FINAL DRAFT

Watershed Restoration and Protection Plan (WRPP)

for the

South Branch Raritan River Watershed

Funding for this project was provided by:

New Jersey Highlands Council

GRANT ID# SNJ-Highlands Council - DR00025535

Developed by:

Rutgers Cooperative Extension Water Resources Program

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AUGUST 2025

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Introduction

The South Branch Raritan River is a significant tributary of the Raritan River, located in central New Jersey, USA. This river stretches approximately 35 miles and begins in Morris County and flows through Hunterdon and Somerset counties. Its headwaters begin in the mountainous terrain of the Highlands region and traverse a varied landscape, including agricultural fields, forests, and suburban areas, before joining the mainstem Raritan River near the town of Bound Brook. This plan will focus on the South Branch Raritan River upstream of Route 78 in the Highlands Region of New Jersey. The study area includes seven HUC14s and portions of 11 municipalities (see Figures 1 and 2).

Historically, the South Branch Raritan River has played an important role in the region's development, serving as a water source for early settlements and a means for transportation and milling. The river's watershed is rich in natural resources and supports diverse ecosystems, making it a vital habitat for various species of fish, amphibians, and birds.

Today, the South Branch is valued for its recreational opportunities, including fishing, kayaking, and hiking along its banks. Conservation efforts are ongoing to maintain and restore water quality and natural habitats, particularly as urbanization and agricultural practices have affected watershed health. The river is also monitored by organizations focused on environmental protection and community engagement to ensure sustainable use and enjoyment for future generations.

Overall, the South Branch Raritan River is not only an important ecological asset but also a cherished recreational area that contributes to the quality of life for residents in the surrounding communities.

HUC14s

- 02030105010010 - Drakes Brook (above Eyland Ave)
- 02030105010020 - Drakes Brook (below Eyland Ave)
- 02030105010040 - Raritan River SB (74d 44m 15s to Rt 46)
- 02030105010050 - Raritan R SB (LongValley br to 74d44m15s)
- 02030105010060 - Raritan R SB (Califon br to Long Valley)
- 02030105010070 - Raritan R SB (StoneMill gage to Califon)
- 02030105010080 - Raritan R SB (Spruce Run-StoneMill gage)

Municipalities

- Califon Borough, Hunterdon County
- Chester Township, Morris County
- Clinton Town, Hunterdon County
- Clinton Township, Hunterdon County
- High Bridge Borough, Hunterdon County
- Lebanon Township, Hunterdon County
- Mount Arlington Borough, Morris County
- Mount Olive Township, Morris County
- Roxbury Township, Morris County
- Tewksbury Township, Hunterdon County
- Washington Township, Morris County

A total maximum daily load (TMDL) was completed for the South Branch Raritan River. The TMDL requires total phosphorus and total suspended solids load reductions ranging from 60% to 84% for urban land uses and agricultural land uses[1]. A TMDL was also completed for fecal coliform requiring reductions of 94% from urban and agricultural land uses.[2] This watershed restoration and protection plan (WRPP) will identify opportunities to reduce pollutant loads to achieve water quality criteria. The plan follows the US Environmental Protection Agency (USEPA) criteria and contains the nine components of a watershed restoration and protection plan.

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[1] Keinfelder-Omni Environmental, 2013. Appendices (K – T), Phase II Final Report, Raritan River Basin Nutrient TMDL Study Watershed Model and TMDL Calculations, Volume 3 of 3.

[2] NJDEP, 2003. Total Maximum Daily Loads for Fecal Coliform to Address 48 Streams in the Raritan River Watershed.

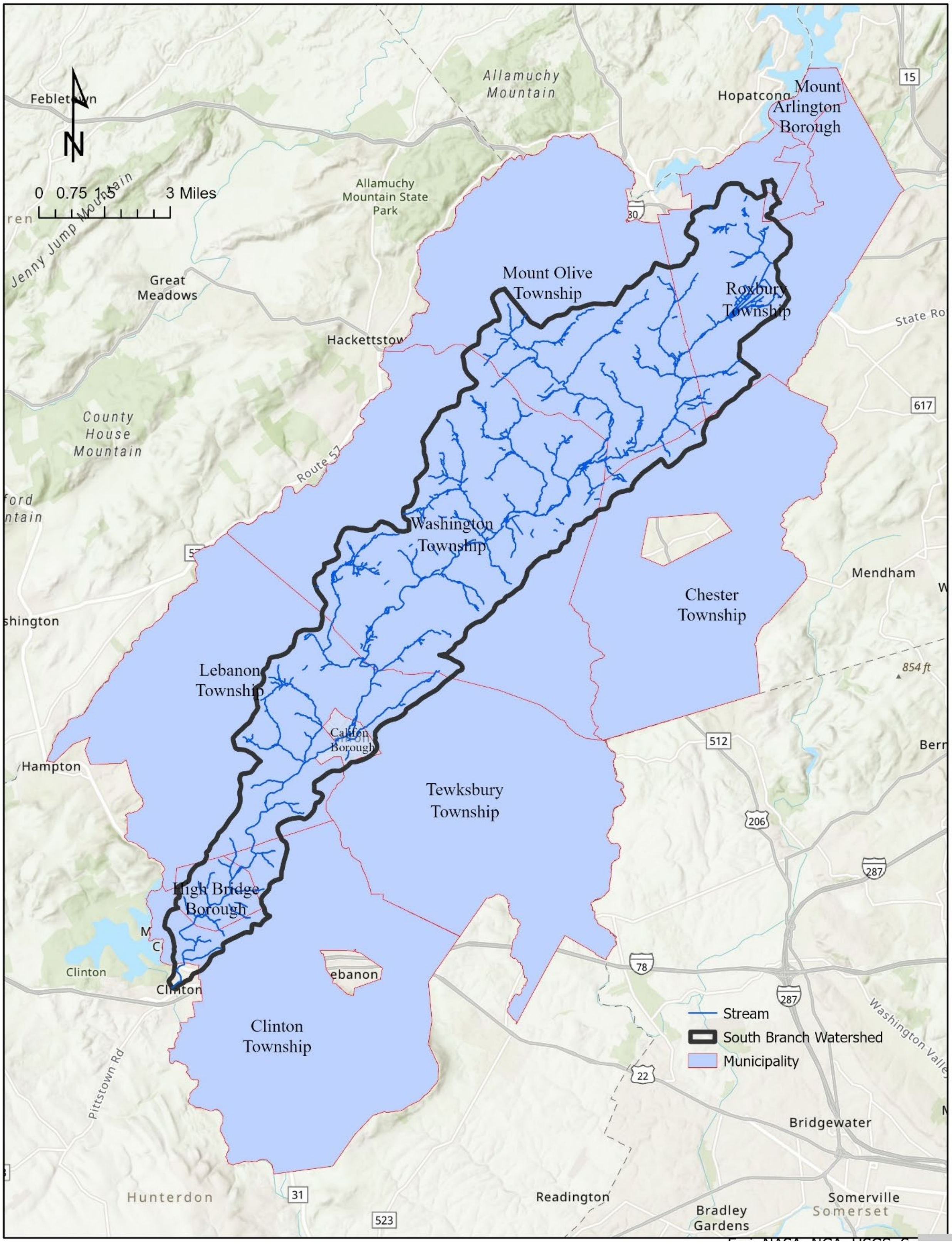

Figure 1: South Branch Raritan River Watershed study area with associated municipalities

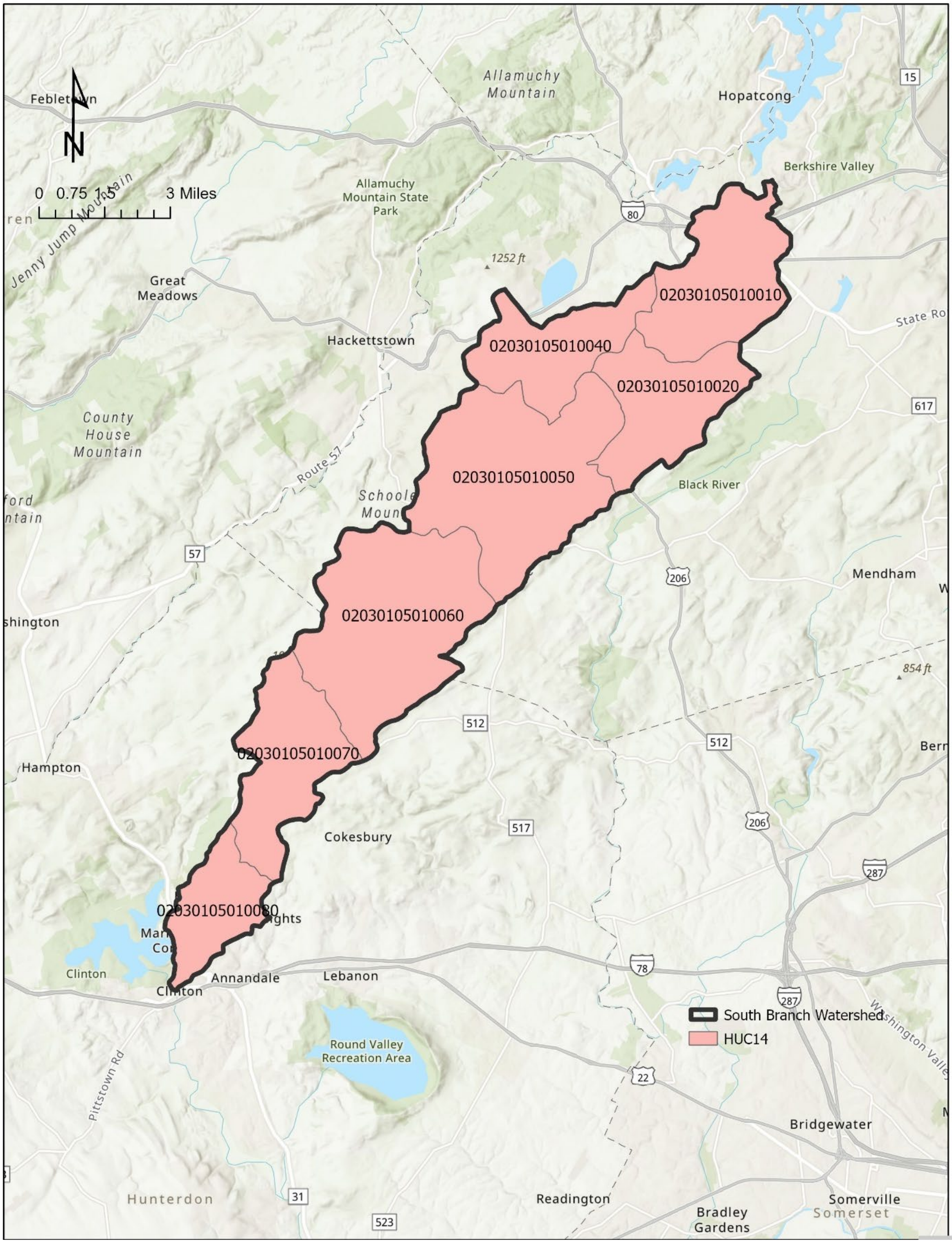

Figure 2: Seven HUC14s in the South Branch Raritan River Watershed study area

Criteria #1: Identification of the causes and sources of nutrient loading to the watershed

A land use analysis was completed for each HUC14 for each watershed. Figures 3 and 4 show the land use distribution for the entire study area based upon the NJDEP 2020 land use/land cover layer. The land use distribution for each HUC14 in acres is summarized in Table 1 and Figure 5. Table 2 provides land use percentages.

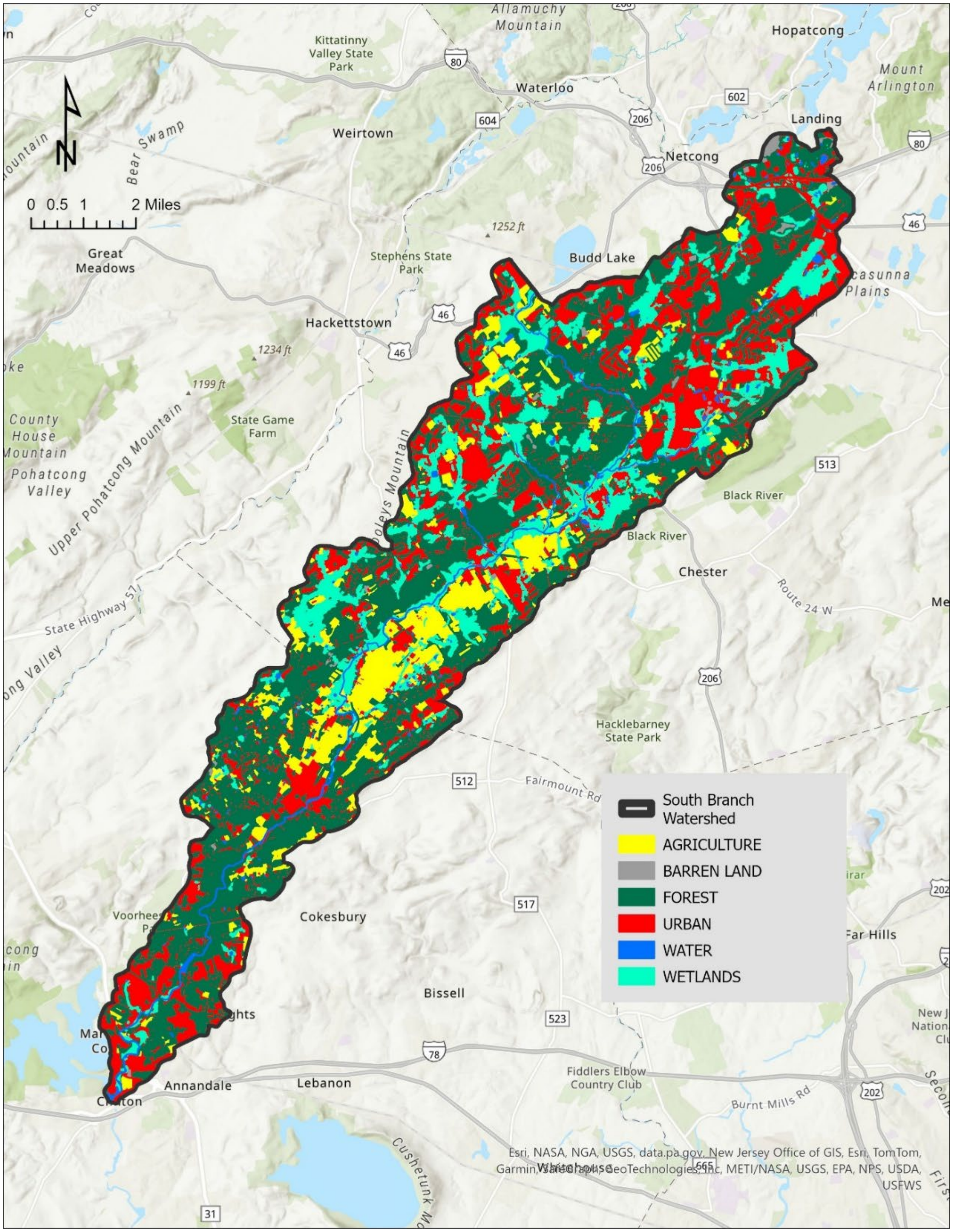

Figure 3: Land use/cover distribution in the South Branch Raritan River Watershed study area

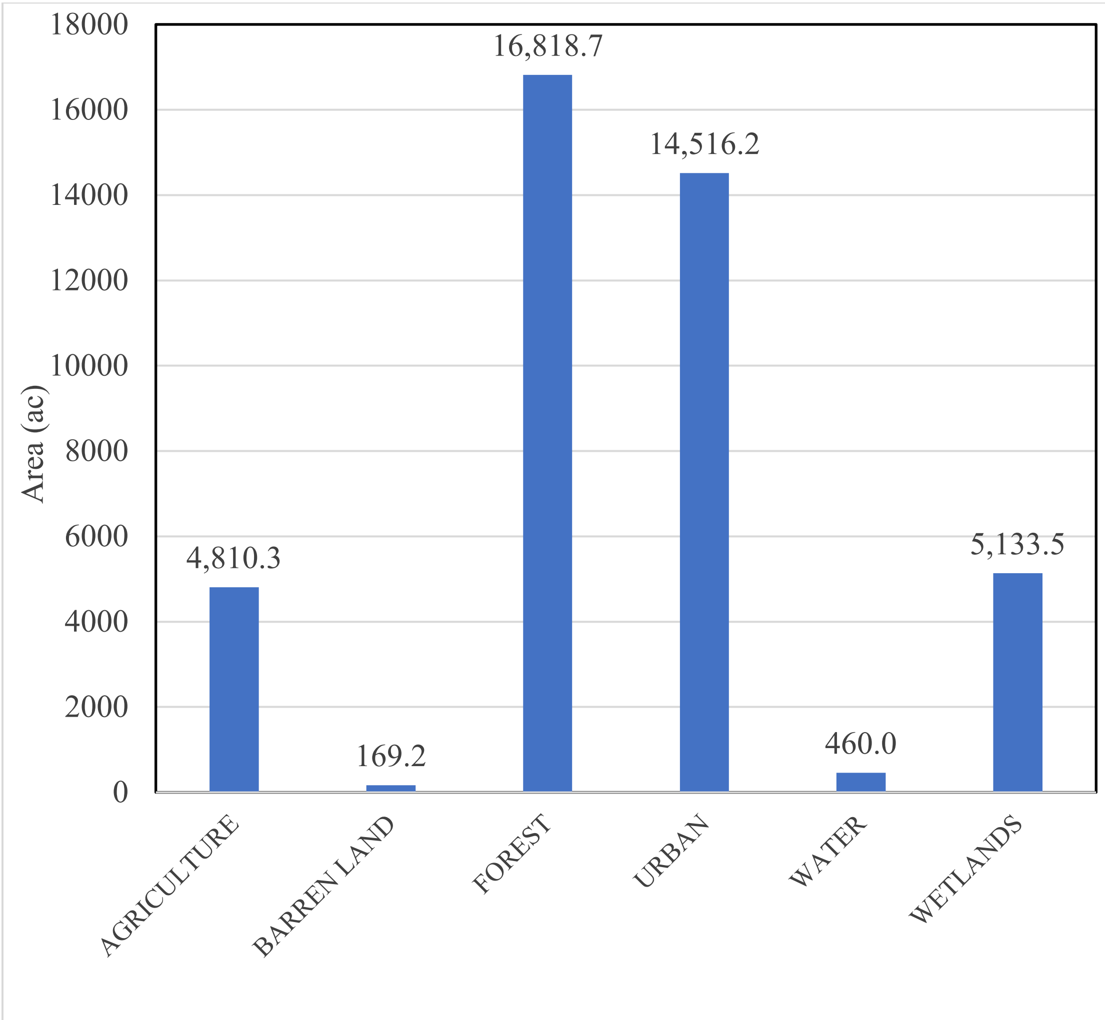

Figure 4: Land use/cover in the South Branch Raritan River Watershed study area

Table 1: Land use distribution for each HUC14 in acres for the South Branch Raritan River Watershed study area

Land Use	Area (acres)		
	HUC14		
	02030105010010	02030105010020	02030105010040
AGRICULTURE	104.3	276.3	502.3
BARREN LAND	98.6	17.9	13.7
FOREST	2,313.6	1,333.7	1,668.9
URBAN	2,455.3	2,294.2	1,356.4
WATER	51.2	49.2	41.3
WETLANDS	627.0	714.0	682.2
Total:	5,650.0	4,685.3	4,264.7

Land Use	Area (acres)		
	HUC14		
	02030105010050	02030105010060	02030105010070
AGRICULTURE	1,027.5	2,325.3	471.8
BARREN LAND	10.7	15.1	8.9
FOREST	3,588.5	3,759.1	2,949.9
URBAN	3,369.9	2,095.0	1,486.6
WATER	98.9	93.4	59.4
WETLANDS	1,670.7	1,242.7	73.8
Total:	9,766.1	9,530.6	5,050.4

Land Use	Area (acres)
	HUC14
	02030105010080
AGRICULTURE	102.8
BARREN LAND	4.4
FOREST	1,204.8
URBAN	1,459.0
WATER	66.8
WETLANDS	123.4
Total:	2,961.3

