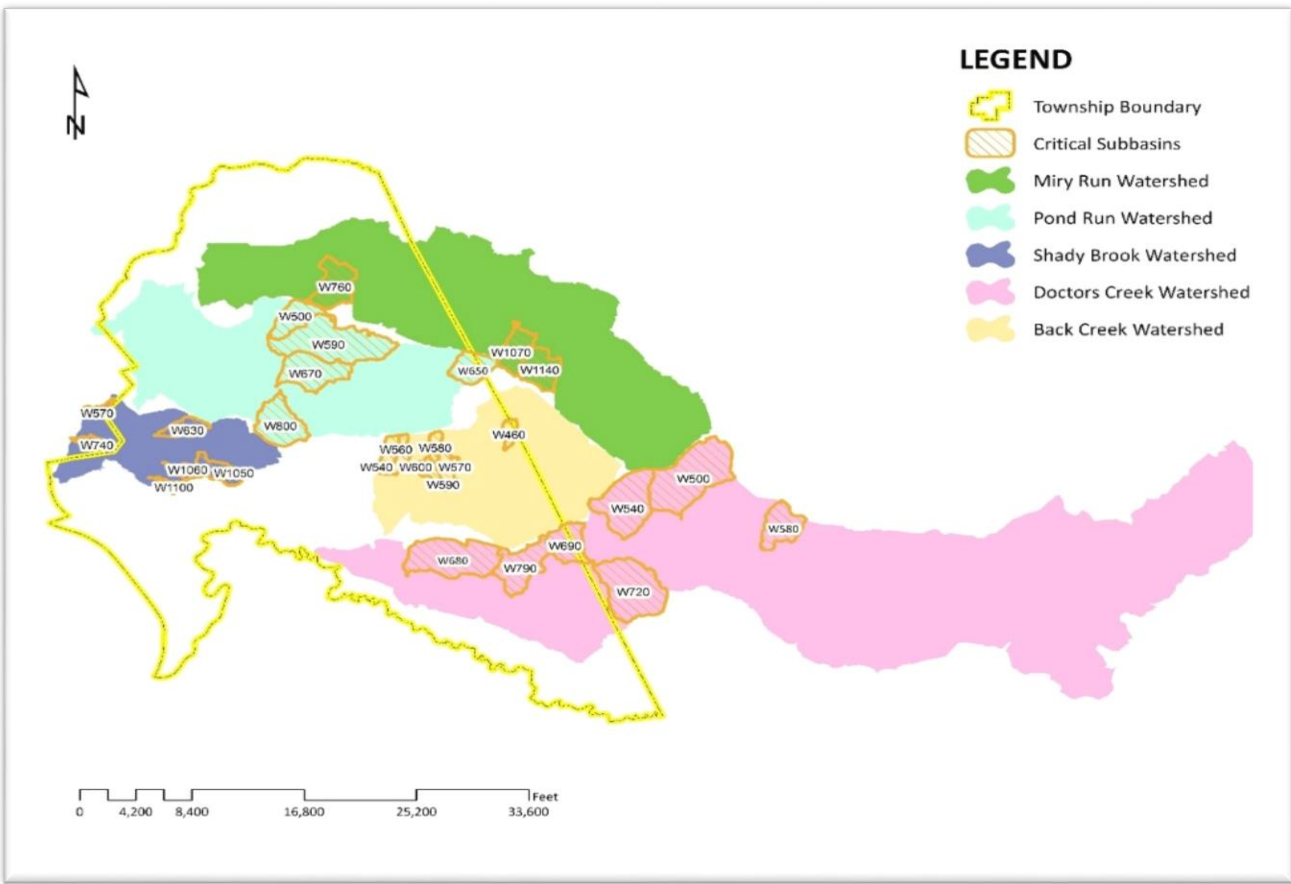

Figure 1: Critical subbasins for Miry Run, Pond Run, Shady Brook, Doctors Creek, and Back Creek generated during ArcGIS processing in HEC-GeoHMS

The following methodology was used to review and verify initial runoff volume calculations in critical subbasins and was then used to evaluate the possible stormwater runoff reductions achieved by disconnecting impervious areas using stormwater best management practices.

Methodology

HydroCAD

HydroCAD is a stormwater runoff modeling software that supports an array of stormwater drainage calculations to include SCS runoff hydrology, unlimited hydrograph points using local rainfall or the predefined rainfall library, and hydrograph routing through ponds and reaches, among other functions.

The purpose of modeling the priority subbasins with HydroCAD was to conduct a refined, detailed evaluation of stormwater runoff volumes associated with increased impervious surfaces due to urban development. HydroCAD modeling of priority subbasins can isolate and analyze pervious surfaces separate from impervious surfaces. Furthermore, by separating pervious from impervious surfaces, the associated decreases in runoff volume from selected impervious areas can be examined.

For this analysis, the stormwater runoff generated by residential impervious areas (rooftops, driveways, patios, etc.) was studied. HydroCAD modeling scenarios were conducted assuming 25, 33, and 50-percent reductions in connected residential impervious cover.

Upon running the three scenarios for residential disconnection aforementioned, the RCE Water Resources Program concluded that simple disconnection can significantly reduce runoff volumes for storm events up to the 2-year frequency storm or 3.3 inches of rain in 24 hours. It is not as effective in managing runoff generated during larger storms, particularly the 10-year and 100-year storms. Under these conditions, individualized disconnection strategies quickly become overwhelmed. To manage stormwater runoff under these conditions, more extensive green infrastructure practices or larger regional or neighborhood improvements would be needed to mitigate flooding.

Conclusions

Over 90% of rainfall in New Jersey comes in storms less than the New Jersey water quality design storm of 1.25 inches of rain in two hours. The following analysis outlines strategies for a variety of disconnection programs that will help neighborhoods reduce runoff volumes and subsequent flooding. Looking forward, efforts are needed to quantify whether 25%, 33%, or 50% residential disconnection is feasible. Further investigation of best management practice (BMP) viability in these critical subbasins is needed to locate appropriate sites and identify specific strategies that can be used to achieve maximum volume reductions. While residential disconnection through diverted downspouts, rain barrels, and rain gardens will help to address stormwater management issues, other methods are also needed in public rights-of-way and industrial and commercial areas. Techniques including depaving of underutilized areas, use of permeable pavements in parking areas, and green streets can provide significant reductions in stormwater runoff. Initial findings indicate that a 10%, 20%, or 30% reduction in overall impervious cover may be needed to achieve measurable change in stormwater runoff volumes. But, if only 1-2% overall reductions in impervious cover can be achieved and are combined with 25%, 33%, or even 50% residential disconnections, runoff volume reductions can decrease significantly, and these combined management measures can collaboratively combat and capture stormwater flow from the streets of Hamilton Township.

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Acknowledgements

The Hamilton Township (Mercer County) Hydrologic Model Report has been produced by the **Rutgers Cooperative Extension Water Resources Program.** Principal author was **Nicole Del Monaco**, Water Resources Program Intern, under the supervision of **Kyle Gourley, EIT,** Program Associate, **Jeremiah Bergstrom, LLA, ASLA,** Senior Research Project Manager, and **Christopher Obropta, Ph.D., P.E.,** Associate Extension Specialist. **Amna Rahman**, **Kaylin Mahoney**, and **Shivangi Ganatra**, Water Resources Program Intern, assisted with the calculations used in this report.

Support material and guidance was provided by **Richard Watson, P.E., P.P., C.M.E.,** Director of the Department of Water Pollution Control (Hamilton Township), **Richard Williams, P.E., P.P., C.M.E.,** Hamilton Township Engineer, **Lester Finch,** Chairman, Hamilton Township Environmental Commission, and **Haig Kasabach,** Hamilton Township Environmental Commission and Planning Board.

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Introduction

Stormwater is a major issue that impacts water quality and quantity as land use changes alter the hydrology of a community. As our natural areas become developed, stormwater runoff volumes and peak flows are increased, causing flooding and degrading local water quality. Stormwater is a major contributor to New Jersey's water pollution; it mirrors the land it flows over as it picks up pollutants from the landscape and deposits those pollutants to the nearest waterbody. Although often not the case, stormwater flooding and water quality issues can be addressed simultaneously with comprehensive cost-effective solutions.

In 2004, the New Jersey Department of Environmental Protection (NJDEP) released stormwater management and permitting regulations. Prior to 2004, NJDEP's Stormwater Management Regulations only concentrated on controlling peak stormwater flows from new developments for large storm events. The 2004 Stormwater Manage Regulations focus not only on managing water quantity, but also on improving water quality and promoting groundwater recharge. These rules also require new development to incorporate nonstructural stormwater management strategies into their designs. Additionally, these rules provide a recipe for developing Regional Stormwater Management Plans, which aim to minimize flooding, eliminate nonpoint source pollution, and assist municipalities in better managing their stormwater. Stormwater issues are typically addressed on a site by site basis often aggravating issues in the larger community as one site release stormwater that is being detained at the same rate as an adjacent site, creating more flooding problems and high stream flows that cause channel and stream bank erosion. Through regional and community-wide stormwater management planning, water quality and quantity issues are evaluated on a watershed basis, taking into account how various management strategies can be designed to complement each other minimizing flooding while maximizing water quality improvements and groundwater recharge. While conduction stormwater management on a watershed basis is ideal, often multiple towns are contained within one watershed, requiring them to work together to develop a comprehensive plan then taking the plan recommendations back to their town and implementing strategies for the good of the watershed, for the good of their town. Ultimately, the NJDEP Stormwater Management Regulations require municipalities to take individual responsibility for managing stormwater along with associated flooding and pollution.

But through proper planning and partnerships with surrounding municipalities, this task can be accomplished in a cost-effective manner.

The NJDEP Municipal Stormwater Permitting Program addresses pollutants entering our waters from storm drainage systems owned or operated by local, county, state, interstate, or federal government agencies. These systems are called “municipal separate storm sewer systems” (MS4s) and are regulated by a General New Jersey Pollution Discharge Elimination System (NJDES) permit to municipalities throughout the state. The permit requirements are divided into two municipal tiers: Tier A municipalities are generally located within more densely populated regions or along the coast (Hamilton Township is a Tier A municipality); Tier B municipalities are generally more rural and in non-coastal areas. New development and redevelopment is addressed, in part, by requiring municipalities to adopt and enforce a stormwater management plan and ordinance in accordance with the NJDEP’s Stormwater Management Regulations. These rules focus on requiring the municipalities to clean and maintain their municipal separate storm sewer system (MS4) and pass ordinances that will limit pollution at its source such as Pet Waste Ordinance, Litter Ordinance, Improper Disposal Waste Ordinance, Wildlife Feeding Ordinance, and others.

Stormwater is a concern because of two main issues: the increased volume of runoff from the precipitation events due to developed areas’ inability to percolate precipitation back into the ground and contamination of stormwater runoff from pollutants that accumulate on the landscape over which it flows. The increased volume of stormwater runoff leads to flooding, increased erosion of stream banks and loss of groundwater supplies due to a lack of infiltration into aquifers. Stormwater pollutants degrade habitats for aquatic life or impair populations of organisms and have far reaching effects on water supplies as they contaminate reservoirs, increase costs to treat drinking water and wastewater, and pollute groundwater.

New Jersey is facing serious water resource problems that continue to worsen as development expands at a rapid pace throughout the State. Although the 2004 stormwater management and permitting rules have significantly changed the way New Jersey manages its stormwater runoff, the rules only apply to new development. This leaves the stormwater runoff impacts from existing developments to be addressed through the municipal stormwater permit rules and the implementation plans for total maximum daily loads (TMDLs). The result will likely be voluntary programs that may have little hope for success unless significant funding can be allocated to support public outreach and education programs centers on progressive stormwater management at the municipal level.

Background

In the spring of 2011, the Rutgers Cooperative Extension (RCE) Water Resources Program partnered with Hamilton Township to evaluate watershed and stormwater management issues and develop recommendations for improving and protecting water resources in the community. In order to address water resources management issues and hydrologic functions in the township, the RCE Water Resources Program established a series of goals for Hamilton Township. These goals include:

- Engage the community in water resources protection
- Manage water quality
- Minimize local flooding
- Improve stormwater facility maintenance

In order to address the goals of water quality and quantity, RCE Water Resources Program has modeled five of the major watersheds within the Township: Miry Run, Pond Run, Shady Brook, Back Creek, and Doctors Creek using Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), a US Army Corps of Engineers (USACOE) software designed to simulate the precipitation runoff of watershed systems[1]. A hydrologic model helps decision-makers understand stormwater runoff volumes from watersheds within the township contributing to flooding and allow for determinations of stream and flood responses to stormwater runoff under various storm conditions. The model was simulated using the water quality storm of 1.25-inches, as well as the 24-hr, Type III Soil Conservation Service (SCS) storm distribution for the 1-year,

[1] USACOE HEC, 2013

2-year, 10-year, and 100-year storm events. Table 1 contains the associated precipitation values for each storm event in Mercer County.

Table 1: 24 hour, Type III SCS Storm Distribution for Mercer County

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Much of the input data for the model was downloaded directly from the New Jersey Department of Environmental Protection (NJDEP) Bureau of GIS website (http://www.nj.gov/dep/gis/download.htm). The Geospatial Hydrologic Modeling Extension for HEC-HMS (HEC-GeoHMS) and Spatial Analyst extension for ArcGIS 9.3 were utilized to combine different layers and extract new attributes from the data to be used as input into the HEC-HMS modeling software.

From the results of the HEC-HMS hydrologic model, subbasins were delineated as critical[2] based on a ranking system that took into consideration direct runoff and drainage area. Figure 1 (shown on the next page) highlights the critical subbasin delineations per watershed.

[2] Critical subbasins are priority subbasins for implementation. These subbasins contain less pervious cover, thus making them a higher risk for flooding.

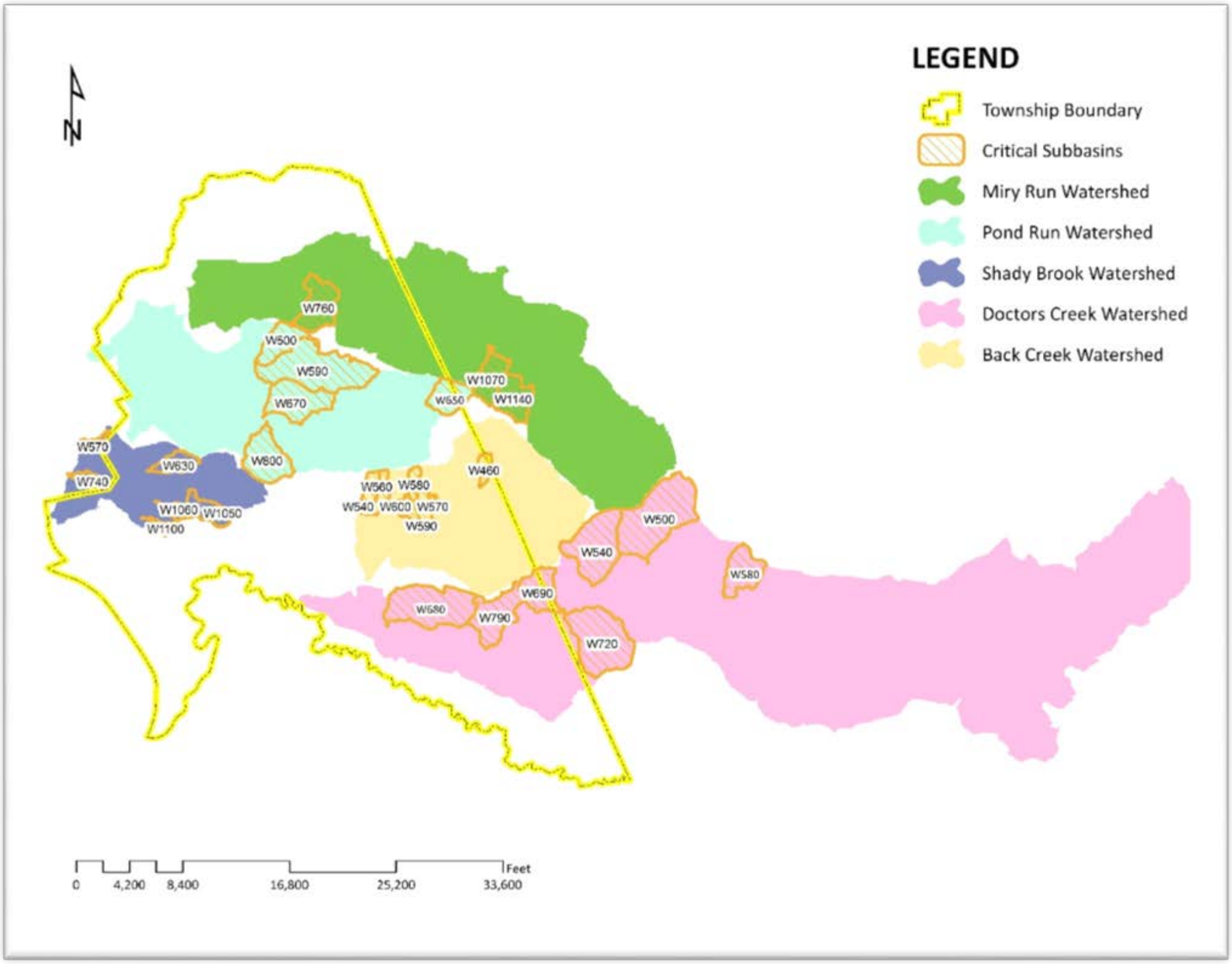


Figure 1: Critical subbasins for Miry Run, Pond Run, Shady Brook, Doctors Creek, and Back Creek generated during ArcGIS processing in HEC-GeoHMS.