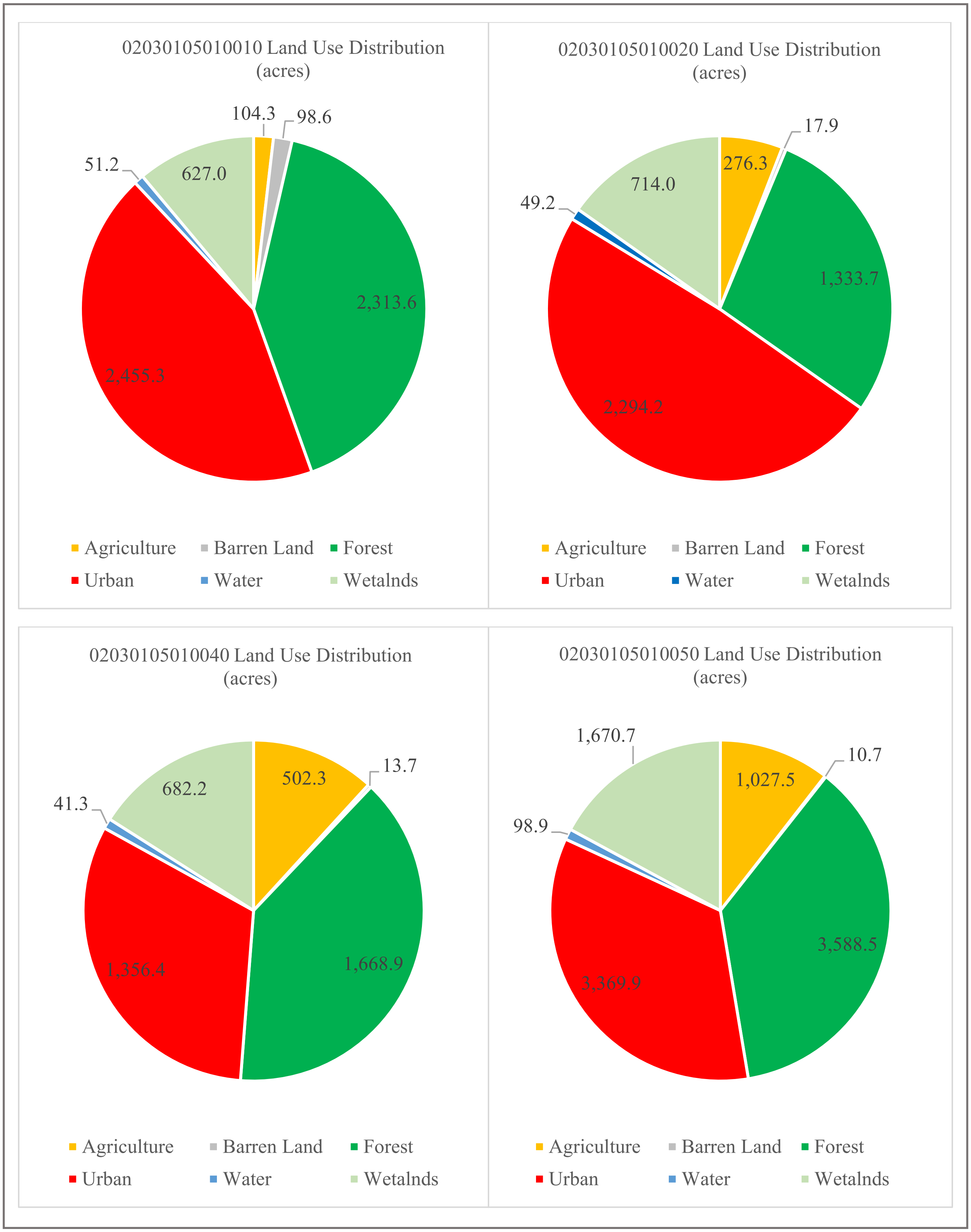

Figure 5a: Land use distribution for each HUC14 (02030105010010, 20, 40, 50) in the South Branch Raritan River Watershed study area

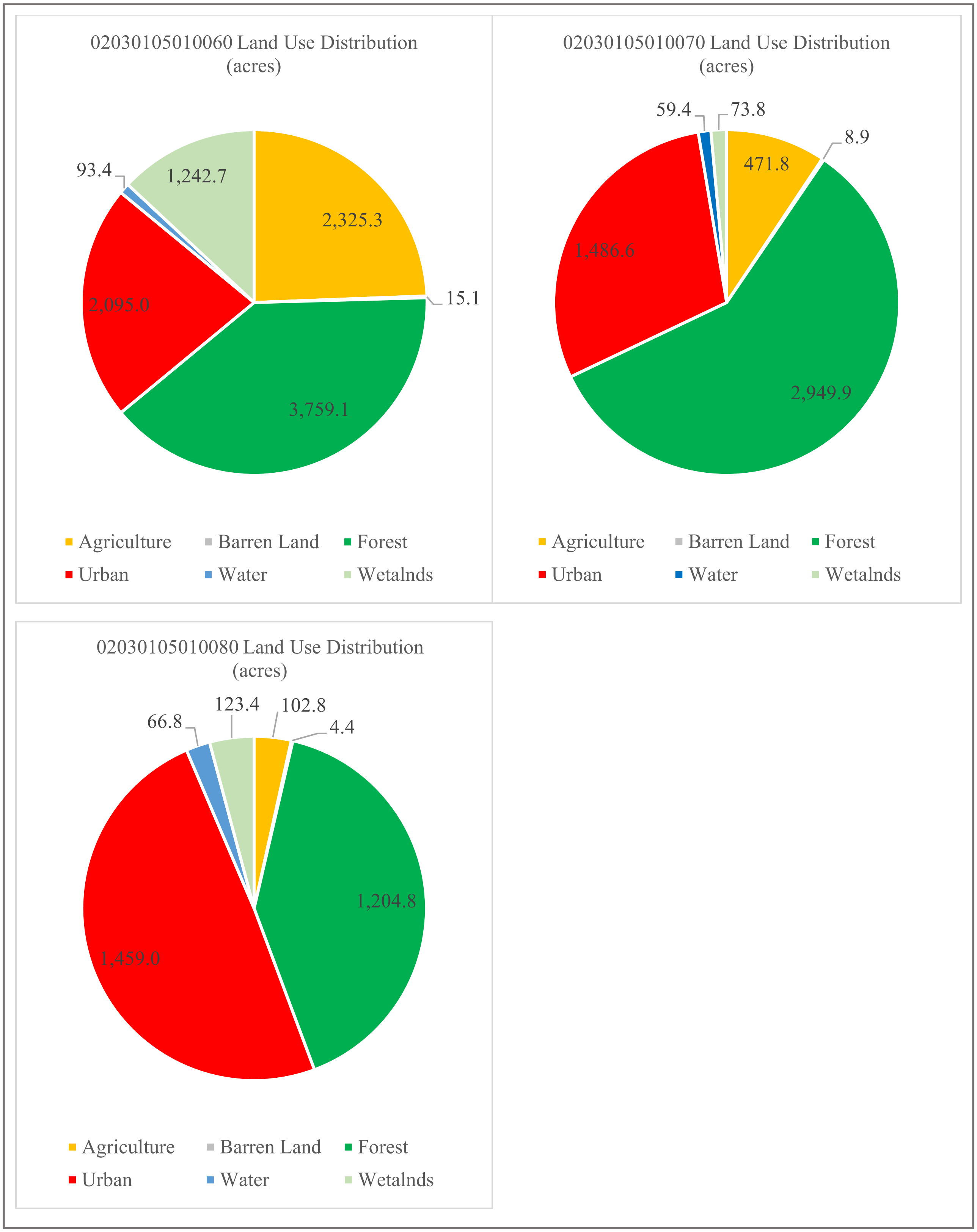

Figure 6b: Land use distribution for each HUC14 (02030105010060, 70, 80) in the South Branch Raritan River Watershed study area

Table 2: Land use percentages for each HUC14 for the South Branch Raritan River Watershed study area

Land Use	**Area (acres)**		
	HUC14		
	02030105010010	02030105010020	02030105010040
AGRICULTURE	1.8%	5.9%	11.8%
BARREN LAND	1.7%	0.4%	0.3%
FOREST	40.9%	28.5%	39.1%
URBAN	43.5%	49.0%	31.8%
WATER	0.9%	1.1%	1.0%
WETLANDS	11.1%	15.2%	16.0%
Total:	100.0%	100.0%	100.0%

Land Use	**Area (acres)**		
	HUC14		
	02030105010050	02030105010060	02030105010070
AGRICULTURE	10.5%	24.4%	9.3%
BARREN LAND	0.1%	0.2%	0.2%
FOREST	36.7%	39.4%	58.4%
URBAN	34.5%	22.0%	29.4%
WATER	1.0%	1.0%	1.2%
WETLANDS	17.1%	13.0%	1.5%
Total:	100.0%	100.0%	100.0%

Land Use	**Area (acres)**
	HUC14
	02030105010080
AGRICULTURE	3.5%
BARREN LAND	0.1%
FOREST	40.7%
URBAN	49.3%
WATER	2.3%
WETLANDS	4.2%
Total:	100.0%

Nonpoint Source Loading Analysis

The causes and sources of nutrient and pollutant loading to the South Branch have been identified. Pollutant loading from the land use within these watersheds was calculated. Nonpoint source pollutant loading coefficients were assigned to each land use. Table 3 was taken from Chapter 3 (*Page 3-11*) of the NJDEP Stormwater Best Management Practices Manual (February 2004)[3]. These pollutant loading coefficients were assigned to the unique land uses contained within the study area (See Table 4). The values in Table 4 were then used to calculate pollutant loads for each HUC14 for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS). These pollutant loads for the entire study area are shown in Table 5. Tables 6 through 12 provide the pollutant loads for each HUC14.

Table 3: Pollutant loads by land cover in pounds per acre per year (lbs/ac/yr)

Land Cover	Total Phosphorus (TP) load (lbs/acre/yr)	Total Nitrogen (TN) load (lbs/acre/yr)	Total Suspended Solids (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	1.0	10	120
Agriculture	1.3	10	300
Forest, Water, Wetlands	0.1	3	40
Barrenland/ Transitional Area	0.5	5	60

[3] https://www.njstormwater.org/bmp_manual2.htm

Table 4: Pollutant loads for each land use in the study area in lbs/ac/yr

Land Use Code	Land Use Label	Land Use Type	TP	TN	TSS
1110	Residential, High Density or Multiple Dwelling	Urban	1.4	15	140
1120	Residential, Single Unit, Medium Density	Urban	1.4	15	140
1130	Residential, Single Unit, Low Density	Urban	0.6	5	100
1140	Residential, Rural, Single Unit	Urban	0.6	5	100
1150	Mixed Residential	Urban	1.4	15	140
1200	Commercial/Services	Urban	2.1	22	200
1211	Military Installations	Urban	2.1	22	200
1214	No Long Military	Urban	2.1	22	200
1300	Industrial	Urban	1.5	16	200
1400	Transportation/Communication/Utilities	Urban	1.5	16	200
1410	Major Roadway	Urban	1.5	16	200
1411	Mixed Transportation Corridor Overlap Area	Urban	1.5	16	200
1419	Bridge Over Water	Water	0.1	3	40
1420	Railroads	Urban	1.5	16	200
1440	Airport Facilities	Urban	1.5	16	200
1461	Wetland Rights-Of-Way	Wetlands	0.1	3	40
1462	Upland Rights-Of-Way Developed	Urban	1	10	120
1463	Upland Rights-Of-Way Undeveloped	Urban	1	10	120
1499	Stormwater Basin	Urban	0.6	5	100
1500	Industrial And Commercial Complexes	Urban	2.1	22	200
1600	Mixed Urban or Built-Up Land	Urban	1	10	120
1700	Other Urban or Built-Up Land	Urban	1	10	120
1710	Cemetery	Urban	1	10	120
1711	Cemetery On Wetlands	Urban	1	10	120
1741	Phragmites Dominate Urban Area	Wetlands	0.1	3	40
1750	Managed Wetland In Maintained Lawn Greenspace	Wetlands	0.1	3	40
1800	Recreational Land	Urban	1	10	120
1804	Athletic Fields (Schools)	Urban	0.6	5	100
1850	Managed Wetland in Built-Up Maintained Rec Area	Wetlands	0.1	3	40
2100	Cropland And Pastureland	Agriculture	1.3	10	300
2140	Agricultural Wetlands (Modified)	Wetlands	0.1	3	40
2150	Former Ag. Wetland (Becoming Shrubby, Not Built-Up)	Wetlands	0.1	3	40
2200	Orchards/Vineyards/Nurseries/Horticultural Areas	Agriculture	1.3	10	300
2300	Confined Feeding Operations	Agriculture	1.3	10	300
2400	Other Agriculture	Agriculture	1.3	10	300
4110	Deciduous Forest (10-50% Crown Closure)	Forest	0.1	3	40
4120	Deciduous Forest (>50% Crown Closure)	Forest	0.1	3	40
4210	Coniferous Forest (10-50% Crown Closure)	Forest	0.1	3	40
4220	Coniferous Forest (>50% Crown Closure)	Forest	0.1	3	40
4230	Plantation	Forest	0.1	3	40
4311	Mixed Forest (>50% Coniferous w/ 10-50% Crown Closure)	Forest	0.1	3	40

4312	Mixed Forest (>50% Coniferous w/ >50% Crown Closure)	Forest	0.1	3	40
4321	Mixed Forest (>50% Deciduous w/ 10-50% Crown Closure)	Forest	0.1	3	40
4322	Mixed Forest (>50% Deciduous w/ >50% Crown Closure)	Forest	0.1	3	40
4410	Old Field (< 25% Brush Covered)	Forest	0.1	3	40
4411	Phragmites Dominate Old Field	Forest	0.1	3	40
4420	Deciduous Brush/Shrubland	Forest	0.1	3	40
4430	Coniferous Brush/Shrubland	Forest	0.1	3	40
4440	Mixed Deciduous/Coniferous Brush/Shrubland	Forest	0.1	3	40
5100	Streams And Canals	Water	0.1	3	40
5190	Exposed Flats	Water	0.1	3	40
5200	Natural Lakes	Water	0.1	3	40
5300	Artificial Lakes	Water	0.1	3	40
5410	Tidal Rivers, Inland Bays, and Other Tidal Waters	Water	0.1	3	40
5412	Tidal Mud Flat	Water	0.1	3	40
6120	Freshwater Tidal Marshes	Wetlands	0.1	3	40
6141	Phragmites Dominate Coastal Wetlands	Wetlands	0.1	3	40
6210	Deciduous Wooded Wetlands	Wetlands	0.1	3	40
6220	Coniferous Wooded Wetlands	Wetlands	0.1	3	40
6221	Atlantic White Cedar Wetlands	Wetlands	0.1	3	40
6231	Deciduous Scrub/Shrub Wetlands	Wetlands	0.1	3	40
6232	Coniferous Wooded Wetlands	Wetlands	0.1	3	40
6233	Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	Wetlands	0.1	3	40
6234	Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	Wetlands	0.1	3	40
6240	Herbaceous Wetlands	Wetlands	0.1	3	40
6241	Phragmites Dominate Interior Wetlands	Wetlands	0.1	3	40
6251	Mixed Wooded Wetlands (Decideous Dom.)	Wetlands	0.1	3	40
6252	Mixed Wooded Wetlands (Coniferous Dom.)	Wetlands	0.1	3	40
7100	Beaches	Barren Land	0.5	5	60
7200	Bare Exposed Rock, Rockslides, Etc	Barren Land	0.5	5	60
7300	Extractive Mining	Barren Land	0.5	5	60
7400	Altered Lands	Barren Land	0.5	5	60
7430	Disturbed Wetlands (Modified)	Wetlands	0.1	3	40
7440	Disturbed Tidal Wetlands	Wetlands	0.1	3	40
7500	Transitional Areas	Barren Land	0.5	5	60
7600	Undifferentiated Barren Lands	Barren Land	0.5	5	60

Table 5: South Branch Raritan River Watershed pollutant load for entire study area (lbs/yr)

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	4,810	6,253	48,102	1,443,063
Barren Land	169	84	846	10,148
Forest	16,819	1,682	50,455	672,736
Urban	14,516	12,633	120,382	1,651,538
Water	460	46	1,381	18,409
Wetlands	5,134	500	14,932	198,711
Totals =	41,908	21,199	236,098	3,994,605

Table 6: Pollutant loads for HUC 02030105010010

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	104.3	135.6	1,043.0	31,289.2
Barren Land	98.6	49.3	492.8	5,913.4
Forest	2,313.6	231.4	6,940.8	92,543.9
Urban	2,455.3	2,543.2	25,232.8	304,751.3
Water	51.2	5.1	153.6	2,048.4
Wetlands	627.0	61.7	1,850.5	24,674.0
Totals =	5,650.0	3,026.2	35,713.5	461,220.1

Table 7: Pollutant loads for HUC 02030105010020

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	276.3	359.2	2,763.3	82,898.6
Barren Land	17.9	8.9	89.5	1,073.6
Forest	1,333.7	133.4	4,001.0	53,346.5
Urban	2,294.2	2,382.7	23,775.8	283,828.6
Water	49.2	4.9	147.6	1,968.1
Wetlands	714.0	65.6	1,969.1	26,255.0
Totals =	4,685.3	2,954.8	32,746.3	449,370.4

Table 8: Pollutant loads for HUC 02030105010040

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	502.3	653.0	5,022.8	150,683.6
Barren Land	13.7	6.8	68.4	820.7
Forest	1,668.9	166.9	5,006.5	66,753.5
Urban	1,356.4	1,199.3	11,509.0	153,725.4
Water	41.3	4.1	123.8	1,650.8
Wetlands	682.2	68.1	2,010.7	26,663.4
Totals =	4,264.7	2,098.2	23,741.2	400,297.4

Table 9: Pollutant loads for HUC 02030105010050

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	1,027.5	1,335.7	10,274.5	308,235.7
Barren Land	10.7	5.3	53.4	640.2
Forest	3,588.5	358.8	10,765.5	143,539.6
Urban	3,369.9	2,471.3	22,336.2	351,385.7
Water	98.9	9.9	296.7	3,955.5
Wetlands	1,670.7	163.1	4,843.1	64,340.7
Totals =	9,766.1	4,344.2	48,569.3	872,097.4

Table 10: Pollutant loads for HUC 02030105010060

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	2,325.3	3,022.8	23,252.7	697,580.7
Barren Land	15.1	7.5	75.3	903.2
Forest	3,759.1	375.9	11,277.3	150,364.2
Urban	2,095.0	1,468.1	13,015.7	222,618.5
Water	93.4	9.3	280.3	3,737.7
Wetlands	1,242.7	123.9	3,718.2	49,575.9
Totals =	9,530.6	5,007.7	51,619.5	1,124,780.2

Table 11: Pollutant loads for HUC 02030105010070

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	471.8	613.4	4,718.3	141,549.3
Barren Land	8.9	4.4	44.3	531.7
Forest	2,949.9	295.0	8,849.6	117,994.6
Urban	1,486.6	1,062.2	9,530.8	155,177.6
Water	59.4	5.9	178.2	2,375.8
Wetlands	73.8	7.2	216.1	2,881.0
Totals =	5,050.4	1,988.1	23,537.3	420,510.1

Table 12: Pollutant loads for HUC 02030105010080

General Land Use Category	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	102.8	133.6	1,027.5	30,825.7
Barren Land	4.4	2.2	22.1	265.6
Forest	1,204.8	120.5	3,614.5	48,193.2
Urban	1,459.0	1,506.4	14,981.9	180,050.9
Water	66.8	6.7	200.4	2,672.5
Wetlands	123.4	10.8	324.1	4,321.2
Totals =	2,961.3	1,780.2	20,170.6	266,329.1

Stormwater Runoff Analysis

Stormwater runoff is often associated with impervious surfaces like roadways, rooftops, and parking lots. As we cover our landscape with these surfaces, the volume of stormwater runoff increases, creating potentially dangerous flooding conditions. In New Jersey when calculating and managing stormwater runoff, four design storms are typically considered. The first storm is the water quality storm, which is 1.25 inches of rain over two hours. In New Jersey, 90% of our rainfall events come in storms that deposit less than 1.25 inches of rain. Typically, attempts are made to manage the water quality storm to improve water quality by capturing, treating, and infiltrating the stormwater runoff volume from this storm. The remaining three storms (2-year, 10-year, and 100-year storms) are typically managed to reduce peak flow. When land is being developed, a pre-development peak flow is calculated for each of these storms, and a stormwater management system must be installed to reduce the post-development peak flow to be less than the pre-development peak flow. As storms increase in size, stormwater runs off all land cover, not just the impervious surfaces. As the pervious surfaces become saturated, they begin to behave like impervious surfaces because additional stormwater cannot infiltrate so it runs off the land. The year associated with the storm indicates the reoccurrence frequency of the storm. For example, the chance of getting the 100-year storm this year is one in 100 or 1%. The chance of getting the

10-year storm is one in 10 or 10%. The chance of getting the 2-year storm is one in two or 50%. Since these storms are producing large volumes of water that is draining into small streams, the stream velocities increase dramatically, thereby causing erosion and downcutting of the stream. The large volumes of water also cause the stream to exceed its banks, thereby causing flooding.

NJDEP released new stormwater regulations in July 2023. These regulations provide new design storm rainfall totals for 2020 (existing conditions) and 2100 (climate change conditions). The U.S. Soil Conservation Service's watershed hydrology model Technical Release 55 (TR-55) was used to calculate runoff volumes for each of the HUC14s for the New Jersey water quality storm, 2-year design storm, 10-year design storm, and 100-year design storm for the 2020 and 2100 design storm totals. TR-55 presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds, especially urbanizing watersheds, in the United States. First issued by the Soil Conservation Service (SCS) in January 1975, TR-55 incorporates current SCS procedures. The first step in this process is to assign a curve number (CN) to each land use classification based upon soil type. These are presented in Appendix A. Table 13 presents the rainfall totals for each design storm. Table 14 presents stormwater runoff volumes for the 2020 design storm totals, and Table 15 shows the stormwater runoff volumes for the 2100 design storm totals. Please note that only the New Jersey water quality storm rainfall total remains the same for 2020 and 2100. Table 16 compares the 2020 to the 2100 total runoff volumes for the entire South Branch Watershed study area. The units in Tables 14, 15 and 16 are standard developer/engineering units for volume, acre-ft. These can be interpreted in two ways. For example, if the volume is 4 acre-ft, this would be equivalent to a basin one acre in size that is four feet deep or a basin that is four acres in size that is one foot deep. These units tend to give the reader an easier way to visualize the amount of stormwater than the units of gallons or cubic feet.

Table 13: Rainfall totals for existing and future design storms

Design Storm	Existing Rainfall Totals (2020) (inches)	Future Rainfall Totals (2100) (inches)
Water Quality Storm	1.25	1.25
2-Year Storm	3.58	4.35
10-Year Storm	5.40	6.71
100-Year Storm	8.85	12.19

Table 14: Stormwater runoff volume (acre-feet) for each HUC14 of the South Branch Raritan River Watershed study area for the 2020 design storms

Design Storm (2020)	HUC 02030105010010	HUC 02030105010020	HUC 02030105010040
Water Quality Storm (1.25″)	65	63	46
2-Year Storm (3.58″)	531	558	451
10-Year Storm (5.40″)	1,086	1,092	911
100-Year Storm (8.85″)	2,325	2,232	1,920

Design Storm (2020)	HUC 02030105010050	HUC 02030105010060	HUC 02030105010070
Water Quality Storm (1.25 ″)	86	72	23
2-Year Storm (3.58″)	978	881	340
10-Year Storm (5.40″)	2,018	1,860	789
100-Year Storm (8.85″)	4,310	4,053	1,857

Design Storm (2020)	HUC 02030105010080
Water Quality Storm (1.25 ″)	27
2-Year Storm (3.58″)	267
10-Year Storm (5.40″)	559
100-Year Storm (8.85″)	1,220

Table 15: Stormwater runoff volume (acre-feet) for each HUC14 of the South Branch Raritan River Watershed study area for the 2100 design storms

Design Storm (2100)	HUC 02030105010010	HUC 02030105010020	HUC 02030105010040
Water Quality Storm (1.25″)	65	63	46
2-Year Storm (4.35″)	753	775	636
10-Year Storm (6.71″)	1,536	1,511	1,280
100-Year Storm (12.19″)	3,640	3,409	2,976

Design Storm (2100)	HUC 02030105010050	HUC 02030105010060	HUC 02030105010070
Water Quality Storm (1.25″)	86	72	23
2-Year Storm (4.35″)	1,396	1,273	516
10-Year Storm (6.71″)	2,853	2,656	1,170
100-Year Storm (12.19″)	6,717	6,377	3,027

Design Storm (2100)	HUC 02030105010080
Water Quality Storm (1.25″)	27
2-Year Storm (4.35″)	383
10-Year Storm (6.71″)	799
100-Year Storm (12.19″)	1,925

Table 16: Total stormwater runoff volume (acre-feet) for the entire South Branch Raritan River Watershed study area for the 2020 and 2100 design storms

Design Storm	2020	2100
Water Quality Storm	382	382
2-Year Storm	4006	5732
10-Year Storm	8315	11805
100-Year Storm	17,917	28,071

Impervious Surface Analysis

The literature suggests a link between impervious cover and stream ecosystem impairment (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. Schueler (1994, 2004) developed an impervious cover model (See Figure 6) that classified "sensitive steams" as those that 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.

Schueler et al. (2009) reformulated the impervious cover model based upon new research that had been conducted. This new analysis determined that stream degradation was first detected at 2 to 15% impervious cover. The updated impervious cover model recognizes the wide variability of stream degradation at impervious cover below 10%. The updated model also moves away from having a fixed line between stream quality classifications (See Figure 7). For example, 5 to 10% impervious cover for the transition from sensitive to impacted, 20 to 25% impervious cover for the transition between impacted and non-supporting, and 60 to 70% impervious cover for the transition from non-supporting to urban drainage.

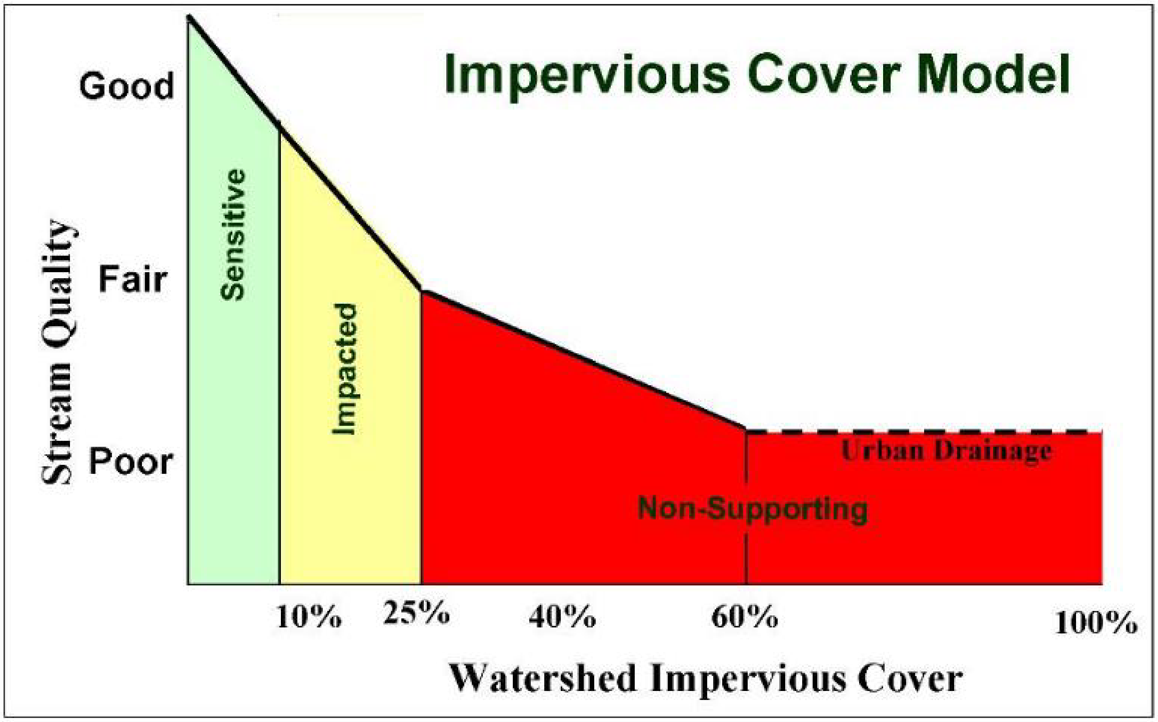

Figure 7: Impervious cover model (Schueler et al., 1994)

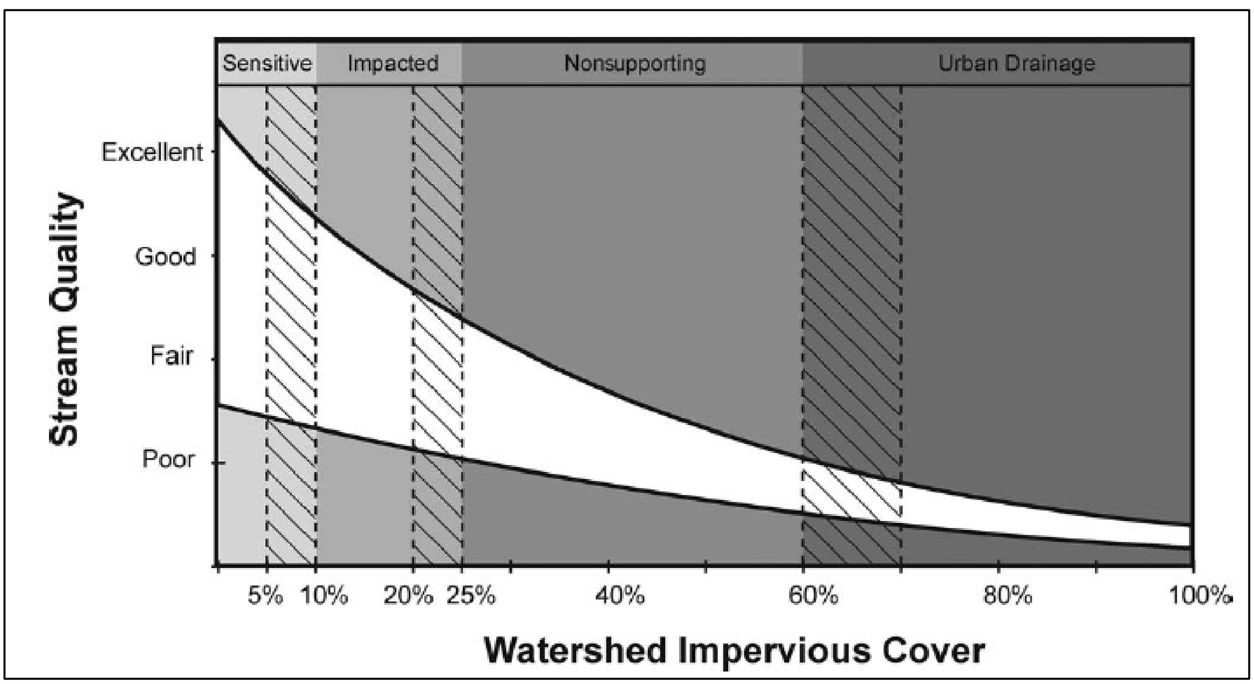

Figure 8: Reformulated impervious cover model (Schueler et al., 2009)

NJDEP developed a very detailed impervious cover geographic information system (GIS) data layer for the 2015 land use/land cover conditions. The 2015 data is the latest available impervious cover layer. The 2020 land use/land cover layer does not include impervious cover like previous dataset from NJDEP. Table 17 illustrates the impervious cover broken down by three classes: *buildings*, *roads*, and *other* based upon these data for each HUC14 in the South Branch Raritan River Watershed study area. Table 18 provides the percentage impervious cover by HUC14. Other impervious cover is any impervious surface that is not a road or building such as driveways, sidewalks, parking lots, and basketball courts. HUC 02030105010010, HUC 02030105010020, HUC 02030105010080, HUC 02030105010040 have an impervious cover percentage greater than 10%, which would suggest that the waterways in these HUC14s are "impacted" as discussed above. The remaining HUC14s have an impervious cover percentage of less than 10%, which means the waterways in this HUC are transitioning from "sensitive" to "impacted." The overall impervious cover for the South Branch Raritan River Watershed study area is 8.7%, which is also transitioning from "sensitive" to "impacted."

Table 17: Impervious cover in each HUC14 for the South Branch Raritan River Watershed study area in acres

HUC14	Impervious Cover (acres)			
	Buildings	Other	Road	Total
02030105010010	214.4	463.7	347	1025.1
02030105010020	196.1	400.5	210.6	807.2
02030105010040	94.8	229.6	136.2	460.5
02030105010050	169.3	397	301.1	867.4
02030105010060	105.19	299.3	177.4	581.9
02030105010070	68.2	175.7	140.4	384.4
02030105010080	97.6	225.3	176.6	499.5
TOTALS =	799.7	1,713.1	1,116.1	3,629

Table 18: Impervious cover by percentage for each HUC14

HUC14	Total Impervious Cover (ac)	Total HUC14 Area (ac)	Impervious Cover (%)
02030105010010	1025.1	5,650.0	18.1%
02030105010020	807.2	4,685.3	17.2%
02030105010040	460.5	4,264.7	10.8%
02030105010050	867.4	9,766.1	8.9%
02030105010060	581.9	9,530.6	6.1%
02030105010070	384.4	5,050.4	7.6%
02030105010080	499.5	2,961.3	16.9%
Totals =	3,629	41,908.4	8.7%

Septic System Analysis

Septic systems are another source of total phosphorus loading to the South Branch Raritan River. There are circumstances where phosphorus from septic systems can contribute to the pollution of lakes or streams. Some of the factors that contribute to problem sites include (National Environmental Services Center, 2013):

- Calcareous soils (i.e., soils that contain calcium carbonate)
- Coarse-grained soils such as sandy and gravelly soils that allow rapid flow rates
- Households that generate more wastewater than their septic systems were designed to handle
- Drainfields with thin soils, shallow bedrock, or high water tables
- Systems with drainfields close to lakes or streams
- Areas where septic systems are densely sited
- Systems where the septic tank effluent is not uniformly distributed across the drainfield
- Older or substandard systems such as cesspools, which may be in direct contact with groundwater during part of the year.

Often it is a combination of these factors that causes phosphorus impacts to local waterways. According to USEPA, 10 to 20% of septic systems fail at some point (USEPA, 2024).

Septic systems are another source of total phosphorus loading to the South Branch Raritan River. In calculating total phosphorus loading from septic system, the NJDEP typically assumes that property within 200 meters (656 feet) of the waterway could contribute phosphorus to the waterway. A 200-meter buffer was placed along the waterways, and residential properties within this buffer were identified. The NJDEP GIS layer of the sewer service area was used to identify which of these residential properties have sewer service (See Figure 8). Finally, properties that were built prior to 2000 were identified as having septic systems that could impact the local waterways.

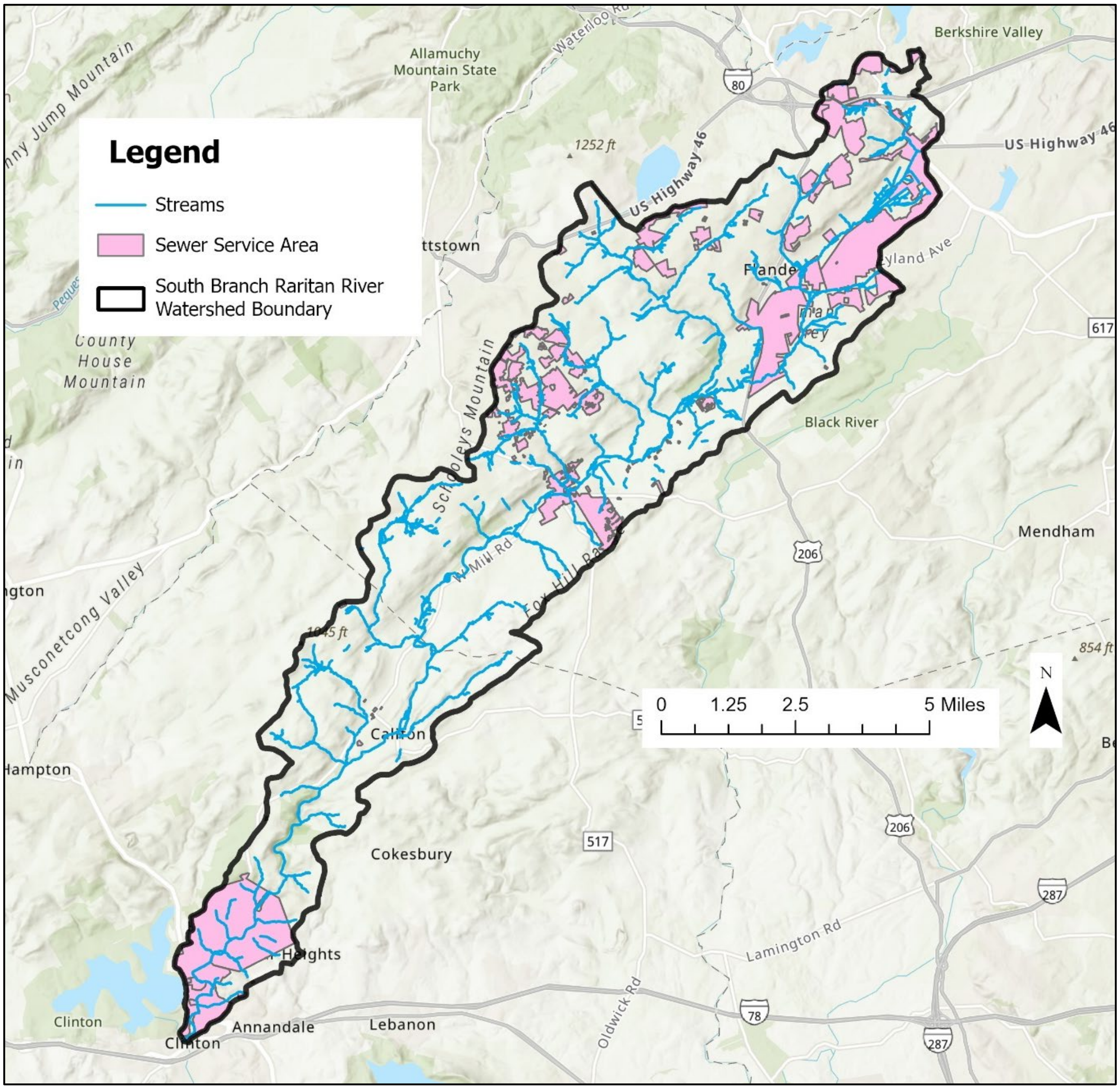

Figure 9: Sewer service area in the study area (NJDEP, 2024)

The NJDEP uses a loading coefficient of 1.07 kg TP/capita/year (2.36 lbs TP/capita/year). Based upon census data, the average capita per dwelling in New Jersey is 2.66 persons/dwelling. Table 19 below presents these results. Septic systems are not a source of TSS to the South Branch Raritan River.

Table 19: Potential TP loading from septic systems for the South Branch Raritan River Watershed study area by HUC14 (lbs/yr)

HUC14	Number of Parcels that are outside Sewer Service Area and Inside the 200-meter Stream Buffer (septic systems)	Homes with Septic Systems Built Prior to 2000	TP Load from Septic Systems (lbs/yr)
02030105010010	355	316	1,983.7
02030105010020	215	190	1,192.7
02030105010040	242	195	1,224.1
02030105010050	561	503	3,157.6
02030105010060	652	600	3,766.6
02030105010070	566	523	3,283.2
02030105010080	52	51	320.2
Totals =	**2,643**	**2,378**	**14,928.1**

Wildlife

One final source of total phosphorus is wildlife. In the areas of the watershed that are forested and wetlands, wildlife would be expected to be plentiful. The aerial loading coefficients used to calculate total phosphorus loads from forest lands and wetlands should account for wildlife that is present in the forest. There are turfgrass areas in the watershed that can attract Canada geese, which can also have a significant load to the South Branch Raritan River. The Canada goose is a tundra species that typically lands in the water and feeds on the surrounding turfgrass. If the waterways have an adequate vegetated buffer, the geese tend to seek out other areas that provide more suitable habitat. The total phosphorus loading from geese ranges from 0.36 to 1.41 lbs per year (Swallow et al., 2010). Therefore, even a small goose population can increase instream phosphorus loading significantly.

Criteria #2: Estimation of the load reductions expected for the management measures

This section will discuss the target load reduction and the load reductions that can be expected for various management practices. Watershed-wide pollutant load reduction management practices will be discussed including state and local ordinances that should result in load reductions, stormwater permitting activities such as street sweeping and catch basin cleaning that will reduce pollutant loads, and education/outreach programs that will promote actions to reduce pollutant loads throughout the watershed. Additionally, site specific pollutant reduction loading practices will be presented. In the next section, individual sites for implementing these practices will be presented with specific load reductions attributed to each practice.

Identifying a Target Load Reduction

A TMDL was completed for total phosphorus (TP) and total suspended solids (TSS) for the South Branch Raritan River.[4] The TP and TSS TMDL reduction recommended was 84% for agricultural and urban land uses from the headwaters at Drakes Brook (HUC 02030105010010) to Spruce Run at Stone Mill Gage (HUC 02030105010070). The remaining HUC14 (02030105010080) requires a TP and TSS reduction of 68% for agricultural land uses and 60% for urban land uses. In 2003, a fecal coliform TMDL was completed for the South Branch Raritan River, which recommended a 94% reduction in fecal coliform loading from agriculture and urban land uses.[5] Fecal coliform is no longer a parameter that is monitored by NJDEP. *E. coli* is now used as the main indicator species for determining pathogen pollution. All recommended practices in this plan will not only reduce TP and TSS but will also reduce *E. coli* and fecal coliform loads.

Watershed-Wide Pollutant Reduction Actions

Many of the watershed-wide actions are often referred to as "source reduction" practices. Some of these practices are designed to promote behavior change while others target maintaining existing infrastructure to avoid the discharge of pollutants. Below the watershed-wide practices will be presented and anticipated pollutant reductions for each practice. The next section will provide more detail on how to implement the watershed-wide practices and provide a detailed estimate of reduction in pollutant load from these practices.

New Jersey Fertilizer Law

This is a state-wide management practice that was adopted on January 5, 2011. New Jersey passed a fertilizer law that prohibits phosphorus from being applied from November 15th to March 1st. While this should have reduced nutrient loading to the South Branch Raritan River Watershed, it is difficult to estimate the quantity of this load reduction. In the South Branch Raritan River Watershed, there are 10,916.3 acres of residential land use. On these residential lands, there are 2,833.8 acres of impervious cover. The remaining land can be assumed to be lawn at 8,082.5 acres. Assuming ¼ of the lawn is fertilized with one pound of phosphate per 1,000 square feet (0.33 lb of TP), approximately 29,046.1 lbs of TP would be applied annually to residential properties in the South Branch Raritan River Watershed study area. If the proper procedures are used in applying the fertilizer, little of the TP would wash off the turf areas. Typically, during application, up to 2.5% of the fertilizer ends up on the road, driveway, sidewalks, or other impervious surfaces, resulting in 726.2 lbs on impervious surfaces in the South Branch Raritan River Watershed, ultimately washing off with stormwater runoff (see Table 20). The New Jersey Fertilizer Law has prevented this TP load to the South Branch Raritan River.

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[4] Kleinfelder-Omni Environmental, 2013. Phase II Executive Summary, Raritan River Basin Nutrient TMDL Study, Watershed Model and TMDL Calculations.

[5] NJDEP, 2003. Total Maximum Daily Loads for Fecal Coliform to Address 48 Streams in the Raritan River Watershed.

Table 20: Reduction in TP loading due to the New Jersey Fertilizer Law for the South Branch Raritan River Watershed study area (lbs/yr)

South Branch Raritan River Watershed				
Residential Area (ac)	Impervious Cover Total (ac)	Lawn (ac)	TP Fertilizer Applied (lbs/yr)	TP Fertilizer Runoff (lbs/yr)
HUC 02030105010010				
1,733.1	575.9	1,157.2	4,158.6	104.0
HUC 02030105010020				
1,394.9	450.0	944.9	3,395.7	84.9
HUC 02030105010040				
916.9	274.1	642.8	2,310.0	57.8
HUC 02030105010050				
2,673.0	610.1	2,062.9	7,413.4	185.3
HUC 02030105010060				
1,854.8	352.2	1,502.6	5,399.9	135.0
HUC 02030105010070				
1,294.5	261.3	1,033.2	3,713.0	92.8
HUC 02030105010080				
1,049.1	310.2	738.9	2,655.4	66.4
TOTALS				
10,916.3	2,833.8	8,082.5	29,046.1	726.2

Municipal separate storm sewer system (MS4) permit requirements

Nine of the 11 municipalities in the study area: Chester Township, Clinton Town, Clinton Township, High Bridge Borough, Lebanon Township, Mount Arlington Borough, Mount Olive Township, Roxbury Township, and Washington Township (Morris County) were classified as Tier A Municipal Separate Storm Sewer System (MS4) communities. Califon Borough and Tewksbury Township were classified as Tier B MS4 communities. Prior to January 1, 2023, Tier B municipalities had minimal requirements to satisfy the MS4 permit. In January 2023, the Tier B classification was eliminated, and these municipalities have received new MS4 general permits that require several management practices to be implemented in their municipalities that will reduce pollutant loading to the South Branch Raritan River.