Upon reviewing the runoff volumes of the critical subbasins, RCE Water Resources Program had decided to focus on in-depth modeling of the priority subbasins using HydroCAD.

Methodology

HydroCAD

HydroCAD is a stormwater runoff modeling software used in an array of drainage calculations, including SCS runoff hydrology, unlimited hydrograph points, using local rainfall or the predefined rainfall library, hydrograph routing through ponds and reaches, among other functions[3].

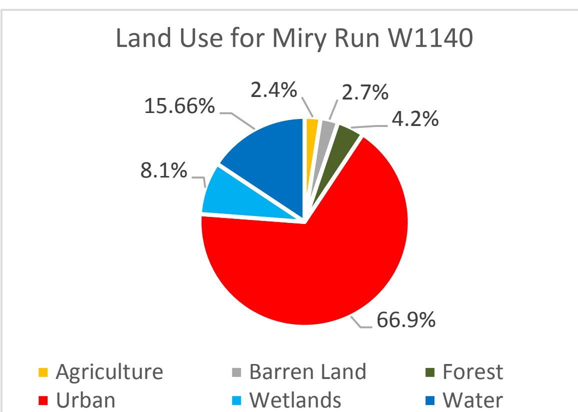
[3] HydroCAD Software Solutions, LLC, 2015

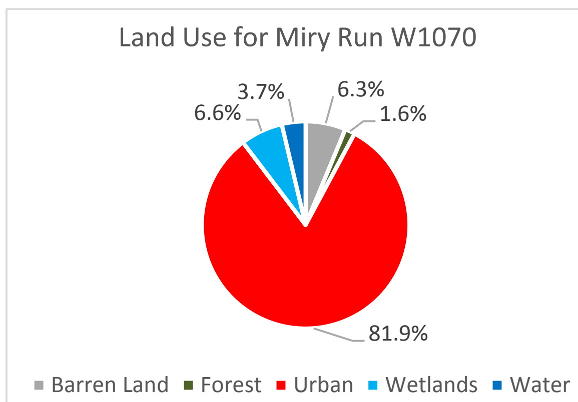
The purpose of modeling the priority subbasins in HydroCAD was to incorporate a refined, more detailed look at the stormwater problems associated with increased impervious surfaces due to urban and industrial development[4]. HydroCAD modeling of priority subbasins would help to isolate and analyze pervious surfaces from impervious surfaces[5].

***Impervious surfaces** are defined as any surface that has been covered with a layer of material so that it is highly resistant to infiltration by water. Examples include but are not limited to paved roadways, paved parking areas, building roofs and greenhouses.*

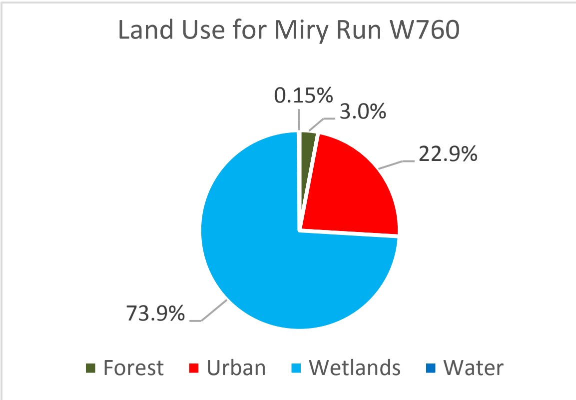
Impervious Cover

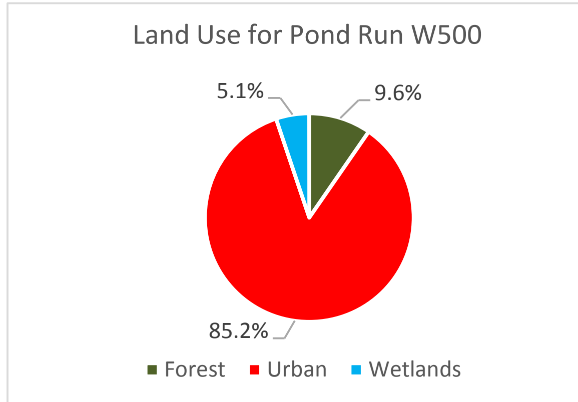
Developed areas have a greater percentage of impervious surfaces, which increases the rate and volume of runoff. Large amounts of impervious surfaces have negative impacts by increasing the amount of water and associated contaminants and sediments that flow through the watershed. This runoff, when managed improperly, is a major transportation of pollutants, including debris, fertilizer, and bacteria. Increased runoff causes flooding when flood control measures are exceeded[6]. Below are the land use breakdowns per priority subbasin.

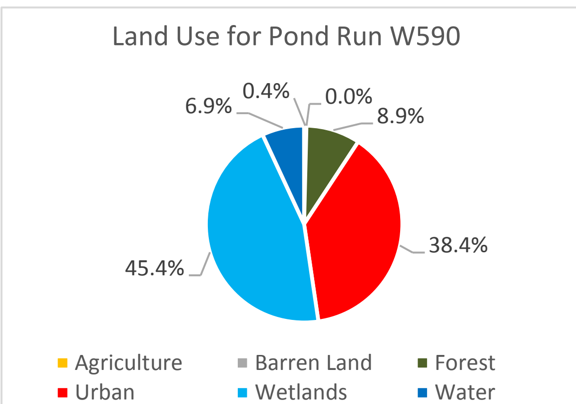


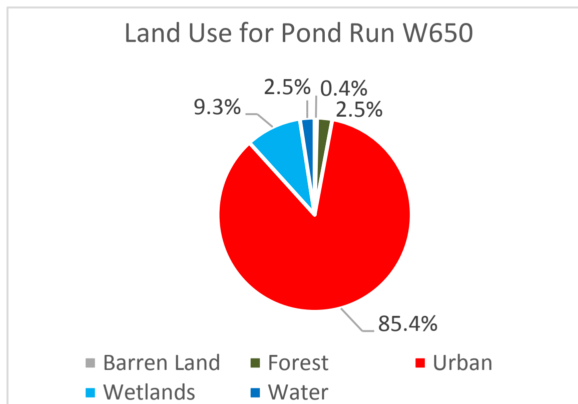


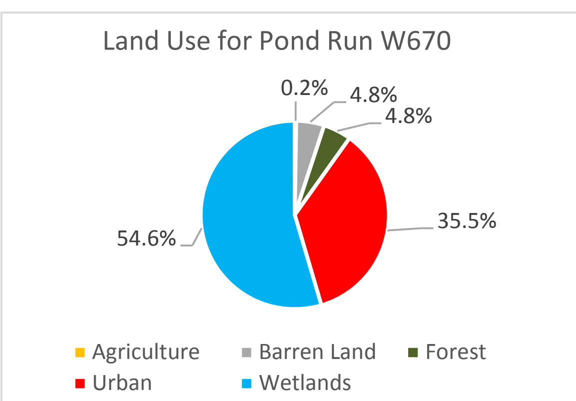
[4] FEMA, 2010
[5,6] RCE Water Resources Program, 2013