The MS4 permit requires all municipalities to adopt community-wide ordinances including a pet waste ordinance, a wildlife feeding ordinance, a yard waste ordinance, and a tree removal/replacement ordinance. These ordinances are intended to reduce pollution sources. These four ordinances are the most significant for helping reduce TP, TSS, and fecal coliform loading to the waterways in the study area. The goal of these ordinances is to promote behavior change among the municipal residents.

The MS4 permit also requires all municipalities to implement community-wide measures such as roadside vegetative waste management, roadside erosion control, and street sweeping. The roadside vegetation waste management program requires the municipality to ensure the proper pickup, handling, storage, and disposal of wood waste and yard trimmings generated by the municipality. Wood waste and yard trimmings shall be managed to minimize the impact of vegetative maintenance activities on stormwater discharge quality and shall be prohibited from being blown or deposited into storm drain inlets and stormwater facilities. Keeping these materials out of the local waterways will help reduce impacts from the nutrients that are in these materials.

The roadside erosion control MS4 permit requirement makes the municipality develop a program to detect and repair erosion along the roads owned or operated by the permittee and to inspect and maintain the stability of shoulders, embankments, ditches, and soils along these roads to ensure that they are not eroding and contributing to the sedimentation of receiving waters or stormwater infrastructure. Inspections of municipal roads shall occur at least once per year, and any repairs shall be completed as soon as practicable, but no later than 90 days from discovery. This is a great opportunity for the municipality to identify roadside ditches that can be transformed into bioretention bioswales. The bioswale will remove 90% of the TSS load, 60% of the TP load, and 30% of the TN load (NJDEP, 2004). Also, bioretention systems have been shown to reduce fecal coliform concentrations by 95% (Rusciano and Obropta, 2007).

The MS4 street sweeping requirement forces municipalities to sweep streets with storm drain inlets that discharge to surface water at least three times per year. For municipal roadways without storm drain inlets that discharge to surface water, these streets must be swept at least once per year.

The MS4 permit also requires municipalities to conduct inspections and maintenance of stormwater facilities owned or operated by the municipality. The permit requires that the municipality shall develop, update, and implement a program to ensure adequate long-term cleaning, operation, and maintenance of all municipally owned or operated stormwater facilities, which include storm drain inlets, catch basins, stormwater outfalls, conveyance systems (stormwater pipes and ditches), and stormwater management facilities such as detention basins. Once again, all these activities can help reduce pollutant loading to the South Branch Raritan River.

As discussed earlier, the inspection of conveyance systems such as drainage ditches provide an opportunity to identify locations where bioretention bioswales can be installed. The inspection of outfall pipes can provide the municipality an opportunity to identify stream bank erosion and downcutting conditions that will release phosphorus laden sediment to the waterway. Stream bank restoration techniques can be used to stabilize these areas and reduce sediment and phosphorus loads into the waterway.

Several studies have been completed to define removal rates for street and storm drain cleaning and for leaf removal. The Chesapeake Bay Program Partnership assembled an expert panel to review removal rates for street sweeping and storm drain cleaning. A final report was released on May 19, 2016.[6] Additionally, Tetra Tech prepared a memorandum to the Minnesota Pollution Control Agency that summarized a survey of crediting approaches to street sweeping.[7]

These reports contain estimates of nutrient loading in roadway sediments. For example, the Chesapeake Bay Program uses 2.0 lbs/impervious acres/year TP, 15.4 lbs/impervious acres/year TN, and 0.65 tons/acre/year TSS. The Florida Department of Environmental Protection assumes

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[6] Donner, Sebastian, Bill Frost, Norm Goulet, Mary Hurd, Neely Law, Thomas Maguire, Bill Selbig, Justin Shafer, Steve Steward and Jenny Tribo, 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Final Report.
[7] Molloy, Aileen and Jennifer Olson, 2019. Final Street Sweeping: Survey of Crediting Approaches. Memorandum to Minnesota Pollution Control Agency.

that sediment cleaned from catch basin contains 679 mg/kg TN and 417 mg/kg TP, and sediment removed from best management practices (BMPs) contains 899 mg/kg TN and 364 mg/kg TP.

The United State Geological Survey (USGS) released a study of the efficiencies of street sweeping for removing suspended solids, fecal coliform bacteria, and total phosphorus (Zarriello, et al., 2002). These efficiencies were a function of the type of equipment: mechanical sweepers (low-end efficiencies), wet assisted-vacuum sweepers and regenerative-air sweepers (mid-range efficiencies), and dry assisted-vacuum sweepers (high-ed efficiencies). These removal efficiencies are presented in Table 21. The best available technology efficiencies are based on the highest reported literature values.

Table 21: Efficiencies of street sweepers adapted from Zarriello, et al., 2002

Type	Total Phosphorus	Suspended Solids
Mechanical	5%	25%
Wet vacuum and regenerative air	20%	45%
Dry vacuum	50%	80%
Best available technology	90%	95%

Based upon these studies, TSS, TP and TN removal by street sweeping is a function of the type of street sweeper and the number of times a street is swept per year. Also, credit is only given for curb and gutter roadways. The Chesapeake Bay Program provides removal rates for 11 different practices which include two different types of sweepers: 1) Advanced Sweeping Technology and 2) Mechanical Broom Technology and frequency ranging from two passes per week to one pass per 12 weeks. The maximum removal rates for TSS, TN, and TP are 21%, 4%, and 10%, respectively for streets that are swept twice a week with Advanced Sweeping Technology. The Chesapeake Bay Program does not give any nutrient removal credit for Mechanical Broom Technology. USEPA Region 1 has a credit program that is like the Chesapeake Bay Program. USEPA Region 1 also has a catch basin cleaning credit that is available based on multiplying the impervious drainage area times the same nutrient load export rates for impervious land uses used for street sweeping times the catch basin cleaning reduction factors of 0.02 for phosphorus and 0.06 for nitrogen, which yields a reduction in pounds per year.

Table 22 compares nutrient loading from roadways to the entire nutrient load from all land uses in South Branch Raritan River Watershed study area. The roadway loads were calculated using values taken from the Chesapeake Bay Program (2.0 lbs/impervious acres/year TP and 15.4 lbs/impervious acres/year TN). Table 23 illustrates the maximum nutrient load reduction that street sweeping can yield based upon the Chesapeake Bay Program data for advanced sweeping technologies at two passes per week. Table 24 illustrates the maximum TSS and fecal coliform reductions that street sweeping can achieve based upon USGS's study (Zarriello, et al., 2002).

Table 22: Loading from roadways in the South Branch Raritan River Watershed study area

Land Use	Area (acres)	TP (lbs/year)	TN (lbs/year)	TSS (lbs/year)
Roadways	1,116	2,232	17,186	1,450,800
All Land Use	41,908	21,199	236,098	3,994,605

Table 23: Roadway load reduction from street sweeping using maximum reduction values from the Chesapeake Bay Program

Land Use	Area (acres)	TP Reduction (lbs/yr)	TN Reduction (lbs/yr)	TSS Reduction (lbs/yr)
Roadways	1,116	223	687	304,668

Table 24: Roadway load reduction from street sweeping using maximum reduction values for dry vacuum from Zarriello, et al., 2002

Land Use	Area (acres)	TP (lbs/year)	TSS (lbs/year)	TP Reduction (lbs/yr)	TSS Reduction (lbs/yr)
Roadways	1,116	2,232	1,450,800	1,116	1,160,640

The Wisconsin Department of Natural Resources (WDNR) has recognized research that estimated that on average 43% of the annual phosphorus load is discharged during the fall. WDNR went on to approve a 17% total phosphorus annual load reduction from leaf collection efforts. This credit only applies to residential land use with a high level of tree canopy. To receive this credit, municipalities must collect leaves three to four times spaced throughout late September, October, and November. Also, within 24 hours of leaf collection, the roadway must be swept. Tables 25 shows the potential reduction for the leaf collection combined with street sweeping for the South Branch Raritan River Watershed study area. Since the 17% reduction only applies for roadways that have curb and gutters, it is assumed that 50% of the residential area has curb and gutter, therefore, the total reduction will be ½ the value in Table 25 or 686.5 lbs of TP/yr. Table 26 illustrates the comparison of the annual aggressive street sweeping (twice per week) versus the fall leaf collection and street sweeping program. Also included in Table 26 is street sweeping once per month, which is more likely for the municipalities in the study area but only reduces TP loads by 4%. The pollutant reduction efficiencies decrease by 46% from once a month sweeping instead of twice per week (Zarriello, et al., 2002). Monthly street sweeping throughout the entire municipality can be coupled with a more aggressive street sweeping in the fall with leaf pick up.

Table 25: Total phosphorus load reduction due to leaf collection coupled with street sweeping from late September through November for the South Branch Raritan River Watershed study area

Residential Land Use	Area (acres)	TP (lbs/year)	TP Reduction (lbs/yr)
HUC 02030105010010	1,733.1	1,508.5	256.4
HUC 02030105010020	1,394.9	1,265.9	215.2
HUC 02030105010040	916.9	680.2	115.6
HUC 02030105010050	2,673.0	1,687.6	286.9
HUC 02030105010060	1,854.8	1,152.3	195.9
HUC 02030105010070	1,294.5	832.8	141.6
HUC 02030105010080	1,049.1	949.1	161.3
Total:	**10,916.3**	**8,076.4**	1,373.0
If ½ roadways are managed, totals:	**5,458.2**	**4,038.2**	686.5

Table 26: Comparison of loading reductions for various watershed-wide street sweeping and leaf collection practices in the South Branch Raritan River Watershed study area

	Watershed-wide Practice	TP Reduction (lbs/yr)	TSS Reduction (lbs/yr)
1	Street sweeping (twice per week throughout entire study area)	1,116	1,160,640
2	Street sweeping (once a month throughout entire study area)	89.3	464,256
3	Fall street sweeping and leaf collection (only residential areas)	686.5	290,160
4	Combination of 2 and 3	775.8	754,416

Stormwater Management Facilities

While inspecting and maintaining stormwater management facilities such as detention basins is a watershed-wide requirement, this section will discuss the individual stormwater facilities in the study area and how they currently perform with regard to reducing pollutant loads and how they can be modified to increase pollutant load reduction. The MS4 permit requires the municipality to ensure that all stormwater management facilities are functioning properly by conducting regular inspections. Many of these stormwater facilities are detention basins, which typically remove only 20% of TP. Several are retention basins or wet ponds, which typically remove 50% of TP (NJDEP, 2004). Several are infiltration or bioretention basins which typically remove 60% of the TP. The detention basins can be naturalized and converted into a bioretention basin, thereby capturing, treating, and infiltrating the 2-year design storm. If these basins were enhanced and able to better capture TP, pollutant loads could be reduced by 60% (NJDEP, 2004). Constructed wetlands TP loading removal was assumed to be similar to bioretention systems or 60%.

Two sources were used to identify stormwater management facilities. The first source was the New Jersey Hydrologic Modeling Database that was prepared by the Soil Conservation Districts (SCD) and Rutgers University. The second data source was the NJDEP 2020 land use/land cover GIS layer. Land use data uses a land use code (1499) to identify stormwater basins. Using these two databases 136 existing stormwater management facilities were identified in the South Branch Raritan River Watershed study area. Aerial photography was reviewed, and site visits were conducted to determine each type of facility (detention, retention, infiltration, naturalized, bioretention, or constructed wetlands). Several of the stormwater facilities were already naturalized, meaning the basins have become vegetated with native plants. Typically, the succession from a turfgrass basin to a naturalized basin occurs due to lack of regular mowing. As discussed earlier, basins in a naturalized condition behave very much like bioretention systems, and pollutant removal is dramatically increased.

The stormwater management facilities are presented in Table 27. The address and type of stormwater management facilities by HUC14 is shown in Table 27. The drainage area, land use of the drainage area, TP load from the drainage area, and the reduction in TP load based upon the type of stormwater facility are presented in Table 28. TSS load from the drainage area and reduction based upon the type of stormwater facility are presented in Table 29. This table also includes the calculation of future TP load reduction if all detention basins were naturalized or converted to bioretention basins. Figure 9 shows the location of the stormwater management facilities in each watershed.

Table 27: Existing stormwater management facilities in the South Branch Raritan River Watershed study area

ID	Address	Type	Town
HUC 02030105010010			
1	5 Lenel Rd	N	Roxbury
2	12 Lenel Rd	R	Roxbury
3	1 Exceptional Way	R	Roxbury
4	400 N Frontage Rd	N	Roxbury
5	1881 Route 46, Ledge	R	Roxbury
6	2 Fox Chase Ln	N	Roxbury
7	1830 Route 46, Ledge	R	Roxbury
8	101 Hillcrest Ave	I	Roxbury
9	102 Hillcrest Ave	N	Roxbury
10	138 Mountain Rd	N	Roxbury
11	138 Mountain Rd	N	Roxbury
12	8 Vanover Dr	N	Roxbury
13	9 Vanover Dr	N	Roxbury
14	1 Howard Blvd	N	Roxbury
15	1115 Us-46	R	Roxbury
16	20 Mary Louise Ave	D	Roxbury
17	Righter Rd	N	Roxbury
18	10 Commerce Blvd	N	Roxbury
19	Valley Rd, Rear	N	Roxbury
20	Valley Rd, Rear	D	Roxbury
21	11 Meredith Ct	D	Roxbury
22	2 Shepherds Ln	D	Roxbury
23	8 Southwind Dr	N	Mount Olive
24	12 Arrow Ct	N	Mount Olive
25	131 Route 206	D	Mount Olive
26	131 Route 206	D	Mount Olive
27	97 Route 206	D	Mount Olive
28	Emmans Rd, Rear	D	Roxbury
29	24 Mountain Ave	D	Mount Olive
30	17 Warwick Rd	D	Mount Olive
31	239 Flanders-Netcong Rd	D	Mount Olive

HUC 02030105010020			
32	Eyland Ave, Rear	N	Roxbury
33	Reger Rd	R	Roxbury
34	Wright Ct	N	Roxbury
35	24 St Andrews Ct	D	Mount Olive
36	5 Laurel Dr	N	Mount Olive
37	230 Us-206	D	Mount Olive
38	65 Flanders-Drakestown Rd	N	Mount Olive
39	6 Courtney Dr	N	Mount Olive
40	90 Bartley-Flanders Rd	D	Mount Olive
41	270 Route 206	D	Mount Olive
42	90 Bartley-Flanders Rd	D	Mount Olive
43	286 Route 206	N	Mount Olive
44	293 Route 206	D	Mount Olive
45	62 Flanders-Bartley Rd	D	Mount Olive
46	62 Flanders-Bartley Rd	D	Mount Olive
47	1 West.Detention Basin, Crossing	D	Mount Olive
48	40 Flanders-Bartley Rd	D	Mount Olive
49	49-51 Flanders Bartley Rd	N	Mount Olive
50	49-51 Flanders Bartley Rd	D	Mount Olive
51	70 Pleasant Hill Rd	D	Mount Olive
52	2 Drake Way	D	Mount Olive
53	70 Pleasant Hill Rd	N	Mount Olive
54	70 Drake Way	R	Mount Olive
55	70 Drake Way	D	Mount Olive
56	700 Bartley Chester Rd	N	Mount Olive
57	703 Bartley-Chester Rd	D	Mount Olive
58	703 Bartley-Chester Rd	D	Mount Olive
59	703 Bartley-Chester Rd	D	Mount Olive
60	703 Bartley-Chester Rd	D	Mount Olive
HUC 02030105010040			
61	152 Flanders-Netcong Rd	N	Mount Olive
62	18 Corey Rd	D	Mount Olive
63	18 Corey Rd	D	Mount Olive
64	13 School House Ln	N	Mount Olive
65	18 Corey Rd	D	Mount Olive
66	Mt. Olive Rd	N	Mount Olive
67	12 Fernwood Ct Rear	N	Mount Olive
68	55 Vista Dr Open Space	N	Mount Olive
69	173 Flanders-Drakestown Rd	N	Mount Olive
70	173 Flanders-Drakestown Rd	R	Mount Olive

71	13 Natures Ct	D	Mount Olive
72	23 Whispering Woods Dr	R	Mount Olive
73	202 Flanders-Drakestown Rd	D	Mount Olive
74	204 Flanders-Drakestown Rd	D	Mount Olive
75	160 Wolfe Rd	D	Mount Olive
76	160 Wolfe Rd	D	Mount Olive
77	11 Meadow Ln	D	Mount Olive
78	376 Sand Shore Rd	N	Mount Olive
79	369 Sand Shore Rd	D	Mount Olive
80	6 Kobert Ave	N	Mount Olive
81	354 Route 46	D	Mount Olive
82	399 Route 46	D	Mount Olive
83	41 Yorkshire Dr	D	Washington
84	Naughright Rd	N	Washington
HUC 02030105010050			
85	1 Twin Brook Ln	N	Mount Olive
86	1 Twin Brook Ln	N	Mount Olive
87	9 Bristol Ter	D	Washington
88	Bentley Way	N	Washington
89	5 Thomas Farm Ln	N	Washington
90	Spring Ln	I/D	Washington
91	10 Belrose Ct	N	Washington
92	Amherst Dr	N	Washington
93	26 Wellington Dr	D	Washington
94	20 Ranney Rd	N	Washington
95	38 Ranney Rd	N	Washington
96	16 Squire Hill Rd	N	Washington
97	14 Stony Brook Rd	N	Washington
98	209 Bartley Rd	D	Washington
99	Bartley/Chancellor	N	Washington
100	79 Rock Rd	D	Washington
101	79 Rock Rd	N	Washington
102	Briarwood Rd	N	Washington
103	Blackberry Pl	N	Washington
104	Fairview Ave/Welsh Farm	R	Washington
105	Fairview Ave/Welsh Farm	R	Washington
106	62 East Mill Rd	N	Washington
HUC 02030105010060			
107	34 Harvest Ln	N	Washington
108	4 Rice Ln	N	Washington
109	10 Allyson Ct	N	Washington
110	W Mill Rd	D	Washington

111	1 Lenore Ct	N	Washington
112	7 Indian Run Rd	N	Washington
113	9 Stonebriar Dr	N	Washington
114	3 High Meadow Ln	N	Washington
115	3 Shenandoah Ct	N	Washington
116	514 Route 513	N	Lebanon
117	Beavers Rd	N	Califon Borough
118	Barclay Rd	I/D	Califon Borough
119	3 Logan Dr	R	Tewksbury
HUC 02030105010070			
120	435 Little Brook Road	N	Lebanon
121	1 Lance Drive	N	Lebanon
122	429 Route 513	N	Lebanon
123	428 County Rd 513	D	Califon Borough
124	1 Windy Heights Road	N	Lebanon
125	17 Windy Heights Road	R	Lebanon
126	17 Country Woods Drive	N	Lebanon
127	1 Perry Road	N	Clinton
HUC 02030105010080			
128	109 Forest Drive	N	Lebanon
129	170 East Main Street	N	Clinton
130	Berrywood Lane	N	Clinton
131	12 Elm Drive	D	Clinton
132	1801 Route 31	N	Clinton
133	7 Arbor Court	D	Clinton
134	1747 Route 31	D	Clinton
135	1738 Route 31	D	Clinton
136	1638 Rt 31 North	N	Clinton Town

“D” = Detention, “R” = Retention, “N” = Naturalized, “I / D” = Infiltration/Detention, “BioRet” = Bioretention, “PP” = Porous Pavement, “CW” = Constructed Wetlands

Table 28: Existing TP load from land use and existing TP load reduction from stormwater management facilities in South Branch Raritan River Watershed study area

ID	Land Use	Drainage Area	Type	TP Load (lbs/yr)	Existing TP Load Reduction	Future TP Load Reduction
HUC 2030105010010						
1	Industrial	5.07	N	7.6	4.6	4.6
2	Commercial/Services	5.31	R	3.2	1.6	1.6
3	Industrial	66.79	R	100.2	50.1	50.1
4	Industrial	35.11	N	52.7	31.6	31.6
5	Industrial	72.31	R	108.5	54.2	54.2
6	Residential, Single Unit, Medium Density	42.89	N	60.0	36.0	36.0

7	Residential, Single Unit, Medium Density	39.47	R	55.3	27.6	27.6
8	Commercial/Services	0.32	I	0.7	0.4	0.4
9	Commercial/Services	6.23	N	13.1	7.9	7.9
10	Residential, Single Unit, Medium Density	39.47	N	55.3	33.2	33.2
11	Residential, Single Unit, Medium Density	39.47	N	55.3	33.2	33.2
12	Residential, Rural, Single Unit	31.56	N	18.9	11.4	11.4
13	Residential, Rural, Single Unit	5.73	N	3.4	2.1	2.1
14	Commercial/Services	20.39	N	12.2	7.3	7.3
15	Commercial/Services	10.44	R	6.3	3.1	3.1
16	Residential, High Density Or Multiple Dwelling	2.56	D	3.6	0.7	2.2
17	Other Urban Or Built-Up Land	0.41	N	0.4	0.2	0.2
18	Commercial/Services	5.17	N	3.1	1.9	1.9
19	Residential, Single Unit, Low Density	27.92	N	16.8	10.1	10.1
20	Residential, Single Unit, Low Density	23.91	D	14.3	2.9	8.6
21	Residential, Single Unit, Medium Density	54.07	D	75.7	15.1	45.4
22	Residential, Rural, Single Unit	4.67	D	2.8	0.6	1.7
23	Residential, Rural, Single Unit	0.04	N	0.0	0.0	0.0
24	Residential, Single Unit, Low Density	16.73	N	10.0	6.0	6.0
25	Residential, Rural, Single Unit	6.65	D	9.3	1.9	5.6
26	Residential, Single Unit, Medium Density	0.04	D	0.1	0.0	0.0
27	Residential, Single Unit, Medium Density	20.10	D	28.1	5.6	16.9
28	Residential, Single Unit, Medium Density	17.15	D	10.3	2.1	6.2
29	Residential, Single Unit, Low Density	18.28	D	11.0	2.2	6.6
30	Residential, Single Unit, Low Density	20.39	D	12.2	2.4	7.3
31	Residential, Rural, Single Unit	23.55	D	14.1	2.8	8.5
HUC 2030105010020						
32	Residential, Single Unit, Low Density	15.88	N	9.5	5.7	5.7
33	Residential, Single Unit, Low Density	7.68	R	4.6	2.3	2.3

34	Residential, Single Unit, Low Density	13.18	N	7.9	4.7	4.7
35	Commercial/Services	16.91	D	10.1	2.0	6.1
36	Commercial/Services	53.10	N	111.5	66.9	66.9
37	Residential, Rural, Single Unit	10.20	D	6.1	1.2	3.7
38	Commercial/Services	22.81	N	13.7	8.2	8.2
39	Residential, Rural, Single Unit	31.61	N	19.0	11.4	11.4
40	Residential, Single Unit, Low Density	23.73	D	14.2	2.8	8.5
41	Residential, Rural, Single Unit	5.19	D	10.9	2.2	6.5
42	Commercial/Services	23.73	D	14.2	2.8	8.5
43	Commercial/Services	7.81	N	16.4	9.8	9.8
44	Residential, Rural, Single Unit	6.39	D	13.4	2.7	8.1
45	Commercial/Services	16.08	D	33.8	6.8	20.3
46	Commercial/Services	16.08	D	33.8	6.8	20.3
47	Commercial/Services	31.17	D	43.6	8.7	26.2
48	Commercial/Services	2.35	D	2.4	0.5	1.4
49	Commercial/Services	1.66	N	2.3	1.4	1.4
50	Commercial/Services	4.98	D	7.0	1.4	4.2
51	Commercial/Services	5.24	D	7.3	1.5	4.4
52	Residential, Single Unit, Medium Density	10.48	D	14.7	2.9	8.8
53	Recreational Land	31.20	N	43.7	26.2	26.2
54	Residential, High Density or Multiple Dwelling	6.50	R	9.1	4.5	4.5
55	Residential, High Density or Multiple Dwelling	6.50	D	9.1	1.8	5.5
56	Residential, High Density or Multiple Dwelling	18.56	N	27.8	16.7	16.7
57	Residential, Single Unit, Medium Density	58.51	D	87.8	17.6	52.7
58	Residential, Single Unit, Medium Density	58.51	D	87.8	17.6	52.7
59	Residential, Single Unit, Medium Density	58.51	D	87.8	17.6	52.7
60	Residential, Single Unit, Medium Density	58.51	D	87.8	17.6	52.7
HUC 2030105010040						
61	Industrial	24.69	N	14.8	8.9	8.9
62	Industrial	15.16	D	31.8	6.4	19.1
63	Industrial	8.63	D	18.1	3.6	10.9
64	Industrial	21.04	N	12.6	7.6	7.6

65	Industrial	12.27	D	25.8	5.2	15.5
66	Residential, Single Unit, Low Density	8.10	N	4.9	2.9	2.9
67	Residential, Single Unit, Low Density	13.69	N	8.2	4.9	4.9
68	Residential, Single Unit, Low Density	10.39	N	6.2	3.7	3.7
69	Residential, Single Unit, Low Density	8.16	N	4.9	2.9	2.9
70	Residential, Single Unit, Low Density	14.78	R	8.9	4.4	4.4
71	Residential, Single Unit, Low Density	29.81	D	17.9	3.6	10.7
72	Residential, Single Unit, Low Density	41.12	R	24.7	12.3	12.3
73	Commercial/Services	21.94	D	13.2	2.6	7.9
74	Commercial/Services	4.83	D	10.1	2.0	6.1
75	Commercial/Services	12.53	D	7.5	1.5	4.5
76	Transportation/Communication/Utilities	12.53	D	18.8	3.8	11.3
77	Residential, Rural, Single Unit	31.38	D	18.8	3.8	11.3
78	Residential, Rural, Single Unit	46.71	N	28.0	16.8	16.8
79	Residential, Rural, Single Unit	4.02	D	8.4	1.7	5.1
80	Residential, Single Unit, Low Density	4.61	N	2.8	1.7	1.7
81	Commercial/Services	0.00	D	0.0	0.0	0.0
82	Residential, Rural, Single Unit	30.42	D	18.3	3.7	11.0
83	Commercial/Services	3.40	D	2.0	0.4	1.2
84	Commercial/Services	29.35	N	17.6	10.6	10.6
HUC 2030105010050						
85	Residential, Rural, Single Unit	10.19	N	6.1	3.7	3.7
86	Commercial/Services	13.05	N	7.8	4.7	4.7
87	Residential, Rural, Single Unit	21.46	D	12.9	2.6	7.7
88	Residential, Rural, Single Unit	23.86	N	14.3	8.6	8.6
89	Residential, Rural, Single Unit	14.36	N	8.6	5.2	5.2
90	Residential, Rural, Single Unit	22.35	I/D	13.4	8.0	8.0
91	Residential, Rural, Single Unit	11.45	N	6.9	4.1	4.1
92	Residential, Single Unit, Low Density	43.08	N	25.8	15.5	15.5

93	Residential, Rural, Single Unit	10.87	D	6.5	1.3	3.9
94	Residential, Rural, Single Unit	10.02	N	6.0	3.6	3.6
95	Residential, Rural, Single Unit	24.01	N	14.4	8.6	8.6
96	Residential, Rural, Single Unit	5.64	N	3.4	2.0	2.0
97	Residential, Rural, Single Unit	16.51	N	9.9	5.9	5.9
98	Recreational Land	1.15	D	1.1	0.2	0.7
99	Residential, Rural, Single Unit	9.40	N	5.6	3.4	3.4
100	Recreational Land	6.85	D	6.8	1.4	4.1
101	Old Field (< 25% Brush Covered)	17.81	N	1.8	1.1	1.1
102	Residential, Single Unit, Low Density	7.72	N	4.6	2.8	2.8
103	Residential, Single Unit, Low Density	14.17	N	8.5	5.1	5.1
104	Residential, Rural, Single Unit	9.59	R	13.4	6.7	6.7
105	Residential, Rural, Single Unit	4.72	R	6.6	3.3	3.3
106	Residential, Rural, Single Unit	7.54	N	15.8	9.5	9.5
HUC 2030105010060						
107	Other Agriculture	2.25	N	1.4	0.8	0.8
108	Residential, High Density Or Multiple Dwelling	7.59	N	4.6	2.7	2.7
109	Residential, High Density Or Multiple Dwelling	9.31	N	5.6	3.4	3.4
110	Commercial/Services	0.30	D	0.4	0.1	0.2
111	Residential, Rural, Single Unit	16.98	N	10.2	6.1	6.1
112	Residential, Rural, Single Unit	12.38	N	7.4	4.5	4.5
113	Residential, Rural, Single Unit	4.40	N	2.6	1.6	1.6
114	Residential, Rural, Single Unit	18.68	N	11.2	6.7	6.7
115	Residential, Rural, Single Unit	7.55	N	4.5	2.7	2.7
116	Industrial	4.75	N	7.1	4.3	4.3
117	Residential (Rural, Single Unit)	19.80	N	11.9	7.1	7.1
118	Residential (Rural, Single Unit)	29.00	I/D	17.4	10.4	10.4

119	Residential, Rural, Single Unit	6.01	R	3.6	1.8	1.8
HUC 2030105010070						
120	Other Agriculture	12.87	N	16.7	10.0	10.0
121	Residential (Single Unit, Low Density)	118.27	N	71.0	42.6	42.6
122	Commercial And Services	2.00	N	4.2	2.5	2.5
123	Commercial And Services	5.78	D	3.5	0.7	2.1
124	Residential, Rural, Single Unit	14.33	N	8.6	5.2	5.2
125	Residential, Rural, Single Unit	6.13	R	3.7	1.8	1.8
126	Residential (Single Unit, Low Density)	2.88	N	1.7	1.0	1.0
127	Residential, Rural, Single Unit	19.20	N	11.5	6.9	6.9
HUC 2030105010080						
128	Residential (Single Unit, Low Density)	26.43	N	15.9	9.5	9.5
129	Residential (Single Unit, Low Density)	22.10	N	13.3	8.0	8.0
130	Residential, High Density or Multiple Dwelling	9.17	N	12.8	7.7	7.7
131	Residential (High Density or Multiple Dwelling)	35.71	D	50.0	10.0	30.0
132	Commercial/Services	9.95	N	6.0	3.6	3.6
133	Residential, Single Unit, Medium Density	2.50	D	3.5	0.7	2.1
134	Commercial And Services	2.69	D	1.6	0.3	1.0
135	Commercial And Services	12.80	D	7.7	1.5	4.6
136	Commercial/Services	9.92	N	5.9	3.6	3.6
	TOTALS:	**2,452.3**		**2,452.0**	**1,021.2**	**1,436.4**

Table 29: Existing TSS load from land use and existing TSS load reduction from stormwater management facilities in the South Branch Raritan River Watershed study area

ID	Land Use	Drainage Area	Type	TSS Load (lbs/yr)	Existing TSS Load Reduction	Future TSS Load Reduction
HUC 2030105010010						
1	Industrial	5.07	N	1,014.0	912.6	912.6
2	Commercial/Services	5.31	R	1,061.8	530.9	530.9
3	Industrial	66.79	R	13,357.6	6,678.8	6,678.8
4	Industrial	35.11	N	7,021.8	6,319.6	6,319.6
5	Industrial	72.31	R	14,462.8	7,231.4	7,231.4
6	Residential, Single Unit, Medium Density	42.89	N	4,289.2	3,860.3	3,860.3
7	Residential, Single Unit, Medium Density	39.47	R	3,946.8	1,973.4	1,973.4
8	Commercial/Services	0.32	I	64.0	57.6	57.6
9	Commercial/Services	6.23	N	1,246.8	1,122.1	1,122.1
10	Residential, Single Unit, Medium Density	39.47	N	3,946.8	3,552.1	3,552.1
11	Residential, Single Unit, Medium Density	39.47	N	3,946.8	3,552.1	3,552.1
12	Residential, Rural, Single Unit	31.56	N	3,156.4	2,840.8	2,840.8
13	Residential, Rural, Single Unit	5.73	N	572.7	515.4	515.4
14	Commercial/Services	20.39	N	4,077.4	3,669.7	3,669.7
15	Commercial/Services	10.44	R	2,088.6	1,044.3	1,044.3
16	Residential, High Density Or Multiple Dwelling	2.56	D	358.4	179.2	322.6
17	Other Urban Or Built-Up Land	0.41	N	49.6	44.6	44.6
18	Commercial/Services	5.17	N	1,034.8	931.3	931.3
19	Residential, Single Unit, Low Density	27.92	N	2,791.8	2,512.6	2,512.6
20	Residential, Single Unit, Low Density	23.91	D	2,390.9	1,195.5	2,151.8
21	Residential, Single Unit, Medium Density	54.07	D	5,407.0	2,703.5	4,866.3
22	Residential, Rural, Single Unit	4.67	D	467.0	233.5	420.3
23	Residential, Rural, Single Unit	0.04	N	4.3	3.9	3.9
24	Residential, Single Unit, Low Density	16.73	N	1,673.4	1,506.1	1,506.1
25	Residential, Rural, Single Unit	6.65	D	664.5	332.3	598.1
26	Residential, Single Unit, Medium Density	0.04	D	4.0	2.0	3.6

27	Residential, Single Unit, Medium Density	20.10	D	2,009.6	1,004.8	1,808.6
28	Residential, Single Unit, Medium Density	17.15	D	1,714.5	857.3	1,543.1
29	Residential, Single Unit, Low Density	18.28	D	1,828.2	914.1	1,645.4
30	Residential, Single Unit, Low Density	20.39	D	2,039.2	1,019.6	1,835.3
31	Residential, Rural, Single Unit	23.55	D	2,355.3	1,177.7	2,119.8
HUC 2030105010020						
32	Residential, Single Unit, Low Density	15.88	N	1,587.5	1,428.8	1,428.8
33	Residential, Single Unit, Low Density	7.68	R	768.0	384.0	384.0
34	Residential, Single Unit, Low Density	13.18	N	1,318.0	1,186.2	1,186.2
35	Commercial/Services	16.91	D	1,691.0	845.5	1,521.9
36	Commercial/Services	53.10	N	10,620.0	9,558.0	9,558.0
37	Residential, Rural, Single Unit	10.20	D	2,039.0	1,019.5	1,835.1
38	Commercial/Services	22.81	N	2,281.3	2,053.2	2,053.2
39	Residential, Rural, Single Unit	31.61	N	3,161.1	2,845.0	2,845.0
40	Residential, Single Unit, Low Density	23.73	D	4,745.6	2,372.8	4,271.0
41	Residential, Rural, Single Unit	5.19	D	1,038.4	519.2	934.6
42	Commercial/Services	23.73	D	4,745.6	2,372.8	4,271.0
43	Commercial/Services	7.81	N	1,562.0	1,405.8	1,405.8
44	Residential, Rural, Single Unit	6.39	D	1,278.0	639.0	1,150.2
45	Commercial/Services	16.08	D	3,215.4	1,607.7	2,893.9
46	Commercial/Services	16.08	D	3,215.4	1,607.7	2,893.9
47	Commercial/Services	31.17	D	3,116.9	1,558.5	2,805.2
48	Commercial/Services	2.35	D	282.2	141.1	254.0
49	Commercial/Services	1.66	N	232.4	209.2	209.2
50	Commercial/Services	4.98	D	697.2	348.6	627.5
51	Commercial/Services	5.24	D	734.2	367.1	660.7
52	Residential, Single Unit, Medium Density	10.48	D	1,048.2	524.1	943.4
53	Recreational Land	31.20	N	3,119.9	2,807.9	2,807.9
54	Residential, High Density or Multiple Dwelling	6.50	R	649.7	324.9	324.9
55	Residential, High Density or Multiple Dwelling	6.50	D	649.7	324.9	584.7

56	Residential, High Density or Multiple Dwelling	18.56	N	3,711.6	3,340.4	3,340.4
57	Residential, Single Unit, Medium Density	58.51	D	11,701.6	5,850.8	10,531.4
58	Residential, Single Unit, Medium Density	58.51	D	11,701.6	5,850.8	10,531.4
59	Residential, Single Unit, Medium Density	58.51	D	11,701.6	5,850.8	10,531.4
60	Residential, Single Unit, Medium Density	58.51	D	11,701.6	5,850.8	10,531.4
HUC 2030105010040						
61	Industrial	24.69	N	2,469.1	2,222.2	2,222.2
62	Industrial	15.16	D	3,032.0	1,516.0	2,728.8
63	Industrial	8.63	D	1,725.6	862.8	1,553.0
64	Industrial	21.04	N	2,104.3	1,893.9	1,893.9
65	Industrial	12.27	D	2,453.6	1,226.8	2,208.2
66	Residential, Single Unit, Low Density	8.10	N	810.4	729.4	729.4
67	Residential, Single Unit, Low Density	13.69	N	1,369.4	1,232.5	1,232.5
68	Residential, Single Unit, Low Density	10.39	N	1,038.5	934.7	934.7
69	Residential, Single Unit, Low Density	8.16	N	815.8	734.2	734.2
70	Residential, Single Unit, Low Density	14.78	R	1,478.1	739.1	739.1
71	Residential, Single Unit, Low Density	29.81	D	2,981.1	1,490.6	2,683.0
72	Residential, Single Unit, Low Density	41.12	R	4,111.5	2,055.8	2,055.8
73	Commercial/Services	21.94	D	4,388.6	2,194.3	3,949.7
74	Commercial/Services	4.83	D	966.0	483.0	869.4
75	Commercial/Services	12.53	D	2,505.8	1,252.9	2,255.2
76	Transportation/Communication/Utilities	12.53	D	2,505.8	1,252.9	2,255.2
77	Residential, Rural, Single Unit	31.38	D	3,138.3	1,569.2	2,824.5
78	Residential, Rural, Single Unit	46.71	N	4,671.0	4,203.9	4,203.9
79	Residential, Rural, Single Unit	4.02	D	803.6	401.8	723.2
80	Residential, Single Unit, Low Density	4.61	N	461.0	414.9	414.9
81	Commercial/Services	0.00	D	0.0	0.0	0.0
82	Residential, Rural, Single Unit	30.42	D	6,084.0	3,042.0	5,475.6
83	Commercial/Services	3.40	D	340.3	170.2	306.3
84	Commercial/Services	29.35	N	5,870.8	5,283.7	5,283.7

HUC 2030105010050						
85	Residential, Rural, Single Unit	10.19	N	1,018.7	916.8	916.8
86	Commercial/Services	13.05	N	1,305.1	1,174.6	1,174.6
87	Residential, Rural, Single Unit	21.46	D	2,145.7	1,072.9	1,931.1
88	Residential, Rural, Single Unit	23.86	N	2,385.5	2,147.0	2,147.0
89	Residential, Rural, Single Unit	14.36	N	1,435.8	1,292.2	1,292.2
90	Residential, Rural, Single Unit	22.35	I/D	2,235.0	2,011.5	2,011.5
91	Residential, Rural, Single Unit	11.45	N	1,144.8	1,030.3	1,030.3
92	Residential, Single Unit, Low Density	43.08	N	4,307.8	3,877.0	3,877.0
93	Residential, Rural, Single Unit	10.87	D	1,087.3	543.7	978.6
94	Residential, Rural, Single Unit	10.02	N	1,001.8	901.6	901.6
95	Residential, Rural, Single Unit	24.01	N	2,400.5	2,160.5	2,160.5
96	Residential, Rural, Single Unit	5.64	N	564.4	508.0	508.0
97	Residential, Rural, Single Unit	16.51	N	1,650.9	1,485.8	1,485.8
98	Recreational Land	1.15	D	137.5	68.8	123.8
99	Residential, Rural, Single Unit	9.40	N	940.0	846.0	846.0
100	Recreational Land	6.85	D	821.8	410.9	739.6
101	Old Field (< 25% Brush Covered)	17.81	N	712.5	641.3	641.3
102	Residential, Single Unit, Low Density	7.72	N	772.0	694.8	694.8
103	Residential, Single Unit, Low Density	14.17	N	1,417.1	1,275.4	1,275.4
104	Residential, Rural, Single Unit	9.59	R	1,342.6	671.3	671.3
105	Residential, Rural, Single Unit	4.72	R	660.9	330.5	330.5
106	Residential, Rural, Single Unit	7.54	N	1,508.6	1,357.7	1,357.7
HUC 2030105010060						
107	Other Agriculture	2.25	N	225.4	202.9	202.9
108	Residential, High Density Or Multiple Dwelling	7.59	N	758.5	682.7	682.7
109	Residential, High Density Or Multiple Dwelling	9.31	N	931.2	838.1	838.1
110	Commercial/Services	0.30	D	90.0	45.0	81.0

111	Residential, Rural, Single Unit	16.98	N	1,698.3	1,528.5	1,528.5
112	Residential, Rural, Single Unit	12.38	N	1,238.2	1,114.4	1,114.4
113	Residential, Rural, Single Unit	4.40	N	439.5	395.6	395.6
114	Residential, Rural, Single Unit	18.68	N	1,868.0	1,681.2	1,681.2
115	Residential, Rural, Single Unit	7.55	N	754.8	679.3	679.3
116	Industrial	4.75	N	949.4	854.5	854.5
117	Residential (Rural, Single Unit)	19.80	N	1,980.0	1,782.0	1,782.0
118	Residential (Rural, Single Unit)	29.00	I/D	2,900.0	2,610.0	2,610.0
119	Residential, Rural, Single Unit	6.01	R	600.5	300.3	300.3
HUC 2030105010070						
120	Other Agriculture	12.87	N	3,862.2	3,476.0	3,476.0
121	Residential (Single Unit, Low Density)	118.27	N	11,827.2	10,644.5	10,644.5
122	Commercial And Services	2.00	N	400.0	360.0	360.0
123	Commercial And Services	5.78	D	1,156.4	578.2	1,040.8
124	Residential, Rural, Single Unit	14.33	N	1,432.7	1,289.4	1,289.4
125	Residential, Rural, Single Unit	6.13	R	612.8	306.4	306.4
126	Residential (Single Unit, Low Density)	2.88	N	288.0	259.2	259.2
127	Residential, Rural, Single Unit	19.20	N	1,920.0	1,728.0	1,728.0
HUC 2030105010080						
128	Residential (Single Unit, Low Density)	26.43	N	2,642.5	2,378.3	2,378.3
129	Residential (Single Unit, Low Density)	22.10	N	2,210.0	1,989.0	1,989.0
130	Residential, High Density or Multiple Dwelling	9.17	N	1,284.1	1,155.7	1,155.7
131	Residential (High Density or Multiple Dwelling)	35.71	D	4,999.7	2,499.8	4,499.7
132	Commercial/Services	9.95	N	1,990.8	1,791.7	1,791.7
133	Residential, Single Unit, Medium Density	2.50	D	250.0	125.0	225.0
134	Commercial And Services	2.69	D	537.6	268.8	483.8
135	Commercial And Services	12.80	D	2,560.0	1,280.0	2,304.0