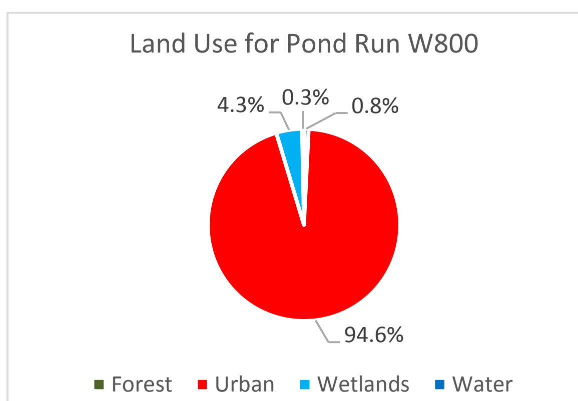

Land Use for Miry Run W760
0.15%
3.0%
22.9%
73.9%
Forest
Urban
Wetlands
Water

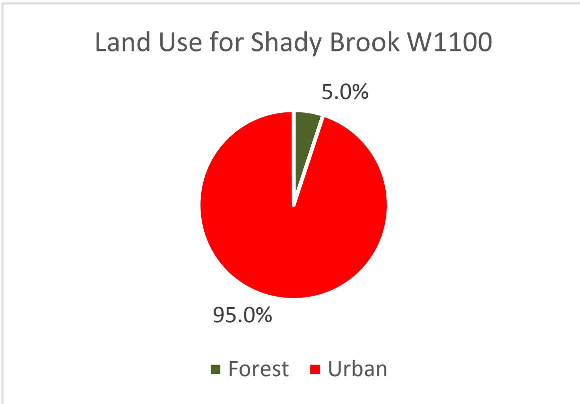

Land Use for Pond Run W500
5.1%
9.6%
85.2%
Forest
Urban
Wetlands

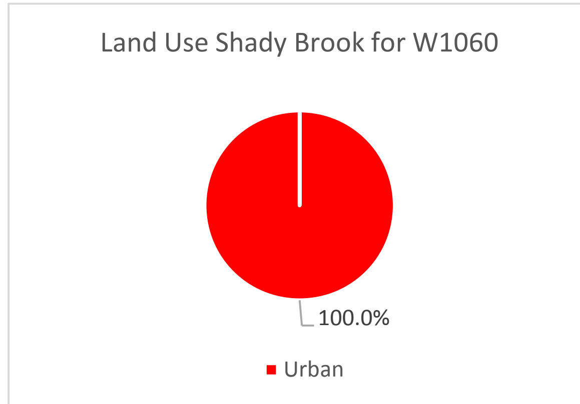

Land Use for Pond Run W590
6.9%
0.4%
0.0%
8.9%
38.4%
45.4%
Agriculture
Barren Land
Forest
Urban
Wetlands
Water

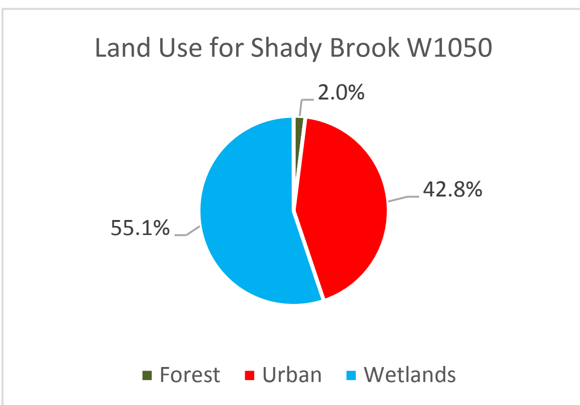

Land Use for Pond Run W650
9.3%
2.5%
0.4%
2.5%
85.4%
Barren Land
Forest
Urban
Wetlands
Water

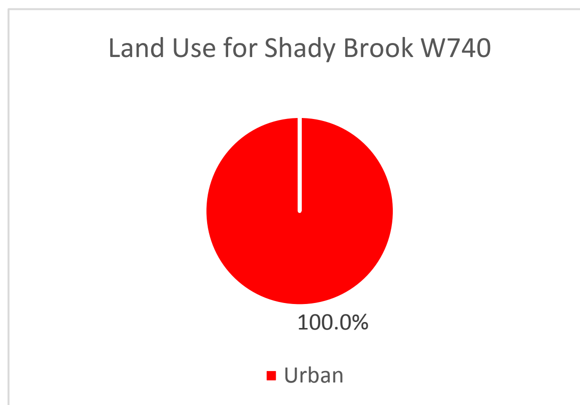

Land Use for Pond Run W670
0.2%
4.8%
4.8%
35.5%
54.6%
Agriculture
Barren Land
Forest
Urban
Wetlands

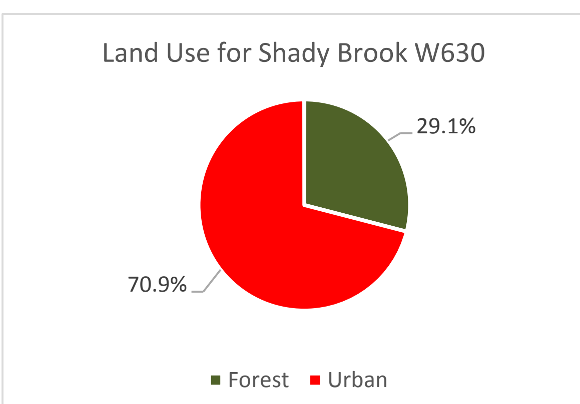

Land Use for Pond Run W800
4.3%
0.3%
0.8%
94.6%
Forest
Urban
Wetlands
Water

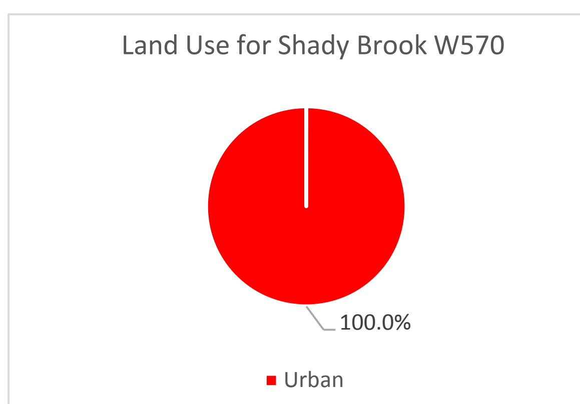

Land Use for Shady Brook W1100
5.0%
95.0%
Forest
Urban

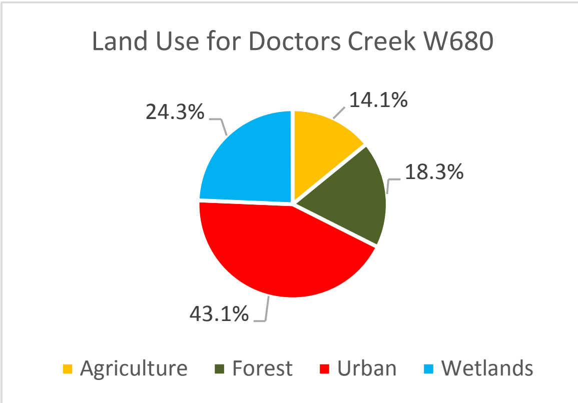

Land Use Shady Brook for W1060
100.0%
Urban

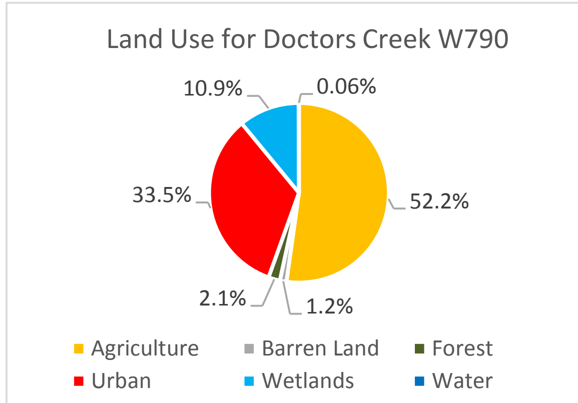

Land Use for Shady Brook W1050
2.0%
42.8%
55.1%
Forest
Urban
Wetlands

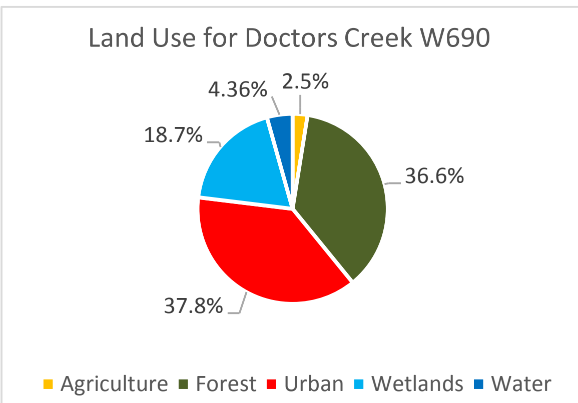

Land Use for Shady Brook W740
100.0%
Urban

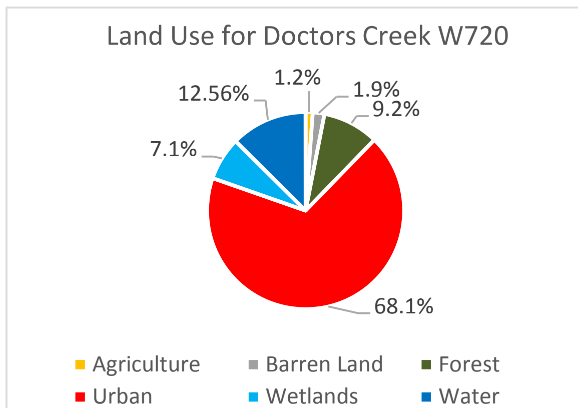

Land Use for Shady Brook W630
29.1%
70.9%
Forest
Urban

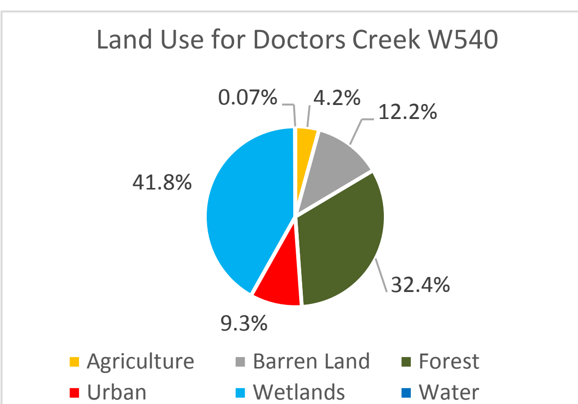

Land Use for Shady Brook W570
100.0%
Urban

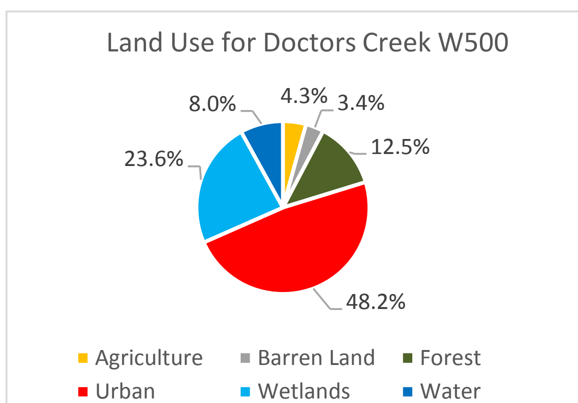

Land Use for Doctors Creek W680
14.1%
18.3%
24.3%
43.1%
Agriculture
Forest
Urban
Wetlands

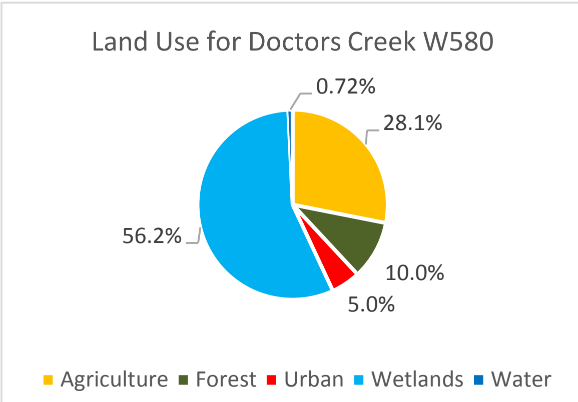

Land Use for Doctors Creek W790
10.9%
0.06%
33.5%
52.2%
2.1%
1.2%
Agriculture
Barren Land
Forest
Urban
Wetlands
Water

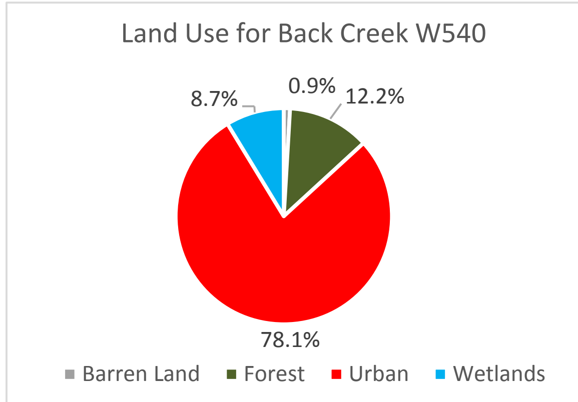

Land Use for Doctors Creek W690
4.36%
2.5%
18.7%
36.6%
37.8%
Agriculture
Forest
Urban
Wetlands
Water

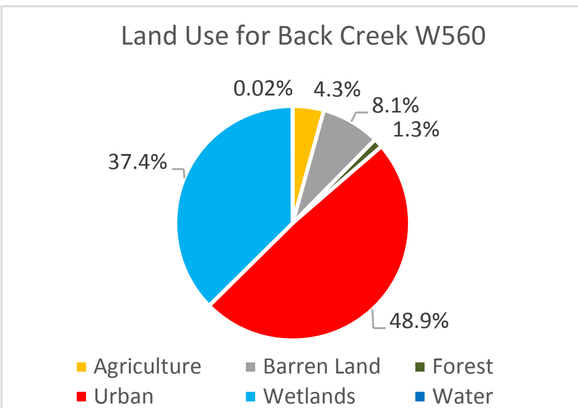

Land Use for Doctors Creek W720
12.56%
1.2%
1.9%
9.2%
7.1%
68.1%
Agriculture
Barren Land
Forest
Urban
Wetlands
Water


Land Use for Doctors Creek W540
0.07%
4.2%
12.2%
41.8%
32.4%
9.3%
Agriculture
Barren Land
Forest
Urban
Wetlands
Water


Land Use for Doctors Creek W500
8.0%
4.3%
3.4%
12.5%
23.6%
48.2%
Agriculture
Barren Land
Forest
Urban
Wetlands
Water


Land Use for Doctors Creek W580
0.72%
28.1%
56.2%
10.0%
5.0%
Agriculture
Forest
Urban
Wetlands
Water


Land Use for Back Creek W540
8.7%
0.9%
12.2%
78.1%
Barren Land
Forest
Urban
Wetlands


Land Use for Back Creek W560
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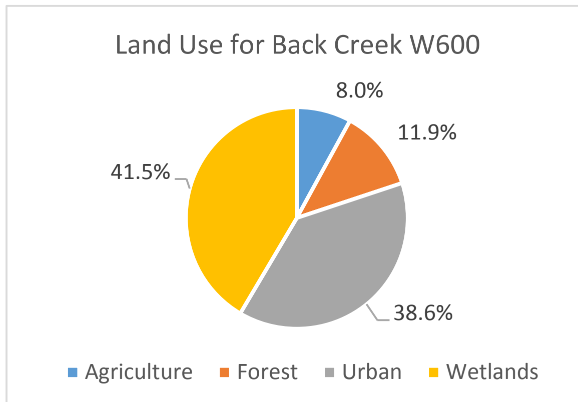
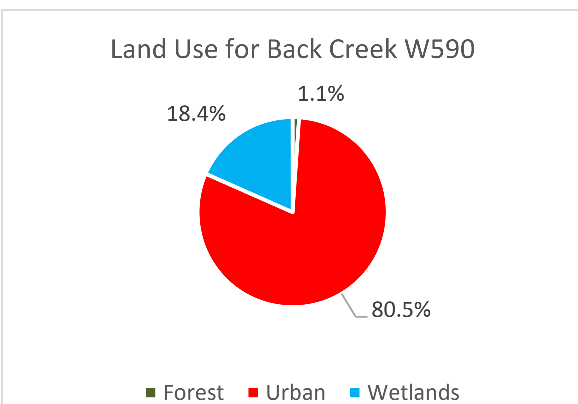
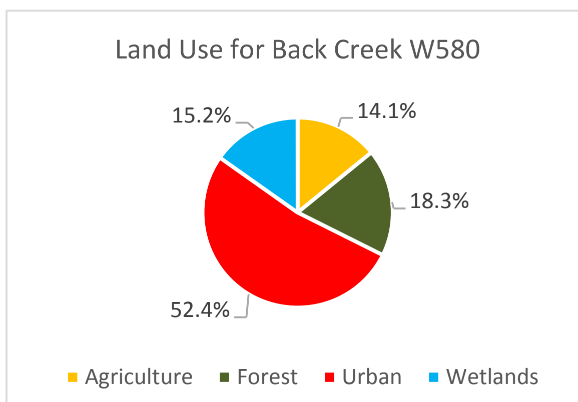
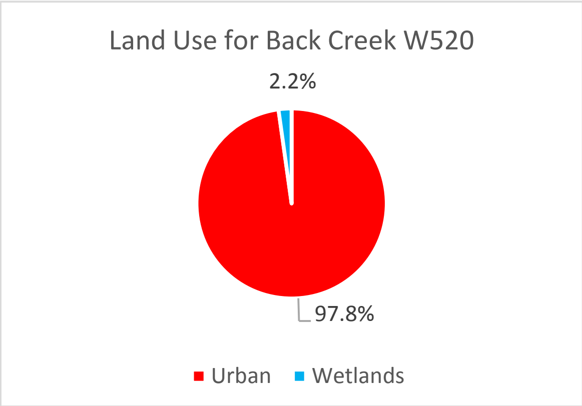
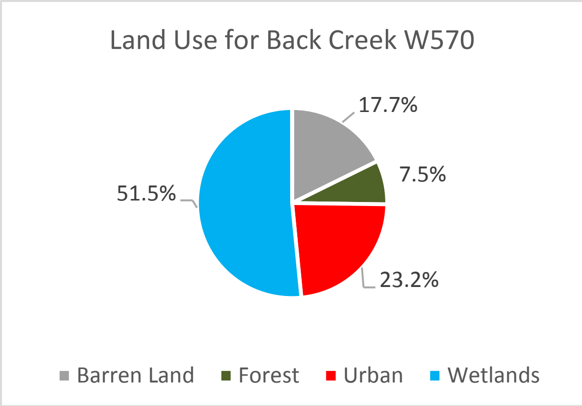
4.3%
8.1%
1.3%
37.4%
48.9%
Agriculture
Barren Land
Forest
Urban
Wetlands
Water