136	Commercial/Services	9.92	N	1,983.2	1,784.9	1,784.9
	TOTALS:	**2,452.3**		**334,872.56**	**227,627.62**	**283,328.61**

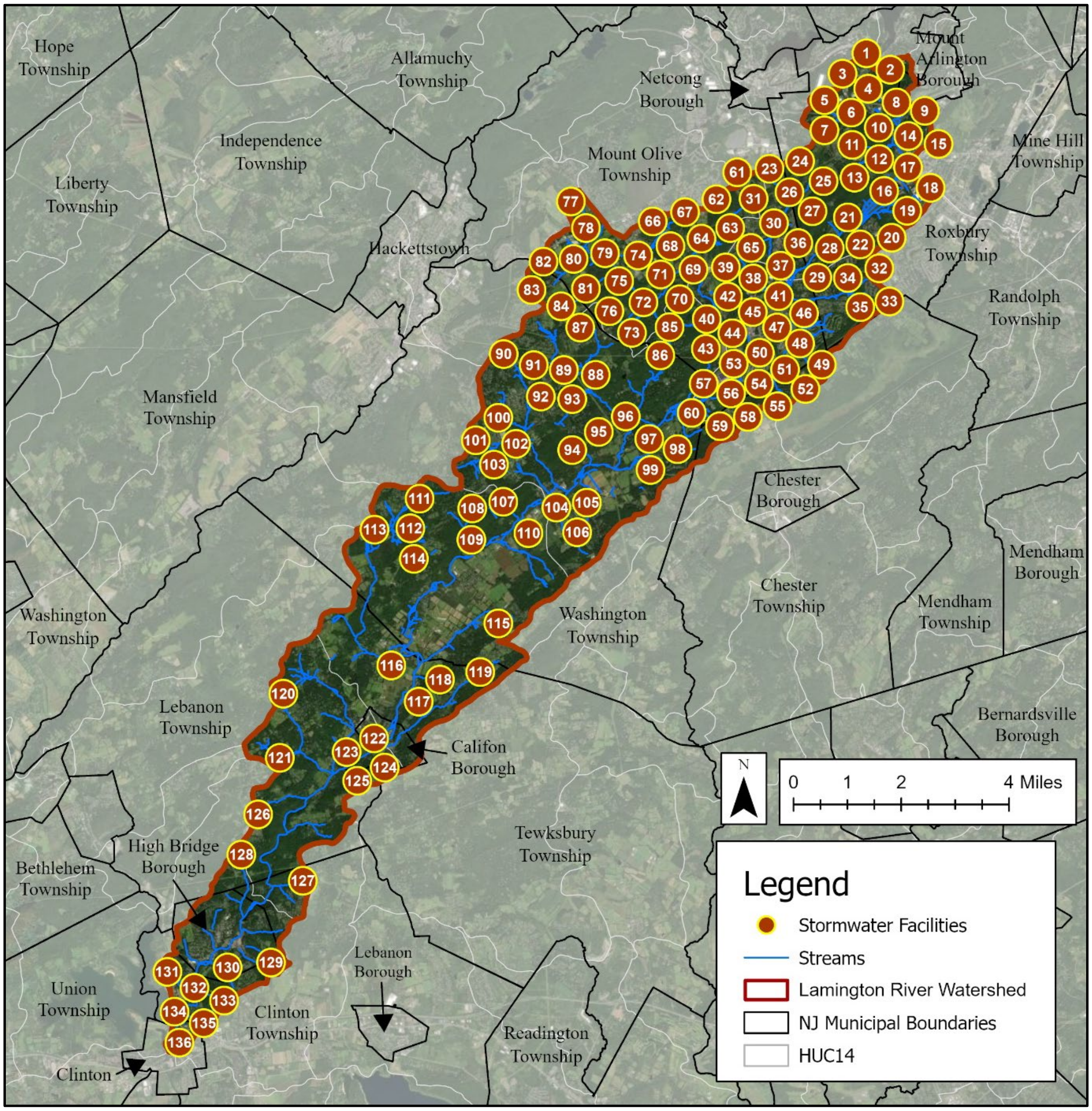

Figure 10: Stormwater management facilities in the South Branch Raritan River Watershed study area

Septic Management

The percentage of HUC14 in the sewer service area is shown in Table 30. The number homes with septic systems that are within the 200-meter buffer along with the TP load from these septic systems are also presented in this table. There are several options for reducing phosphorus loading from septic systems. The first is to reduce total phosphorus in the wastewater entering the septic system. Approximately 37% of the phosphorus load to the septic system is namely phosphorus in detergent from baths, sinks, and appliances. Approximately 4% of the phosphorus is from garbage disposals. Approximately 59% is from toilet wastewater with 2/3[rd] attributed to urine.

Table 30: Potential TP Loading from Septic Systems in the South Branch Raritan River Watershed study area (lbs/yr)

HUC14	Percentage of HUC14 in Sewer Service Area	Homes with Septic Systems Built Prior to 2000 within 200-meter buffer	TP Load from Septic Systems (lbs/yr)
HUC 02030105010010	33.50%	316	1,983.7
HUC 02030105010020	30.60%	190	1,192.7
HUC 02030105010040	8.50%	195	1,224.1
HUC 02030105010050	14.40%	503	3,157.6
HUC 02030105010060	1.30%	600	3,766.6
HUC 02030105010070	0.20%	523	3,283.2
HUC 02030105010080	70.5%	51	320.2
Total =		**2,378**	**14,928.1**

Through a public education initiative, the municipalities in the study area and local watershed groups could encourage homeowners to use only phosphate free detergents. This should significantly reduce the phosphorus load from baths, sinks, and appliances from septic systems to the South Branch Raritan River. The same program could encourage homeowners to remove their garbage disposal or simply throw out or compost food waste. These efforts could reduce phosphorus loading from septic systems by 20%. Regarding toilet wastewater, using a composting or urine diverting toilet would prevent most nitrogen and phosphorus from entering the septic system.

Additionally, all septic systems should be regularly inspected and pumped every 1 to 3 years. When problems are discovered, repairs should be made, or replacement systems should be installed. As part of this process, the filter material should be replaced.

All septic systems should have an effluent filter, which will help prevent the drainfield from clogging. This effluent filter should be rinsed or replaced annually.

All households should seek to improve water efficiency by using EPA Water Sense appliances, low flush toilets, and low flow shower heads and faucets. Toilet account for 25 to 30% of household water use. A high-efficiency toilet is 1.6 gallons per flush instead of the 3.5 to 5 gallons per flush.

Homeowners should watch what goes down the drain. Do not flush dental floss, feminine hygiene products, condoms, diapers, cotton swabs, cigarette butts, coffee grounds, cat litter, paper towels, or other kitchen and bathroom items that can clog or damage septic system components. Also, flushing household chemicals, gasoline, oil, pesticides, antifreeze, and paint can stress or destroy the biological treatment taking place in the system. NJDEP has a Homeowner's Guide to Septic Systems that should be distributed to everyone in the watershed (See Appendix B).

When replacing a septic system, considerations should be given to advance treatment systems that can better filter phosphorus such as media filters. There are also drainfield modifications that can increase phosphorus removal. For example, placing a layer of phosphorus removal media between the gravel and underlying original soil can increase phosphorus removal. Also, operating the drainfield through times, pressurized dosing of septic effluent to equalize flow over the entire drainfield can enhance phosphorus removal. Another option is the use of a drip distribution system which can disperse the effluent within the root zone of plants, thereby promoting uptake of phosphorus.

The homeowner education and outreach program could result in a phosphorus loading reduction from septic systems by 20%. The repair of existing systems and the replacement of failing systems could eliminate the phosphorus load from septic systems.

An analysis of homes in proximity of the stream in the watersheds yielded 2,378 homes in the South Branch Raritan River Watershed study area. The TP loading from these homes was estimated as 14,928.1 lbs/yr. It was assumed that 30% of these homes (713 homes) have failing septic systems. If the septic systems of the 713 homes were replaced, the TP load would be reduced by 4,475.9 lbs/yr. If the homes that are assumed to not have failing septic systems reduce their phosphates in detergent and use of their garbage disposal, the TP loading reduction from these homes would be 2,090.4 lbs/yr, which is a 20% reduction.

Education and Outreach

Mitigating the deterioration in water quality is contingent on changing human behaviors. Community-based behavioral change initiatives are one approach to changing people's actions, which is distinct from many behavioral change programs that target the actions of individuals (Osawe, 2023). Outreach and education are powerful tools that can be used in watershed protection efforts. Both can help develop an awareness of the value of our water resources, educate people on what's threatening the resources, and encourage protective action. Because polluted runoff is the major source of contamination in our nation's waters, there is a need to educate individuals on pollutant sources and show them how their daily activities degrade water quality. For example, runoff from suburban areas can contain fertilizer and pesticides leached from lawns, oil and antifreeze washed off driveways, bacteria and organic matter from pet wastes, and sediment from construction sites. Runoff from farms, homes, or factories in rural areas can contain many of the same pollutants. Outreach can educate individuals about the causes of water pollution and provide solutions to these problems. Outreach and education can also help change behaviors and promote responsible attitudes in the watershed (MacPherson and Tonning, 2024).

An information and education program will be presented in section 5 of this plan. While it is difficult to determine the load reductions that can be expected from education and outreach programs, it is universally accepted that behavior change created by these types of programs is required to improve water quality in a watershed. The information and education program will target farmers, municipal officials and employees, and residents and other property owners.

<u>Site Specific Pollutant Reduction Actions</u>

There are two land uses that must be targeted for site specific pollutant reductions: 1) Urban and 2) Agricultural. For urban land uses, specific developed sites were identified and evaluated for retrofitting with green infrastructure. When evaluating existing development for retrofitting, bioretention tends to be the first choice due it is low cost and high effectiveness. Typically, runoff from impervious surfaces is identified to be captured, treated, and infiltrated. Bioretention can reduce TP concentrations by 60% and TP pollutant loads by 90% if designed to capture, treat, and infiltrate the water quality storm. As discussed earlier, bioretention systems can also reduce TN, TSS, and fecal coliform loading to local waterways. Bioretention systems are typically rain gardens or bioswales. Education and outreach programs can also be offered to encourage individual homeowners to install rain gardens and bioswales. The second practice frequently used to retrofit existing development is permeable pavement. Permeable pavement can also reduce TP concentrations by 60% and have a 90% load reduction if the entire water quality storm is infiltrated. Permeable pavement reduced TSS, TN, and fecal coliform concentrations by 80%, 50%, and 95%. Finally, vegetative filters can also be used to retrofit existing development. These can reduce TP and TN concentrations by 30% and TSS by 60 to 80%.

For agricultural management practices, the first approach is to develop a nutrient management plan that balances the fertilizer usage with the crop uptake to minimize excess fertilizer that can wash off during storm events. Many farmers have already taken this approach, mainly because of the high cost of fertilizer. By using only the fertilizer that the plants need, the farmer can save money. The second approach to agriculture is to install a physical practice such as vegetative filter strip, which can achieve a 30% TP removal and 60 to 80% TSS removal. Another practice that is fairly common among agricultural users is wetlands. Wetlands along the field edge can achieve a 50% TP concentration reduction, 30% TN reduction, and a 90% TSS reduction. When used in combination with a vegetative filter strip and a constructed wetland, a 65% reduction in TP concentration can be achieved.

Finally, instream measures could be installed to help reduce pollutants from entering the South Branch Raritan River. The practices described above will reduce stormwater runoff flowrate and volumes to the waterways. This will help prevent stream bank erosion and stream downcutting, two processes that can add a considerable amount of phosphorus laden sediment to the stream systems and ultimately to the reservoir. Globally, the relative contribution of streambank erosion to phosphorus is estimated to range from 6% to 93% (Fox et al., 2016). Streambank stabilization can also help reduce these increases in sediment. Under the MS4 permits, each municipality must regularly inspect their stormwater outfalls to the streams. This would be a good opportunity to identify stream banks that can be stabilized to prevent erosion. Also, volunteers could be used to conduct stream visual assessments using the NJDEP or USDA protocols.

Summary of Existing Pollutant Loads for the Study Area

Table 31 below shows the existing nonpoint source TP loading based upon land use, septic system loads, and the load reductions for the existing stormwater basins. Although additional pollutant load reductions can be attributed to existing agricultural management practices, data are not available to clearly document these practices, so these reductions are not included in Table 31.

Table 31: Existing TP pollutant loads for the study area (lbs/yr)

	TP (lbs/yr)	TSS (lbs/yr)
Nonpoint source based upon land use	21,199	3,994,605
Septic system load	14,928	0
Detention basin load reduction	-1,021	-227,628
Total existing load	**35,106**	**3,766,977**

Criteria #3: Recommendation of nonpoint source management measures to address the causes and sources

Recommendations for Urban Land Uses

As discussed earlier, there are watershed-wide recommendations for addressing the impacts of urban land use and there are site specific recommendations. While source reduction through leaf collection, street sweeping, and catch basin cleaning can help reduce phosphorus loads to the South Branch Raritan River, stormwater management practices will have to be installed to capture and treat stormwater runoff from existing developed areas. Seventy-four sites have been identified throughout the South Branch Raritan River Watershed study area that might be suitable to retrofit with green infrastructure. Green infrastructure is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure projects capture, filter, absorb, and reuse stormwater to maintain or mimic natural systems and to treat runoff as a resource. Green infrastructure practices use soil and vegetation to recycle stormwater runoff through infiltration and evapotranspiration. These practices are very scalable and can be incorporated into almost any existing landscape to intercept stormwater at its source. Green infrastructure practices such as bioretention, green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.

All 74 sites were inspected for suitability for green infrastructure retrofit. These sites were selected by reviewing aerial photographs, parcel data, and site visits to the study area. Sites were selected that had substantial impervious surfaces and lawn area where the runoff from these impervious surfaces could be treated. Sites with existing stormwater management such as detention or retention basins were not evaluated since they already had some level of treatment. The initial target was tax except properties such as schools, public owned property, and churches. The goal was to confirm that green infrastructure could be used at these sites to capture and treat stormwater runoff from impervious surfaces to reduce pollutant loads to the South Branch Raritan River. All sites require additional soil testing before determining the soil's suitability for green infrastructure. Each site is discussed below, and concept plans are contained in Appendix C.

02030105010010 – Drakes Brook (above Eyland Avenue)

1. American Christian School-South Campus, 126 South Hillside Avenue, Succasunna NJ 07876

The pavement in the front of the building can be converted to porous pavement to capture and infiltrate stormwater runoff from the roof via already disconnected downspouts; the western downspout may require redirection towards the porous pavement. A rain garden with a curb cut can be installed in the turfgrass area near the northwest corner of the building, and a rain garden with a trench drain can be installed south of the building to capture, treat, and infiltrate stormwater runoff from the pavement.

2. Fun-N-Friends Nursery School, 58 Drakesdale Road, Flanders NJ 07836

Rain gardens can be installed in multiple turfgrass areas around the property to capture, treat, and infiltrate stormwater runoff from the rooftops and the driveway. Downspout redirections and disconnections will be required for some of these rain gardens. A gutter system will need to be installed on the western section of the building for the northwestern rain garden. A trench drain and curb cut will be needed for the southwestern rain garden. Existing parking spaces to the south and west of the lot can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt.

3. Holy Wisdom Byzantine Catholic Church, 197 Emmans Road, Roxbury NJ 07836

Parking spaces in the lot next to the southeast building can be converted to porous pavement to capture and infiltrate stormwater runoff from the asphalt and rooftop via already disconnected downspouts. Rain gardens can be installed in multiple turfgrass areas around the property to capture, treat, and infiltrate stormwater runoff from the roofs and pavement. Trench drains and downspout disconnection and redirection will be required for some of these gardens.

4. Jefferson Elementary School, 35 Corn Hollow Road, Succasunna NJ 07876

Parking spaces can be replaced with pervious pavement to capture and infiltrate stormwater. Downspout planter boxes can be installed on multiple locations north of the building. A rain garden can be installed in the parking island to capture, treat, and infiltrate additional stormwater runoff. Downspout planter boxes can be installed near the entrances to capture rooftop runoff and provide visual interest.

5. Lake Rogerene Fire Department, 173 Orben Drive, Landing NJ 07850

Cisterns can be installed to the northeast and southeast of the building to divert and detain the stormwater runoff from the rooftop for later non-potable reuse such as washing vehicles.

6. Ledgewood Baptist Church, 233 Main Street, Ledgewood NJ 07852

Four rain gardens that require downspout disconnection and redirection can be installed in the turfgrass areas around the property building to capture, treat, and infiltrate stormwater runoff from the roofs. One rain garden can be installed in the turfgrass area on the east side of the site to capture, treat, and infiltrate stormwater runoff from the parking lot.

7. Ledgewood Historic Park, 211-209 East Main Street, Ledgewood NJ 07852

A rain garden can be installed in the turfgrass area next to the west building to capture, treat, and infiltrate stormwater runoff from the roof. Three rain gardens, one of which requires downspout disconnection, can be installed next to the east building to capture, treat, and infiltrate stormwater runoff from the roof.

8. Roxbury Township Court Clerk and Police Department, 1715 US-46, Ledgewood NJ 07852

Three rain gardens can be installed in the turfgrass areas on the east and west sides at the front of the building to capture, treat, and infiltrate stormwater runoff from the pavement. The gardens will require curb cuts and trench drains. Parking spaces on the west side of the building and behind the building can be converted to porous pavement to capture and infiltrate stormwater runoff from the parking lot.

9. St. Dunstan's Episcopal Church, 179 South Hillside Avenue, Succasunna NJ 07876

Parking spaces in the lot can be converted to porous pavement using trench drains to redirect, capture and infiltrate stormwater runoff from the pavement. A rain garden with a curb cut can be installed in the turfgrass area near the entrance of the parking lot to capture, treat, and infiltrate stormwater runoff from the pavement. Two rain gardens can be installed near the building entrance to capture, treat, and infiltrate stormwater runoff from the roof via already disconnected downspouts that will require redirection.

10. The Church of Jesus Christ of Latter-Day Saints, 156 Mountain Road, Ledgewood NJ 07852

Several rain gardens that require downspout disconnection and redirection can be installed in the turfgrass areas around the building to capture, treat, and infiltrate stormwater runoff from the roof. One rain garden that requires a curb cut and a trench drain can be installed in the turfgrass area southwest of the building to capture, treat, and infiltrate stormwater runoff from the pavement.

02030105010020 – Drakes Brook (below Eyland Avenue)

11. Calvary Bible Chapel, 76 Main Street, Flanders NJ 07836

Rain gardens can be installed to the east and west of the building to capture, treat, and infiltrate stormwater runoff from the rooftop. This will require the installation of a gutter system on the building. Existing parking spaces to the west and north of the building can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt.

12. Chabad Jewish Center of Mount. Olive, 58 Pleasant Hill Road, Flanders NJ 07836

Rain gardens can be installed to the north and east of the building to capture, treat, and infiltrate stormwater runoff from the rooftop and the driveway. This will require downspout redirections beneath the sidewalk and the driveway, as well as trench drains. A cistern can be installed to the northwest of the building to divert and detain the stormwater runoff from the rooftop for later non-potable reuse such as watering the landscaping vegetation.

13. Flanders Park, 40 Flanders-Bartley Road, Flanders NJ 07836

A rain garden can be installed to the southeast corner of the pavilion to capture, treat, and infiltrate stormwater runoff from the rooftop. A gutter system will need to be installed. Another rain garden can be installed to the west of the driveway entrance to capture, treat, and infiltrate stormwater runoff from the asphalt. A trench drain will be required. The rain garden can be installed near the existing catch basin, which can be used as an overflow. Existing parking spaces to the west of the lot can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt. The basketball courts can be converted to pervious pavement to capture and infiltrate stormwater runoff from the courts.

14. Flanders United Methodist Church & Thrift Shop, 4 Park Place, Flanders NJ 07836

Rain gardens can be installed in multiple turfgrass areas around the buildings using the existing disconnected downspouts to capture, treat, and infiltrate stormwater runoff from the rooftops. Some of the disconnected downspouts will need to be extended to the rain gardens. The existing parking spaces to the north of the thrift shop building can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt.

15. Kiwanis Park, 9 Makin Lane, Succasunna NJ 07876

Parking spaces can be replaced with pervious pavement on the southernmost parking strip in the lot to capture and infiltrate stormwater. A rain garden can be installed near the tennis court to capture stormwater.

16. Mountain View Elementary School, 118 Clover Hill Drive, Flanders NJ 07836

Rain gardens can be installed in multiple turfgrass areas around the property to capture, treat, and infiltrate stormwater runoff from the driveways and the southern parking lot. Curb cuts and a trench drain will be required for some of these rain gardens. Existing parking spaces to the north of the northern lot can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt.

17. Roxbury Community Garden, 281 Eyland Avenue, Succasunna NJ 07876

A cistern can be installed to capture stormwater from the roof of the shed in front of the garden, and the water can be reused for watering plants or other non-potable purposes.

18. St. Thomas Orthodox Church, 50 Flanders-Bartley Road, Flanders NJ 07836

Rain gardens can be installed to the east and west of the building to capture, treat, and infiltrate stormwater runoff from the rooftop. Downspout redirections beneath the sidewalk will be required for the eastern rain garden. Downspout redirection and disconnection will be required for the western rain garden. Existing parking spaces to the north and east of the building can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt.

19. Temple Shalom, 215 South Hillside Avenue, Succasunna NJ 07876

Parking spaces in the lot to the north and south of the building can be converted to porous pavement to capture and infiltrate stormwater runoff from the roof and asphalt; this requires downspout disconnection and trench drains for redirection. A rain garden requiring downspout disconnection can be installed in the turfgrass area in the rear of the building to capture, treat, and infiltrate stormwater runoff from the roof.