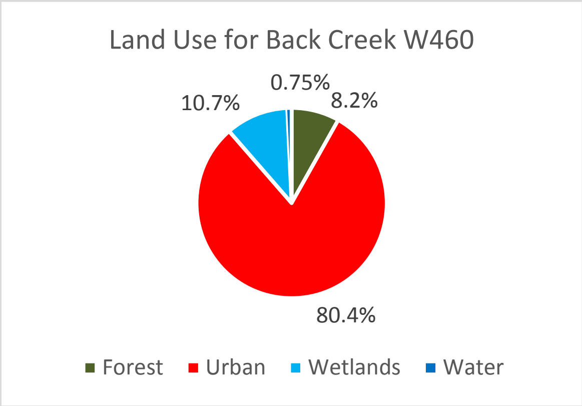

Land Use for Back Creek W600
8.0%
11.9%
41.5%
38.6%
Agriculture
Forest
Urban
Wetlands


Land Use for Back Creek W590
1.1%
18.4%
80.5%
Forest
Urban
Wetlands


Land Use for Back Creek W580
15.2%
14.1%
18.3%
52.4%
Agriculture
Forest
Urban
Wetlands







In New Jersey, the land use GIS layers contain attributes on percent impervious cover. These data were used to determine the percent impervious soccer for each priority subbasins. These values are presented in Table 2. It is important to note that the literature suggests a link between impervious cover and stream ecosystem impairment starting at approximately 10% impervious surface cover (Schueler, 1994; Arnold and Gibbons, 1996; May et al., 1997). Impervious cover may be linked to the quality of lakes, reservoirs, estuaries, and aquifers (Caraco et al., 1998), and the amount of impervious cover in a watershed can be used to project the current and future quality of streams. Based on the scientific literature, Caraco et al. (1998) classified urbanizing streams into the following three categories: sensitive streams, impacted streams, and non-supporting streams. Sensitive steams typically have a watershed impervious surface cover from 0 – 10%. Impacted streams have a watershed impervious cover ranging from 11-25% and typically show clear signs of degradation from urbanization. Non-supporting streams have a watershed impervious cover of greater than 25%; at this high level of impervious cover, streams are simply conduits for stormwater flow and no longer support a diverse stream community.

Table 2: Data values used to determine percent impervious cover for each priority subbasin.

Watershed	Subbasin	Total Area		Land Use Area		Water Area		Impervious Cover		
		ac	mi²	ac	mi²	ac	mi²	ac	mi²	%
Miry Run	W1140	189	0.29	159	0.25	30	0.05	47	0.07	29.8%
	W1070	155	0.24	149	0.23	6	0.01	64	0.10	43.1%
	W760	223	0.35	223	0.35	0	0.00	64	0.10	28.6%
Pond Run	W500	161	0.25	161	0.25	0	0.00	77	0.12	47.8%
	W590	530	0.83	493	0.77	37	0.06	226	0.35	45.7%
	W650	156	0.24	152	0.00	4	0.01	67	0.10	43.9%
	W670	273	0.43	273	0.43	0	0.00	105	0.16	38.4%
	W800	255	0.40	254	0.40	1	0.00	115	0.18	45.5%
Shady Brook	W1100	32	0.05	32	0.05	0	0.00	22	0.03	67.9%
	W1060	42	0.07	42	0.07	0	0.00	17	0.03	41.5%
	W1050	120	0.19	120	0.19	0	0.00	42	0.07	35.2%
	W740	43	0.07	43	0.07	0	0.00	31	0.05	72.1%
	W630	91	0.14	91	0.14	0	0.00	43	0.07	47.4%
	W570	35	0.05	35	0.05	0	0.00	19	0.03	54.1%
Doctors Creek	W680	437	0.68	436	0.68	0	1.41	43	0.07	9.8%
	W790	259	0.40	259	0.40	0	0.00	19	0.03	7.1%
	W690	182	0.28	174	0.27	0	0.00	11	0.02	6.3%
	W720	455	0.71	398	0.62	57	0.09	94	0.15	23.6%
	W540	388	0.61	388	0.61	0	0.00	24	0.04	6.3%
	W500	564	0.88	519	0.81	45	0.07	138	0.22	26.6%
	W580	194	0.30	193	0.30	0	0.00	7	0.01	3.7%
Back Creek	W540	75	0.12	75	0.12	0	0.00	32	0.05	42.8%
	W560	67	0.10	67	0.10	0	0.00	21	0.03	31.4%
	W600	64	0.10	64	0.10	0	0.00	13	0.02	19.8%
	W590	73	0.11	73	0.11	0	0.00	33	0.05	45.9%
	W580	44	0.07	44	0.07	0	0.00	8	0.01	17.8%
	W520	5	0.01	5	0.01	0	0.00	1	0.00	19.2%

	W570	6	0.01	6	0.01	0	0.00	1	0.00	13.7%
	W460	46	0.07	46	0.07	0	0.00	21	0.03	46.3%

Curve Number

During the initial hydrologic modeling of the five Hamilton watersheds, the Geospatial Hydrologic Modeling Extension for HEC-HMS (HEC-GeoHMS) and Spatial Analyst extension for ArcGIS 9.3, the ArcCN Runoff Tool[7] were used to generate a weighted curve number per subbasin using soil hydrologic group and land use/land cover data.

In order to differentiate between pervious surfaces and impervious surfaces, different curve numbers were calculated and integrated into the model. A generic curve number of 98 was used to model impervious surfaces in each priority subbasins. High curve number values, such as 98, cause much of the rainfall to appear as runoff, with minimal losses[8]. To calculate the curve number for pervious surfaces, the following equation was used:

$$CN_P = \frac{(A * CN_W) - (CN_I * A_I)}{A_P},$$

where CN_P is the pervious curve number, A is the total area of the subbasin, CN_W is the weighted curve number for the subbasin, generated from the ArcCN Runoff Tool, CN_I is the impervious curve number (98 was used for each subbasin), A_I is the impervious area of the subbasin, taken from the NJDEP GIS layer's Land Use/Land Cover data, and A_P is the pervious area of the subbasin (the difference between total area and impervious area of the subbasin).

The curve numbers used in the HydroCAD models can be found in Appendix A.

HydroCAD uses a time of concentration, T_c, to model stormwater runoff from a watershed. Time of concentration is the time it take a drop of water to travel from the most hydrologically distant point in the watershed to the watershed outlet. The smaller the T_c, the higher the peak runoff rate. The larger the T_c, the lower the peak runoff rate. Since the runoff volume is not a function of the T_c, an exact determination of T_c for this analysis was not important[9]. Therefore, a default value

[7] Zhan and Huang, 2004
[8] HydroCAD Software Solutions, LLC, 2015
[9] An arbitrary time of concentration of 120 minutes was used for each simulation.

for T_c was used in the modeling of each subbasin to calculate runoff volumes for various storm events.

Analysis

To get a more accurate representation of runoff volumes, the model was run separately for pervious areas and for impervious areas. Using the land use/land cover GIS layer from the NJDEP, the impervious area for each priority subbasin was extracted and simulated through the model with the curve number of 98. The remaining pervious areas were run using the pervious curve number that was calculated.

The model used the SCS unit hydrograph values for the water quality, 1-year, 2-year, 10-year, and 100-year storm distribution for Mercer County (refer to Table 1 for specific values).

The runoff volumes from pervious surfaces and impervious surfaces were then summed together to generate total runoff volume for each priority subbasin. The results can be seen in Appendix B.

If a 10, 20, or 30-percent reduction in overall impervious cover throughout each priority subbasin was achieved, there would be a noticeable decrease in associated runoff volumes. Future action items include developing a model to generate theoretical runoff volumes for these three scenarios, as well as determining feasibility of meeting these 10, 20, or 30-percent reductions by installing best management practices (BMPs). By installing BMPs in these flood-prone subbasins, stormwater runoff will be detained or infiltrated, which reduces the rate and volume of runoff as well as improving local water quality[10].