20 .Tinc Road School, 24 Tinc Road, Flanders NJ 07836

Rain gardens can be installed in multiple turfgrass areas around the property to capture, treat, and infiltrate stormwater runoff from the driveway. Curb cuts will be required, and a trench drain may also be needed for the rain garden to the north of the school. Existing parking spaces in the lot can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt. Trench drains will be required. The basketball courts can be converted into pervious pavement to capture and infiltrate stormwater runoff from the courts. A cistern can be installed to the northwest of the northern shed to divert and detain the stormwater runoff from the rooftop for later non-potable reuse such as watering the nearby garden. The downspouts can be reworked so that all shed runoff is managed by the cistern.

02030105010040 – Raritan River South Branch (74d 44m 15s to Route 46)

21. Drakestown United Methodist Church, 6 Church Road, Hackettstown NJ 07840

Downspout planter boxes can be installed to capture and retain runoff from the rooftop. Pervious pavement is proposed along the south edge of the parking lot to treat the entire parking lot's drainage area.

22. Mount Olive High School, 18 Corey Road, Flanders NJ 07836

A rain garden can be installed to the south of the eastern sheds to capture, treat, and infiltrate stormwater runoff from the rooftops. This may require gutter installation or reworking of existing downspouts. Existing parking spaces in the eastern, western, and northern lots can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt. The concrete entryway to the south of the school can be replaced with permeable pavers.

23. Sandshore Elementary School, 498 Sand Shore Road, Hackettstown NJ 07840

A rain garden can be installed to the north of the eastern sheds to capture, treat, and infiltrate stormwater runoff from the rooftops. This will require gutter system installations. Existing parking spaces to the south and west of the building can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt. The basketball court can be converted into pervious pavement to capture and infiltrate stormwater runoff from the court.

24. Turkey Brook Park, 30 Flanders Road, Budd Lake NJ 07828

A rain garden can be installed to the northwest corner of the southwestern shed to capture, treat, and infiltrate stormwater runoff from the rooftop. This will require gutter system installation. Another rain garden can be installed to the north of the southwestern parking lot to capture, treat, and infiltrate stormwater runoff from the asphalt. Existing parking spaces to the north, east, and southwest can be converted into pervious pavement to capture and infiltrate stormwater runoff from the asphalt. The tennis and basketball courts can be converted into pervious pavement to capture and infiltrate stormwater runoff from the courts.

02030105010050 – Raritan River South Branch (Long Valley Bridge to 74d44m15s)

25. Benedict A. Cucinella School, 470 Naughright Road, Long Valley NJ 07853

Downspout planter boxes are suggested at the entrance of the school to promote green infrastructure awareness. A section of parking spaces can be converted to pervious pavement to capture and infiltrate runoff from the parking lot. Tree filter boxes can be installed in islands in the parking lot to capture runoff from other spaces in the parking lot.

26. Immanuel Lutheran Church, 40 Coleman Road, Long Valley NJ 07853

In the southwest corner of the property, there is an existing retention basin to which water is conveyed from the rooftop and pavement via connected downspouts and catch basins. This can be converted into a rain garden to capture, treat, and infiltrate stormwater runoff. A trench drain can be installed half-way up the driveway coming from the southwest to increase runoff capture and convey it to the rain garden. Two rain gardens can also be installed off the northwest facade of the house in the southeast section of the property.

27. Long Valley Presbyterian Church, 39 Bartley Road, Long Valley NJ 07853

Rain gardens can be installed off the north and west ends of the parking lot, and the west face of the church to capture, treat, and infiltrate stormwater runoff. In the west end of the parking lot, a trench drain could be installed on the western side of the roundabout to increase stormwater runoff capture. The existing parking spaces off the south and east faces of the building can be converted into pervious pavement to capture and infiltrate stormwater. The pervious pavement off the south face of the building would collect runoff from the parking lot and via downspouts which require disconnection, and the pervious pavement off the east face would collect runoff from the parking lot.

28. Old Farmers Road Elementary School, 51 Old Farmers Road, Long Valley NJ 07853

Two rain gardens can be installed to capture, treat, and infiltrate stormwater runoff from the building's roof as well as the adjacent parking lot.

29. Schooleys Mountain Park Parking, 91 East Springtown Road, Long Valley NJ 07853

Rain gardens can be installed to capture, treat, and infiltrate stormwater runoff coming from the rooftops of buildings in the northwest corner of the property, in the west corners of the central parking lot, and the smaller parking lot further southeast. A bioswale can be installed off the northern edge of the central eastern parking lot to treat stormwater runoff while conveying it toward a catch basin in the western corner of this lot. In the furthest southeast parking lots, rows of parking stalls can be converted to pervious pavement to capture and infiltrate stormwater runoff from the pavement.

30. St. Mark the Evangelist Roman Catholic Church, 59 Spring Lane, Long Valley NJ 07853

A bioretention system can be installed in the southeast corner of the property to mitigate flooding. Additionally, pervious pavement is suggested adjacent to the southwest edge of the building to capture and infiltrate stormwater runoff from the parking lot.

31. Washington Township Department of Public Works, 54 Rock Road, Long Valley NJ 07853

Rain gardens can be installed off the northwest corner and southern edge of the two buildings in the west edge of the property, and off the southern facades of the two buildings in the southeast edge of the property to capture, treat, and infiltrate stormwater from the rooftops via downspouts requiring disconnection. Rows of parking stalls off the west face of the western buildings, south face of the building in the northeast, and northwest corner of the building in the east can be converted to pervious pavement to capture and infiltrate stormwater runoff. The northeast and east buildings require one downspout each to be disconnected.

32. Washington Township Police Department, 1 East Springtown Road, Long Valley NJ 07853

A rain garden can be installed off the southeast facade of the building to capture, treat, and infiltrate stormwater runoff from the rooftop. The rows of parking stalls off the southwest and northeast facades of the building can be converted into pervious pavement to capture and infiltrate stormwater from the rooftop. Two cisterns could be installed off the northeast corner and eastern nook of the building to divert and detain stormwater runoff for later non-potable reuse such as washing police vehicles. All stormwater conveyed from the rooftop is via downspouts which would require disconnection.

33. Washington Township Public Library and Senior Citizen Center, 35 & 37 East Springtown Road, Long Valley NJ 07853

Rain gardens can be installed off the northeast and southwest corners of the senior center, and the south face of the library to capture, treat, and infiltrate stormwater from the roof via disconnected downspouts. Rows of parking stalls in the two parking lots to the north, the small parking lot off the south facade of the senior center, and the southern tip of the library's parking lot can be converted to pervious pavement to capture and infiltrate stormwater from the roof and pavement.

A bioswale can also be installed along the northern half of the library's parking lot to convey water to the catch basins along the way while treating it.

34. West Morris Central High School, 259 Bartley Road, Chester NJ 07930

Rain gardens may be installed off portions of the west, south, and east facades of the school building to capture, treat and infiltrate stormwater runoff. Runoff would be conveyed to these rain gardens via downspouts requiring disconnection. Two existing swales can be converted to bioswales on the north and northwest sections of the property to treat stormwater runoff from adjacent parking lots, while conveying it to catch basins. Rows of parking stalls in the southeastern and northeastern parking lots can be converted to pervious pavement to capture and infiltrate stormwater runoff from the pavement.

35. Zion Lutheran Church and Parish Center, 11 Schooleys Mountain Road, Long Valley NJ 07853

Rain gardens can be installed on the north and southwest faces of the church, the north face of the parish center building, and along the southwest corner of the parking lot to capture, treat, and infiltrate stormwater from the rooftops via disconnected downspouts and from the parking lot.

02030105010060 – Raritan River South Branch (Califon Bridge to Long Valley)

36. Califon Borough Elementary School, 6 School Street, Califon NJ 07830

A rain garden centralized in the courtyard could be installed to collect rooftop stormwater.

37. Califon First Aid Squad, 107 Bank Street, Califon NJ 07830

A rain garden can be installed next to the entrance of the parking lot to capture stormwater from the sloped lot. A cistern can be installed to harvest rainwater from the rooftop. Collected rainwater can be used for washing first aid squad vehicles or be used to water landscaping.

38. Califon Island Park, 111 Bank Street, Califon NJ 07830

Porous pavement can be installed in the rear parking spaces to aid in the infiltration of stormwater.

39. Long Valley Middle School, 51 West Mill Road, Long Valley NJ 07853

Pervious pavement is proposed in a section of parking spaces to capture and infiltrate runoff from the parking lot. A bioretention system is proposed in the north turfgrass area to capture runoff from the roof of the school.

40. St. Luke Parish, 265 West Mill Road, Long Valley NJ 07853

A bioretention system can be installed to infiltrate the water from three disconnected downspouts on the west side of the building. In addition, pervious pavement is proposed along the southeast corner of the parking lot.

41. Washington Township Municipal Building, 43 Schooleys Mountain Road, Long Valley NJ 07853

A rain garden can be installed adjacent to the building to infiltrate water from two connected downspouts. Additionally, pervious pavement can capture and infiltrate the stormwater runoff from the entire parking lot and a portion of the roof. Downspout planter boxes can be installed at downspouts to capture runoff from the roof as well.

02030105010070 – Raritan River South Branch (Stone Mill Gage to Califon)

42. Body of Christ Ministries, 101 Voorhees Road, Glen Gardner NJ 08826

Two bioretention systems are proposed to infiltrate the water from the sloped lawn and a disconnected downspout.

43. Bunnyvale Library, 7 Bunnvale Road, Califon NJ 07830

Rain gardens can be installed to the northeast and to the west of the building using the existing disconnected downspouts to capture, treat, and infiltrate the stormwater runoff from the rooftop. Downspout redirection may be needed. An additional rain garden can be constructed to the south of the parking lot to capture, treat, and infiltrate the stormwater runoff from the asphalt.

44. Califon General Store, 75 Main Street, Califon NJ 07830

Porous pavement can be installed in the rear parking spaces to aid in infiltration of stormwater. A downspout planter box can be constructed along the building to allow roof runoff to be reused.

45. Califon Municipal Office, Allentown Bypass, Allentown NJ 08501

In the parking lot center islands, two bioswales can be installed to help convey the stormwater runoff from the parking lot toward rain gardens in the larger part of the turfgrass islands. The rain gardens can capture, treat, and infiltrate the stormwater runoff that is directed to it by the bioswales to help manage the runoff from the parking lot. Rain gardens can also be placed alongside the roadway to capture the stormwater runoff from the roadway.

46. Califon Train Station, 15 Center Street, Califon NJ 07830

Rain gardens can be installed north of the building and in the turfgrass area east of the building to infiltrate stormwater draining from the parking lot.

47. Califon United Methodist Church, 15 Raritan River Road, Califon NJ 07830

Two rain gardens can be installed to capture, treat, and infiltrate stormwater runoff from the roof. Downspout planter boxes can be constructed along the building to allow roof runoff to be reused.

48. Califon Wine and Spirits, 430 County Road 513, Califon NJ 07830

Areas of the parking lot can be retrofitted with porous pavement to capture stormwater runoff from the parking lot.

49. Coughlin Funeral Home, 15 Academy Street, Califon NJ 07830

A central rain garden can be installed to capture stormwater runoff from the inward sloping rooftops. A downspout planter box can be constructed along the building to allow roof runoff to be reused.

50. Groendyke Associates, 295 County Road 513, Califon NJ 07830

Two bioretention systems are proposed in the front of the building to infiltrate the water from the roof as well as the downspouts.

51. James M. Murray CPA, 37 School Street, Califon NJ 07830

A rain garden can be installed at the end of the parking lot to capture, treat, and infiltrate stormwater runoff from the parking lot. Downspout planter boxes can be constructed along the building to allow roof runoff to be reused.

52. Lower Valley Presbyterian Church, 445 County Road 513, Califon NJ 07830

A rain garden can be installed to capture, treat, and infiltrate stormwater runoff from the roof. Downspout planter boxes can be constructed along the building to allow roof runoff to be reused.

53. Oldwick Village Auto Body, 363 County Road 513, Califon NJ 07830

Two rainwater harvesting cisterns are proposed on opposite corners of the building to capture stormwater runoff from the roof. The water can be used for washing vehicles, watering plants, or other non-potable purposes.

54. St. John Neumann Roman Catholic Church, 398 County Road 513, Califon NJ 07830

Rain gardens can be installed in multiple turfgrass areas around the property to capture, treat, and infiltrate the stormwater runoff from various rooftops. This may require downspout redirections and disconnections, as well as trench drains. Existing parking spaces in the northern, southern, and western parking lots can be converted into pervious pavement to capture and infiltrate the stormwater runoff from the asphalt, roadway, and sidewalks. This may require trench drains.

55. Staianos Furniture, 442 County Road 513, Califon NJ 07830

Porous pavement can be installed along the parking spots in the back lot of the building. The downspouts currently empty onto asphalt which is impervious and does not aid in infiltration.

56. United States Postal Service, 53 Main Street, Califon NJ 07830

Porous pavement can be installed to collect stormwater from both the disconnected downspouts as well as from the parking lot surface.

02030105010080 – Raritan River South Branch (Spruce Run-Stone Mill Gage)

57. Borough of High Bridge Municipal Buildings, 97 West Main Street, High Bridge NJ 08829

Parking spaces in the parking lot to the north and east of the building can be converted to porous pavement to capture and infiltrate stormwater runoff from the parking lot and downspouts. Porous pavements can support parked vehicles while allowing stormwater to infiltrate and have an underlying stone layer to store and slowly release captured stormwater into the ground. Rain gardens can be installed in the turfgrass areas adjacent to the parking lot areas to capture additional stormwater runoff from the parking lot.

58. Clinton Presbyterian Church, 91 Center Street, Clinton NJ 08809

Porous pavement can be installed in the northwestern corner of the parking lot to capture stormwater from the parking lot as well as the nearby building's disconnected downspouts. A downspout planter box can be installed next to the south entrance of the building to capture and treat the rooftop runoff.

59. Clinton United Methodist Church, 12 Halstead Street, Clinton NJ 08809

Rain gardens can be installed in multiple turfgrass areas around the property to capture, treat, and infiltrate the stormwater runoff from the asphalt and rooftops. This will require downspout disconnections, trench drains, and curb cuts. Existing parking spaces in the east and south of the lot can be converted into pervious pavement to capture and infiltrate the stormwater runoff from the asphalt. The pervious pavement will also manage some rooftop runoff, as the connected downspouts on the east of the church building direct runoff to the parking lot. Trench drains will be needed to intercept and redirect some of the parking lot runoff to the pervious pavement.

60. East Main Street Alley, Washington Avenue, High Bridge NJ 08829

The alleyway between Washington Avenue and Elm Street can be converted to a low-speed pervious pavement road. It will capture and infiltrate the nearby stormwater runoff from Washington Avenue, Elm Street, and the adjacent properties.

61. High Bridge Department of Works, 26 Main Street, High Bridge NJ 08829

Downspouts on the garages at the High Bridge Department of Public Works can be connected to cisterns to harvest rainwater from the rooftops. Collected rainwater from the cisterns can then be used for washing public works vehicles as part of a green car wash or be used to water landscaping.

62. High Bridge Elementary School, 40 Fairview Avenue, High Bridge NJ 08829

A rain garden can be installed in the turfgrass area near the garden shed and another near the rear parking lot to capture, treat, and infiltrate stormwater runoff from the roof and parking lot. Parking spaces can be converted to porous pavement to intercept water before reaching nearby catch basins. A small cistern could be installed on the shed to collect water for use in watering the garden.

63. High Bridge Fire Department, 7 Maryland Avenue, High Bridge NJ 08829

The connected downspouts of the High Bridge Fire Department, near the south end, can be rerouted into a cistern. The cistern can capture and store rainwater from the rooftop that can then be used for washing fire department vehicles or watering landscaping. The parking spaces adjacent to the side building can be repaved with porous asphalt.

64. High Bridge Golf Club, 203 Cregar Road, High Bridge NJ 08829

Near the entrance of the main building, a rain garden can be installed to collect water from the rooftop. Areas of the parking lot can be retrofitted with porous pavement to capture stormwater runoff from the parking lot.

65. High Bridge Middle School, 50 Thomas Street, High Bridge NJ 08829

Rain gardens can be installed on the front lawn of the school to capture, filter, and infiltrate rainwater from the rooftop by redirecting downspouts into them. The blacktop playground area could be partially or fully repaved with pervious pavement to capture additional stormwater.

66. High Bridge Public Library, 71 Main Street, High Bridge NJ 08829

A rain barrel could be installed at one of the downspouts to collect rainwater to be used for watering the plants at the front of the building. A rain garden could be installed adjacent to the neighboring shed if the homeowner gives permission to redirect their gutter into it. The parking space could be repaved with porous asphalt to capture a majority of the parking lot’s runoff.

67. High Bridge Reformed Church, 23 Church Street, High Bridge NJ 08829

A rain garden to the east the church can be installed to capture, filter, and infiltrate roof runoff. The garden will also provide aesthetic value to the property, attract natural pollinators, and create an education experience.

68. High Bridge United Methodist Church, 36 Church Street, High Bridge NJ 08829

A rain garden can be installed to the west of the church to capture, treat, and infiltrate stormwater from the rooftop. The garden will provide aesthetic value to the property, attract natural pollinators, and create an educational experience.

69. Hilltop Deli & Catering, 115 Fairview Avenue, High Bridge NJ 08829

Downspout planter boxes can be installed at the downspouts of the building. Downspout planter boxes are constructed at the base of downspouts with plants that will utilize rooftop runoff.

70. Hunterdon Art Museum, 7 Lower Center Street, Clinton NJ 08809

A stormwater planter can be installed in the sidewalk to intercept stormwater runoff from the roadway or sidewalk to allow the stormwater to infiltrate into the ground. Downspout planter boxes can be constructed along the building to allow roof runoff to be reused.

71. St. Jospeh Church, 59 Main Street, High Bridge NJ 08829

The downspouts along the north side of the building can be rerouted into downspout planter boxes to filter roof runoff. A small rain garden can be installed at the front of the building by redirecting downspouts into it.

72. Union Forge Park, 16-34 Washington Avenue, High Bridge NJ 08829

The southern corner of the parking lot can be converted to pervious pavement to allow for capture and infiltration of the stormwater runoff from the parking lot area. A bioretention system can be installed north of the parking lot to capture, treat, and infiltrate the stormwater runoff from the nearby turfgrass and uphill area.

73. United States Postal Service, 10 McDonald Street, High Bridge NJ 08829

The parking spaces to the north and south of the building can be converted into porous pavement. Porous pavement will allow water directed from the rooftop to pass through where it is stored and will allow it to infiltrate into the ground.

74. Voorhees Residential Community Home, 201 County Road 513, Glen Gardner NJ 08826

A bioretention system is proposed at the entrance of the property to reduce erosion and infiltrate the stormwater runoff from the parking area.

For the sites listed above (See Figure 10), mainly two green infrastructure practices are recommended: bioretention (rain gardens and bioswales) and porous pavement. Each of these practices can reduce total phosphorus concentrations by 60% (NJDEP, 2004). These practices, in concert, can reduce total phosphorus loads by 90% if designed to capture, treat, and infiltrate the 2-year design storm. For the South Branch Raritan River Watershed study area, Table 32 shows the drainage area proposed to manage for each site and the site of the green infrastructure practices. Tables 33 and 34 below show TP and TSS load reductions that can be achieved for each retrofitted site for each watershed and each HUC14. Load reductions assume a reduction in TP of 60% (NJDEP, 2004) with an underdrain and 90% without an underdrain (i.e., complete infiltration of runoff from the water quality storm). Load reductions assume a reduction in TSS of 90% (NJDEP, 2004).