Due to the fact that land availability may limit BMP opportunities in these priority subbasins, the Rutgers WRP began looking at other management measures to reduce runoff volumes. Simple disconnection of a downspout to allow water to drain onto the lawn is an easy method to reduce the flashy hydrology of the local streams, promote groundwater recharge and improve water quality. When discharging stormwater runoff onto a pervious surface, great care needs to be taken to ensure that the water passes onto the surface at sheet flow. As rain water moves across a parking lot, it travels as a sheet of water about 1 inch thick. When this sheet of water hits a 2 to 3 inch tall

[10] RCE Water Resources Program, 2013

grassed area, the water is slowed down, filtered and allowed to infiltrate. This is simple disconnection[11].

In order to see how much of an impact simple disconnection could make on runoff volumes in each priority subbasin, three scenarios were evaluated – 25% disconnection, 33% disconnection, and 50% disconnection. The Rutgers WRP decided to look at residential disconnections, since most homes have a downspout and lawn that would make this option feasible. Appendix C contains the residential breakdown per critical subbasin, categorized by high density or multiple dwelling, rural single unit, single unit low density, or single unit medium density.

Appendix D contains the results of the HydroCAD simulation for the three evaluated disconnection scenarios for the water quality, 1-year, 2-year, 10-year, and 100-year storm distribution. This was done in HydroCAD by taking the runoff generated from the impervious surfaces of the residential land use within each priority subbasin, dividing the generated runoff volume by the total pervious surfaces of the residential land use within each priority subabasin, converting to inches and calculating a new runoff depth, and re-running the model with the new depth over the pervious surface. Refer to Appendix A to see what curve numbers were used. Note that Back Creek was not included in the analysis because none of the critical subbasins within the watershed contain residential land use.

Results and Conclusions

Upon running the three scenarios for residential disconnection for 25%, 33%, and 50%, the Rutgers WRP compared the runoff values to the control runoff volumes originally generated from the model (Appendix B). Table 3 illustrates the percent change in disconnecting 25%, 33%, and 50% of impervious surfaces, respectively, for the water quality, 1-year, 2-year, 10-year, and 100-year storm distribution.

[11] RCE Water Resources Program, 2013

Table 3: Percent change for residential disconnections for the water quality, 1-year, 2-year, 10-year, and 100-year storm distributions.

Watershed	Subbasin	Percent Change for 25% Residential Disconnection (%)					Percent Change for 33% Residential Disconnection (%)					Percent Change for 50% Residential Disconnection (%)				
		Water Quality storm	1-year storm	2-year storm	10-year storm	100-year storm	Water Quality storm	1-year storm	2-year storm	10-year storm	100-year storm	Water Quality storm	1-year storm	2-year storm	10-year storm	100-year storm
Miry Run	W1140	24.9%	14.6%	12.4%	7.6%	3.7%	32.7%	18.9%	16.1%	9.7%	4.7%	48.7%	27.6%	23.2%	13.9%	6.7%
	W1070	25.0%	22.4%	20.5%	15.2%	9.2%	33.0%	28.8%	26.2%	19.2%	16.1%	55.9%	41.4%	37.4%	26.9%	15.8%
	W760	25.0%	19.2%	18.2%	10.4%	5.1%	33.0%	25.1%	23.1%	13.5%	6.6%	100.0%	37.3%	33.3%	14.2%	9.7%
Pond Run	W500	24.9%	13.7%	11.6%	6.8%	3.3%	32.7%	17.9%	15.1%	8.8%	4.2%	48.5%	26.1%	21.6%	12.5%	5.8%
	W590	22.0%	10.3%	8.4%	4.7%	2.2%	28.8%	13.4%	10.8%	6.1%	2.8%	42.6%	19.3%	15.7%	8.7%	3.8%
	W650	18.4%	6.7%	5.3%	2.7%	1.2%	23.7%	8.6%	6.8%	3.6%	1.5%	35.0%	12.4%	9.8%	5.1%	2.2%
	W670	21.1%	10.4%	8.4%	4.9%	2.3%	27.4%	13.2%	10.7%	6.2%	2.9%	40.2%	18.7%	15.4%	8.6%	3.9%
	W800	25.6%	14.4%	12.0%	7.2%	3.4%	33.3%	18.9%	15.9%	9.5%	4.6%	49.4%	27.6%	23.1%	13.6%	6.5%
Shady Brook	W1100	15.3%	5.7%	4.5%	2.5%	1.0%	20.1%	7.5%	5.8%	3.1%	1.3%	26.5%	8.7%	6.3%	2.6%	0.3%
	W1060	5.8%	1.6%	1.4%	0.7%	0.3%	7.5%	2.2%	1.6%	0.8%	0.3%	10.8%	2.6%	1.9%	0.7%	0.1%
	W1050	17.4%	6.5%	5.0%	2.7%	1.2%	23.3%	8.7%	6.7%	3.6%	1.6%	34.3%	12.4%	9.8%	5.2%	2.3%
	W740	11.2%	4.1%	3.2%	1.7%	0.7%	14.2%	5.1%	3.9%	2.0%	0.9%	19.7%	6.5%	4.9%	2.3%	0.7%
	W630	24.4%	13.1%	11.1%	6.6%	3.1%	31.9%	17.2%	14.3%	8.5%	4.0%	47.3%	24.9%	20.6%	11.8%	5.4%
	W570	8.7%	2.9%	2.2%	1.2%	0.4%	11.0%	3.7%	2.8%	1.4%	0.6%	15.8%	5.0%	3.8%	1.9%	0.8%
Doctors Creek	W680	14.7%	4.4%	3.2%	1.6%	0.7%	20.1%	5.5%	4.4%	2.2%	0.9%	29.8%	8.5%	6.3%	3.2%	1.3%
	W790	18.5%	5.1%	1.1%	1.7%	0.8%	24.8%	6.7%	2.6%	2.5%	0.9%	36.8%	9.5%	4.8%	3.1%	1.1%
	W690	16.1%	4.3%	3.2%	1.4%	0.7%	21.7%	5.8%	4.2%	2.0%	0.8%	31.9%	8.9%	6.2%	3.0%	1.2%

	W720	22.7%	10.5%	8.7%	4.8%	2.2%	29.6%	13.6%	11.0%	6.2%	2.8%	44.2%	20.2%	16.2%	8.9%	3.9%
	W540	13.3%	3.2%	2.7%	1.2%	0.5%	17.1%	4.3%	3.2%	1.6%	0.5%	24.2%	4.7%	3.4%	1.3%	0.0%
	W500	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	W580	9.7%	2.8%	2.3%	0.9%	0.3%	20.8%	5.9%	4.3%	2.4%	1.2%	29.2%	8.2%	5.8%	3.1%	1.5%

The findings conclude that simple disconnection drastically reduces runoff volumes for the smaller storms, i.e. the water quality, 1- year, and 2-year storm distribution. It is not effective for larger storms, particularly the 10-year and 100-year storms because there is too much runoff. Therefore more extensive green infrastructure practices must be put in place to mitigate flooding for those events.

Next Steps

Looking forward, plans should focus on visiting Hamilton Township to determine whether 25%, 33%, or 50% residential disconnection is feasible. Further investigation of BMP viability in these priority subbasins to reduce overall impervious cover should also occur in the upcoming months in order to achieve maximum volume reductions. While residential disconnections will help to address flooding issues, other methods should be considered as well, namely depavement, permeable pavement, simple disconnection, rain barrels, rain gardens, and green streets. While 10%, 20%, and 30% reductions in overall impervious cover may be difficult to achieve, if 1-2% overall reductions can be achieved, combined with 25%, 33%, or even 50% residential disconnections, runoff volume reductions can decrease drastically and these combined management measures can collaboratively combat and capture stormwater flow from the streets of Hamilton Township.

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APPENDIX A
CURVE NUMBERS

Watershed	Subbasin	Weighted Curve Number	Impervious Curve Number	Pervious Curve Number
Miry Run	W1140	68.5	98	59
	W1070	65.6	98	51
	W760	64.4	98	43
Pond Run	W500	78.2	98	60
	W590	79.6	98	66
	W650	82.9	98	72
	W670	79.2	98	67
	W800	76.4	98	59
Shady Brook	W1100	91.0	98	76
	W1060	91.5	98	87
	W1050	81.0	98	72
	W740	93.3	98	81
	W630	78.3	98	61
	W570	91.5	98	84
Doctors Creek	W680	75.4	98	73
	W790	70.3	98	72
	W690	73.1	98	72
	W720	71.8	98	65
	W540	75.0	98	74
	W500	73.9	98	66
	W580	73.2	98	72
Back Creek	W540	85.2	98	76
	W560	83.3	98	77
	W600	84.0	98	80
	W590	86.6	98	77
	W580	78.2	98	74
	W520	89.9	98	88
	W570	82.2	98	79
	W460	85.3	98	75

APPENDIX B

RUNOFF VOLUMES USING PERVIOUS CURVE NUMBER AND IMPERVIOUS CURVE NUMBER

Watershed	Subbasin	Area (acres)		Water Quality Runoff Volume (acre-ft)	1-year Runoff Volume (acre-ft)	2-year Runoff Volume (acre-ft)	10-year Runoff Volume (acre-ft)	100-year Runoff Volume (acre-ft)
		Pervious	Impervious					
Miry Run	W1140	141.3	47.0	3.009	8.301	10.355	18.152	35.442
	W1070	90.3	64.0	5.061	12.572	15.082	24.213	43.787
	W760	158.9	64.0	5.311	13.976	17.956	32.45	68.627
Pond Run	W500	83.7	76.7	2.888	8.318	10.503	18.935	37.928
	W590	304.1	225.2	8.553	26.628	33.717	60.499	119.046
	W650	88.8	66.6	1.577	5.454	6.979	12.681	24.942
	W670	168.1	104.6	6.066	17.538	21.791	37.398	70.469
	W800	139.1	115.3	2.923	8.336	10.532	19.051	38.388
Shady Brook	W1100	10.2	22.0	0.339	1.074	1.343	2.319	4.343
	W1060	24.7	17.0	1.488	4.504	5.546	9.183	16.421
	W1050	78.3	42.0	2.554	9.129	11.719	21.441	42.396
	W740	12.0	31.0	1.62	4.65	5.7	9.39	16.791
	W630	47.8	43.0	1.388	3.986	5.009	8.912	17.582
	W570	15.6	19.0	1.62	4.716	5.783	9.517	16.969
Doctors Creek	W680	393.7	43.0	2.592	11.687	15.458	29.892	61.542
	W790	239.8	19.0	0.476	2.553	3.41	7.317	16.121
	W690	170.7	11.0	0.911	4.716	6.372	12.859	27.427
	W720	360.2	94.0	6.746	21.584	27.572	50.522	101.505
	W540	363.8	24.0	0.24	1.31	1.769	3.548	7.495
	W500	425.6	138.0	0.000	0.000	0.000	0.000	0.000
	W580	187.2	7.0	0.072	0.392	0.531	1.07	2.276
Back Creek	W540	43.0	32.0	3.122	10.015	12.559	21.79	40.961
	W560	45.7	21.0	2.256	8.055	10.254	18.321	35.233
	W600	50.8	13.0	1.853	7.446	9.581	17.399	33.723
	W590	39.4	33.0	3.229	10.132	12.647	21.705	40.374
	W580	36.3	8.0	0.913	4.085	5.385	10.329	21.092
	W520	4.3	1.0	0.232	0.801	1.002	1.709	3.126
	W570	5.2	1.0	0.153	0.669	0.872	1.618	3.195
	W460	25.1	21.0	1.993	6.24	7.802	13.467	25.236

APPENDIX C

RESIDENTIAL LAND USE BREAKDOWN

Watershed	Subbasin	Residential, High Density or Multiple Dwelling (%)	Residential Rural, Single Unit (%)	Residential, Single Unit, Low Density (%)	Residential, Single Unit, Medium Density (%)
Miry Run	W1140	23.6%	2.6%	14.5%	0.0%
	W1070	58.2%	0.0%	0.0%	0.0%
	W760	77.5%	2.2%	5.7%	0.0%
Pond Run	W500	7.9%	0.8%	2.0%	42.7%
	W590	6.8%	0.4%	1.2%	38.5%
	W650	0.5%	0.0%	0.0%	31.8%
	W670	29.2%	0.0%	20.3%	0.0%
	W800	7.3%	0.0%	0.2%	27.1%
Shady Brook	W1100	23.7%	0.0%	0.0%	0.8%
	W1060	60.6%	0.0%	0.0%	4.0%
	W1050	16.3%	0.0%	1.2%	53.9%
	W740	64.7%	0.0%	0.0%	0.0%
	W630	23.1%	1.0%	0.0%	18.1%
	W570	80.4%	0.0%	0.0%	0.0%
Doctors Creek	W680	0.0%	12.2%	10.1%	7.9%
	W790	0.0%	9.1%	4.8%	1.2%
	W690	0.0%	21.9%	1.6%	6.3%
	W720	15.7%	16.1%	3.6%	13.3%
	W540	0.0%	2.6%	1.6%	0.0%
	W500	0.0%	0.0%	0.0%	0.0%
	W580	0.0%	2.6%	0.0%	0.0%
Back Creek	W540	0.0%	0.0%	0.0%	0.0%
	W560	0.0%	0.0%	0.0%	0.0%
	W600	0.0%	0.0%	0.0%	0.0%
	W590	0.0%	0.0%	0.0%	0.0%
	W580	0.0%	0.0%	0.0%	0.0%
	W520	0.0%	0.0%	0.0%	0.0%
	W570	0.0%	0.0%	0.0%	0.0%
	W460	0.0%	0.0%	0.0%	0.0%

APPENDIX D

RUNOFF VOLUMES FOR RESIDENTIAL DISCONNECTION

Watershed	Subbasin	Proposed 25% Residential Disconnection Runoff Volumes (acre-ft)					Proposed 33% Residential Disconnection Runoff Volumes (acre-ft)					Proposed 50% Residential Disconnection Runoff Volumes (acre-ft)				
		Water Quality storm	1-year storm	2-year storm	10-year storm	100-year storm	Water Quality storm	1-year storm	2-year storm	10-year storm	100-year storm	Water Quality storm	1-year storm	2-year storm	10-year storm	100-year storm
Miry Run	W1140	2.26	7.093	9.075	16.772	34.122	2.026	6.732	8.693	16.385	33.765	1.545	6.008	7.956	15.631	33.058
	W1070	3.796	9.757	11.994	20.535	39.762	3.391	8.952	11.129	19.558	36.742	2.23	7.369	9.438	17.692	36.88
	W760	3.983	11.292	14.691	29.091	65.133	3.558	10.467	13.806	28.063	64.096	0	8.759	11.97	27.856	61.945
Pond Run	W500	2.169	7.177	9.282	17.645	36.689	1.943	6.826	8.921	17.275	36.342	1.486	6.147	8.23	16.562	35.715
	W590	6.671	23.895	30.891	57.673	116.445	6.089	23.066	30.07	56.788	115.748	4.912	21.482	28.425	55.21	114.467
	W650	1.287	5.088	6.608	12.334	24.645	1.204	4.983	6.504	12.224	24.558	1.025	4.776	6.295	12.03	24.392
	W670	4.787	15.719	19.951	35.566	68.87	4.401	15.227	19.449	35.072	68.414	3.63	14.257	18.442	34.179	67.708
	W800	2.175	7.134	9.265	17.674	37.075	1.951	6.759	8.859	17.248	36.635	1.478	6.036	8.101	16.464	35.889
Shady Brook	W1100	0.287	1.013	1.283	2.262	4.298	0.271	0.993	1.265	2.248	4.286	0.249	0.981	1.259	2.259	4.332
	W1060	1.402	4.432	5.468	9.12	16.375	1.376	4.407	5.456	9.109	16.372	1.328	4.386	5.443	9.122	16.408
	W1050	2.11	8.535	11.131	20.872	41.902	1.958	8.336	10.935	20.67	41.717	1.677	7.993	10.567	20.328	41.43
	W740	1.438	4.461	5.52	9.235	16.676	1.39	4.415	5.478	9.201	16.647	1.301	4.348	5.421	9.171	16.671
	W630	1.05	3.462	4.451	8.325	17.033	0.945	3.301	4.294	8.154	16.871	0.732	2.994	3.976	7.862	16.63
	W570	1.479	4.579	5.653	9.407	16.894	1.441	4.543	5.621	9.384	16.873	1.364	4.479	5.562	9.332	16.836
Doctors Creek	W680	2.212	11.176	14.96	29.401	61.128	2.07	11.044	14.776	29.222	60.986	1.819	10.688	14.488	28.939	60.743
	W790	0.388	2.423	3.374	7.19	15.996	0.358	2.381	3.32	7.134	15.973	0.301	2.311	3.248	7.088	15.95
	W690	0.764	4.515	6.17	12.676	27.241	0.713	4.441	6.104	12.606	27.207	0.62	4.295	5.975	12.467	27.105
	W720	5.215	19.325	25.183	48.075	99.314	4.749	18.638	24.53	47.403	98.702	3.765	17.231	23.118	46.045	97.512

	W540	0.208	1.268	1.721	3.504	7.455	0.199	1.254	1.712	3.493	7.454	0.182	1.249	1.709	3.501	7.495
	W500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	W580	0.065	0.381	0.519	1.06	2.269	0.057	0.369	0.508	1.044	2.248	0.051	0.36	0.5	1.037	2.242