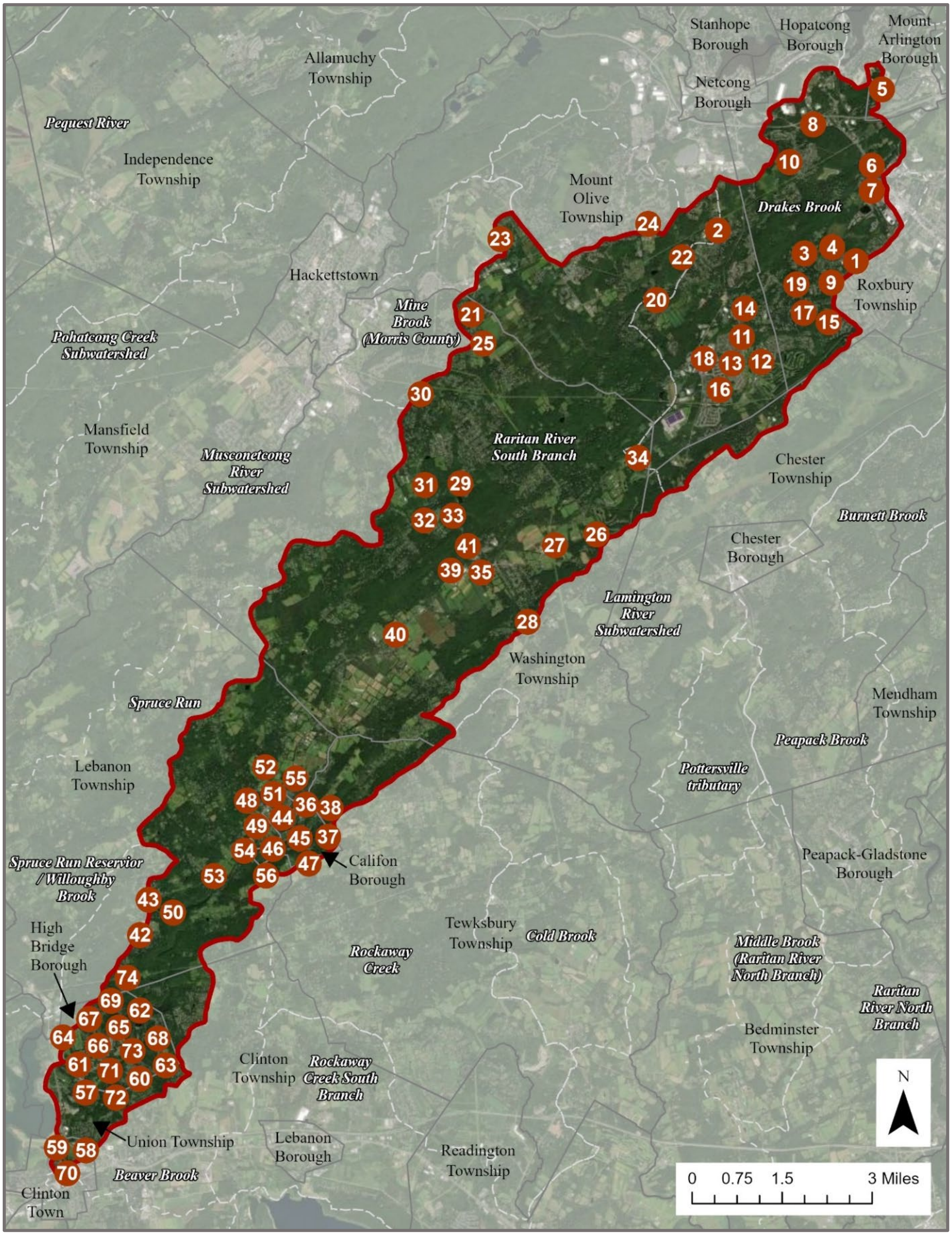

Figure 11: Sites within the South Branch Raritan River Watershed study area suitable for retrofit with green infrastructure

Table 32: South Branch Raritan River Watershed study area proposed retrofit sites with drainage area to be treated and size of green infrastructure practices

Site ID	Site Name and Address	Lot Area (sq.ft.)	Impervious Cover for Lot (sq.ft.)	Total Drainage Area (sq.ft.)	Size of Rain Garden Practice (sq.ft.)	Size of Porous Asphalt Practice (sq.ft.)	Size of Other Practice
HUC 02030105010010							
1	American Christian School-South Campus, 126 South Hillside Avenue, Succasunna NJ 07876	193,601	60,281	12,575	2,740	900	0
2	Fun-N-Friends Nursery School, 58 Drakesdale Road, Flanders NJ 07836	225,845	55,191	9,240	710	1,600	0
3	Holy Wisdom Byzantine Catholic Church, 197 Emmans Road, Roxbury NJ 07836	393,578	27,418	7,410	1,090	1,790	0
4	Jefferson Elementary School, 35 Corn Hollow Road, Succasunna NJ 07876	628,915	192,288	20,340	740	178	8[2]
5	Lake Rogerene Fire Department, 173 Orben Drive, Landing NJ 07850	11,949	9,910	1,295	0	0	1,100[1]
6	Ledgewood Baptist Church, 233 Main Street, Ledgewood NJ 07852	100,592	57,354	7,585	1,895	0	0
7	Ledgewood Historic Park, 211-209 East Main Street, Ledgewood NJ 07852	227,319	125,744	1,370	345	0	0
8	Roxbury Township Court Clerk and Police Department, 1715 US-46, Ledgewood NJ 07852	227,319	125,744	47,055	2,660	6,505	0

9	St. Dunstan's Episcopal Church, 179 South Hillside Avenue, Succasunna NJ 07876	214,839	41,200	23,815	1,970	2,885	0
10	The Church of Jesus Christ of Latter-Day Saints, 156 Mountain Road, Ledgewood NJ 07852	251,582	98,786	16,650	4,170	0	0
HUC 02030105010020							
11	Calvary Bible Chapel, 76 Main Street, Flanders NJ 07836	37,042	16,792	12,870	660	3,860	0
12	Chabad Jewish Center of Mount. Olive, 58 Pleasant Hill Road, Flanders NJ 07836	101,680	41,364	6,555	1,545	0	300[1]
13	Flanders Park, 40 Flanders-Bartley Road, Flanders NJ 07836	830,055	109,178	37,500	600	22,310	0
14	Flanders United Methodist Church & Thrift Shop, 4 Park Place, Flanders NJ 07836	59,170	29,335	9,240	710	1,600	0
15	Kiwanis Park, 9 Makin Lane, Succasunna NJ 07876	4,578,278	88,107	21,900	1,630	3,460	0
16	Mountain View Elementary School, 118 Clover Hill Drive, Flanders NJ 07836	867,709	237,638	46,150	7,270	4,715	0
17	Roxbury Community Garden, 281 Eyland Avenue, Succasunna NJ 07876	371,852	16,186	250	0	0	200[1]
18	St. Thomas Orthodox Church, 50 Flanders-Bartley Road, Flanders NJ 07836	130,673	44,957	30,640	675	6,410	0
19	Temple Shalom, 215 South Hillside Avenue, Succasunna NJ 07876	178,553	103,414	26,720	250	4,620	0

20	Tinc Road School, 24 Tinc Road, Flanders NJ 07836	1,306,368	219,401	81,290	7,970	13,555	1,500[1]
HUC 02030105010040							
21	Drakestown United Methodist Church, 6 Church Road, Hackettstown NJ 0784	42,024	16,468	6,838	0	1,630	2[2]
22	Mount Olive High School, 18 Corey Road, Flanders NJ 07836	2,112,315	967,478	195,085	380	50,120	0
23	Sandshore Elementary School, 498 Sand Shore Road, Hackettstown NJ 07840	868,001	220,998	47,055	560	16,075	0
24	Turkey Brook Park, 30 Flanders Road, Budd Lake NJ 07828	11,330,892	867,872	103,490	1,800	41,655	0
HUC 02030105010050							
25	Benedict A. Cucinella School, 470 Naughright Road, Long Valley NJ 07853	1,278,641	287,755	38,880	0	2,715	2[2] 33
26	Immanuel Lutheran Church, 40 Coleman Road, Long Valley NJ 07853	218,150	33,865	26,010	6,505	0	0
27	Long Valley Presbyterian Church, 39 Bartley Road, Long Valley NJ 07853	441,899	71,830	38,430	3,695	5,520	0
28	Old Farmers Road Elementary School, 51 Old Farmers Road, Long Valley NJ 07853	636,598	151,534	13,400	3,350	0	0
29	Schooleys Mountain Park Parking, 91 East Springtown Road, Long Valley NJ 07853	1,975,631	206,323	73,645	10,145	10,680	0

30	St. Mark the Evangelist Roman Catholic Church, 59 Spring Lane, Long Valley NJ 07853	366,270	158,478	62,630	1,525	8,910	0
31	Washington Township Department of Public Works, 54 Rock Road, Long Valley NJ 07853	576,734	329,629	26,625	1,385	5,405	0
32	Washington Township Police Department, 1 East Springtown Road, Long Valley NJ 07853	105,858	69,597	27,530	535	6,040	1,650[1]
33	Washington Township Public Library and Senior Citizen Center, 35 & 37 East Springtown Road, Long Valley NJ 07853	3,126,890	292,858	66,115	5,080	13,410	0
34	West Morris Central High School, 259 Bartley Road, Chester NJ 07930	1,827,488	734,334	191,735	40,590	8,280	0
35	Zion Lutheran Church and Parish Center, 11 Schooleys Mountain Road, Long Valley NJ 07853	401,736	63,124	15,560	3,885	0	0
HUC 02030105010060							
36	Califon Borough Elementary School, 6 School Street, Califon NJ 07830	96,268	49,605	4,155	1,040	0	0
37	Califon First Aid Squad, 107 Bank Street, Califon NJ 07830	27,012	14,648	2,960	430	0	1,000[1]
38	Califon Island Park, 111 Bank Street, Califon NJ 07830	537,044	31,444	10,060	0	2,400	0
39	Long Valley Middle School, 51 West Mill Road, Long Valley NJ 07853	1,089,160	349,813	22,605	600	3,610	0

40	St. Luke Parish, 265 West Mill Road, Long Valley NJ 07853	494,989	136,492	29,195	580	4,800	0
41	Washington Township Municipal Building, 43 Schooleys Mountain Road, Long Valley NJ 07853	42,944	34,223	22,710	400	4,020	6[2]
HUC 02030105010070							
42	Body of Christ Ministries, 101 Voorhees Road, Glen Gardner NJ 08826	205,769	101,155	7,185	1,800	0	0
43	Bunnyvale Library, 7 Bunnvale Road, Califon NJ 07830	43,965	13,775	6,420	1,605	0	0
44	Califon General Store, 75 Main Street, Califon NJ 07830	12,272	4,664	5,030	0	800	1[2]
45	Califon Municipal Office, Allentown Bypass, Allentown NJ 08501	11,422	4,817	2,275	440	0	2[2]
46	Califon Train Station, 15 Center Street, Califon NJ 07830	41,501	19,639	840	195	0	0
47	Califon United Methodist Church, 15 Raritan River Road, Califon NJ 07830	39,832	25,759	3,150	645	0	2[2]
48	Califon Wine and Spirits, 430 County Road 513, Califon NJ 07830	23,453	15,317	6,600	0	1,135	0
49	Coughlin Funeral Home, 15 Academy Street, Califon NJ 07830	7,381	4,062	600	100	0	1[2]
50	Groendyke Associates, 295 County Road 513, Califon NJ 07830	26,175	15,042	3,555	890	0	0
51	James M. Murray CPA, 37 School Street, Califon NJ 07830	44,433	8,775	2,580	600	0	2[2]

52	Lower Valley Presbyterian Church, 445 County Road 513, Califon NJ 07830	101,066	47,178	1,410	170	0	2[2]
53	Oldwick Village Auto Body, 363 County Road 513, Califon NJ 07830	167,230	12,467	2,000	0	0	1,000[1]
54	St. John Neumann Roman Catholic Church, 398 County Road 513, Califon NJ 07830	1,350,160	122,936	52,840	2,460	10,050	0
55	Staianos Furniture, 442 County Road 513, Califon NJ 07830	94,240	61,927	2,735	0	800	0
56	United States Postal Service, 53 Main Street, Califon NJ 07830	10,212	8,102	3,640	0	1,000	0
HUC 02030105010080							
57	Borough of High Bridge Municipal Buildings, 97 West Main Street, High Bridge NJ 08829	233,540	53,215	14,520	1,650	3,925	0
58	Clinton Presbyterian Church, 91 Center Street, Clinton NJ 08809	71,446	31,409	4,600	0	970	1[2]
59	Clinton United Methodist Church, 12 Halstead Street, Clinton NJ 08809	56,694	45,045	34,825	405	6,965	0
60	East Main Street Alley, Washington Avenue, High Bridge NJ 08829	121,730	55,855	54,090	0	8,240	0
61	High Bridge Department of Works, 26 Main Street, High Bridge NJ 08829	139,030	57,930	6,415	0	0	5,000[1]
62	High Bridge Elementary School, 40 Fairview Avenue, High Bridge NJ 08829	983,060	197,850	34,040	800	6,700	400[1]

63	High Bridge Fire Department, 7 Maryland Avenue, High Bridge NJ 08829	26,190	12,005	4,450	0	900	2,200[1]
64	High Bridge Golf Club, 203 Cregar Road, High Bridge NJ 08829	4,084,580	280,165	18,870	185	3,240	0
65	High Bridge Middle School, 50 Thomas Street, High Bridge NJ 08829	96,240	69,510	13,400	600	4,000	0
66	High Bridge Public Library, 71 Main Street, High Bridge NJ 08829	13,155	10,300	3,595	50	900	0
67	High Bridge Reformed Church, 23 Church Street, High Bridge NJ 08829	7,730	3,920	1,400	350	0	0
68	High Bridge United Methodist Church, 36 Church Street, High Bridge NJ 08829	6,540	2,780	1,620	410	0	0
69	Hilltop Deli & Catering, 115 Fairview Avenue, High Bridge NJ 08829	7,040	2,990	430	0	0	2[2]
70	Hunterdon Art Museum, 7 Lower Center Street, Clinton NJ 08809	41,440	11,704	1,540	0	0	3[2] 240[4]
71	St. Jospeh Church, 59 Main Street, High Bridge NJ 08829	5,990	4,870	1,205	140	0	3[2]
72	Union Forge Park, 16-34 Washington Avenue, High Bridge NJ 08829	311,670	40,355	22,350	1,850	2,800	0
73	United States Postal Service, 10 McDonald Street, High Bridge NJ 08829	10,090	7,228	3,540	0	1,300	0
74	Voorhees Residential Community Home, 201 County Road 513, Glen Gardner NJ 08826	18,782,281	626,716	7,480	1,830	0	0

	TOTALS:	**64,257,132**	**8,423,030**	**1,723,533**	**132,010**	**308,915**	**14,350[1]** **37[2]** **3[3]** **240[4]**

[1] Rainwater harvesting systems (gallons)
[2] Planter boxes (number of boxes)
[3] Tree filter boxes (number of boxes)
[4] Stormwater planters (square feet)

Table 33: Load reductions for proposed retrofit sites in South Branch Raritan River Watershed study area

Site ID	Site Name and Address	TP Loading reduction with underdrain (lbs/yr)	TP Loading reduction w/o underdrain (lbs/yr)
HUC 02030105010010			
1	American Christian School-South Campus, 126 South Hillside Avenue, Succasunna NJ 07876	1.74	2.61
2	Fun-N-Friends Nursery School, 58 Drakesdale Road, Flanders NJ 07836	1.62	2.43
3	Holy Wisdom Byzantine Catholic Church, 197 Emmans Road, Roxbury NJ 07836	0.78	1.17
4	Jefferson Elementary School, 35 Corn Hollow Road, Succasunna NJ 07876	5.58	8.37
5	Lake Rogerene Fire Department, 173 Orben Drive, Landing NJ 07850	0.30	0.45
6	Ledgewood Baptist Church, 233 Main Street, Ledgewood NJ 07852	1.68	2.52
7	Ledgewood Historic Park, 211-209 East Main Street, Ledgewood NJ 07852	0.24	0.36
8	Roxbury Township Court Clerk and Police Department, 1715 US-46, Ledgewood NJ 07852	3.66	5.49
9	St. Dunstan's Episcopal Church, 179 South Hillside Avenue, Succasunna NJ 07876	1.20	1.80
10	The Church of Jesus Christ of Latter-Day Saints, 156 Mountain Road, Ledgewood NJ 07852	2.88	4.32

HUC 02030105010020			
11	Calvary Bible Chapel, 76 Main Street, Flanders NJ 07836	0.48	0.72
12	Chabad Jewish Center of Mount. Olive, 58 Pleasant Hill Road, Flanders NJ 07836	1.20	1.80
13	Flanders Park, 40 Flanders-Bartley Road, Flanders NJ 07836	3.18	4.77
14	Flanders United Methodist Church & Thrift Shop, 4 Park Place, Flanders NJ 07836	0.84	1.26
15	Kiwanis Park, 9 Makin Lane, Succasunna NJ 07876	2.52	3.78
16	Mountain View Elementary School, 118 Clover Hill Drive, Flanders NJ 07836	6.90	10.35
17	Roxbury Community Garden, 281 Eyland Avenue, Succasunna NJ 07876	0.48	0.72
18	St. Thomas Orthodox Church, 50 Flanders-Bartley Road, Flanders NJ 07836	1.32	1.98
19	Temple Shalom, 215 South Hillside Avenue, Succasunna NJ 07876	3.00	4.50
20	Tinc Road School, 24 Tinc Road, Flanders NJ 07836	6.36	9.54
HUC 02030105010040			
21	Drakestown United Methodist Church, 6 Church Road, Hackettstown NJ 0784	0.48	0.72
22	Mount Olive High School, 18 Corey Road, Flanders NJ 07836	27.96	41.94
23	Sandshore Elementary School, 498 Sand Shore Road, Hackettstown NJ 07840	6.42	9.63
24	Turkey Brook Park, 30 Flanders Road, Budd Lake NJ 07828	25.08	37.62
HUC 02030105010050			
25	Benedict A. Cucinella School, 470 Naughright Road, Long Valley NJ 07853	8.34	12.51

26	Immanuel Lutheran Church, 40 Coleman Road, Long Valley NJ 07853	0.96	1.44
27	Long Valley Presbyterian Church, 39 Bartley Road, Long Valley NJ 07853	2.10	3.15
28	Old Farmers Road Elementary School, 51 Old Farmers Road, Long Valley NJ 07853	4.38	6.57
29	Schooleys Mountain Park Parking, 91 East Springtown Road, Long Valley NJ 07853	5.94	8.91
30	St. Mark the Evangelist Roman Catholic Church, 59 Spring Lane, Long Valley NJ 07853	4.56	6.84
31	Washington Township Department of Public Works, 54 Rock Road, Long Valley NJ 07853	9.54	14.31
32	Washington Township Police Department, 1 East Springtown Road, Long Valley NJ 07853	2.04	3.06
33	Washington Township Public Library and Senior Citizen Center, 35 & 37 East Springtown Road, Long Valley NJ 07853	8.46	12.69
34	West Morris Central High School, 259 Bartley Road, Chester NJ 07930	21.24	31.86
35	Zion Lutheran Church and Parish Center, 11 Schooleys Mountain Road, Long Valley NJ 07853	1.80	2.70
HUC 02030105010060			
36	Califon Borough Elementary School, 6 School Street, Califon NJ 07830	1.44	2.16
37	Califon First Aid Squad, 107 Bank Street, Califon NJ 07830	0.42	0.63
38	Califon Island Park, 111 Bank Street, Califon NJ 07830	0.90	1.35
39	Long Valley Middle School, 51 West Mill Road, Long Valley NJ 07853	10.14	15.21
40	St. Luke Parish, 265 West Mill Road, Long Valley NJ 07853	3.96	5.94
41	Washington Township Municipal Building, 43 Schooleys Mountain Road, Long Valley NJ 07853	1.38	2.07

HUC 02030105010070			
42	Body of Christ Ministries, 101 Voorhees Road, Glen Gardner NJ 08826	2.94	4.41
43	Bunnyvale Library, 7 Bunnvale Road, Califon NJ 07830	0.42	0.63
44	Califon General Store, 75 Main Street, Califon NJ 07830	0.12	0.18
45	Califon Municipal Office, Allentown Bypass, Allentown NJ 08501	0.12	0.18
46	Califon Train Station, 15 Center Street, Califon NJ 07830	0.54	0.81
47	Califon United Methodist Church, 15 Raritan River Road, Califon NJ 07830	0.72	1.08
48	Califon Wine and Spirits, 430 County Road 513, Califon NJ 07830	0.42	0.63
49	Coughlin Funeral Home, 15 Academy Street, Califon NJ 07830	0.12	0.18
50	Groendyke Associates, 295 County Road 513, Califon NJ 07830	0.42	0.63
51	James M. Murray CPA, 37 School Street, Califon NJ 07830	0.24	0.36
52	Lower Valley Presbyterian Church, 445 County Road 513, Califon NJ 07830	1.38	2.07
53	Oldwick Village Auto Body, 363 County Road 513, Califon NJ 07830	0.36	0.54
54	St. John Neumann Roman Catholic Church, 398 County Road 513, Califon NJ 07830	3.54	5.31
55	Staianos Furniture, 442 County Road 513, Califon NJ 07830	1.80	2.70
56	United States Postal Service, 53 Main Street, Califon NJ 07830	0.24	0.36

HUC 02030105010080			
57	Borough of High Bridge Municipal Buildings, 97 West Main Street, High Bridge NJ 08829	1.56	2.34
58	Clinton Presbyterian Church, 91 Center Street, Clinton NJ 08809	0.90	1.35
59	Clinton United Methodist Church, 12 Halstead Street, Clinton NJ 08809	1.32	1.98
60	East Main Street Alley, Washington Avenue, High Bridge NJ 08829	1.62	2.43
61	High Bridge Department of Works, 26 Main Street, High Bridge NJ 08829	1.68	2.52
62	High Bridge Elementary School, 40 Fairview Avenue, High Bridge NJ 08829	5.70	8.55
63	High Bridge Fire Department, 7 Maryland Avenue, High Bridge NJ 08829	0.36	0.54
64	High Bridge Golf Club, 203 Cregar Road, High Bridge NJ 08829	8.10	12.15
65	High Bridge Middle School, 50 Thomas Street, High Bridge NJ 08829	2.04	3.06
66	High Bridge Public Library, 71 Main Street, High Bridge NJ 08829	0.30	0.45
67	High Bridge Reformed Church, 23 Church Street, High Bridge NJ 08829	0.12	0.18
68	High Bridge United Methodist Church, 36 Church Street, High Bridge NJ 08829	0.06	0.09
69	Hilltop Deli & Catering, 115 Fairview Avenue, High Bridge NJ 08829	0.06	0.09
70	Hunterdon Art Museum, 7 Lower Center Street, Clinton NJ 08809	0.36	0.54
71	St. Jospeh Church, 59 Main Street, High Bridge NJ 08829	0.12	0.18
72	Union Forge Park, 16-34 Washington Avenue, High Bridge NJ 08829	1.14	1.71

73	United States Postal Service, 10 McDonald Street, High Bridge NJ 08829	0.14	0.21
74	Voorhees Residential Community Home, 201 County Road 513, Glen Gardner NJ 08826	18.12	27.18
	TOTALS:	**250.58**	**375.87**

Table 34: Load reductions for proposed retrofit sites in South Branch Raritan River Watershed study area

Site ID	Site Name and Address	TSS Loading Reduction (lbs/yr)
1	American Christian School-South Campus, 126 South Hillside Avenue, Succasunna NJ 07876	205.0
2	Fun-N-Friends Nursery School, 58 Drakesdale Road, Flanders NJ 07836	60.6
3	Holy Wisdom Byzantine Catholic Church, 197 Emmans Road, Roxbury NJ 07836	130.0
4	Jefferson Elementary School, 35 Corn Hollow Road, Succasunna NJ 07876	418.0
5	Lake Rogerene Fire Department, 173 Orben Drive, Landing NJ 07850	56.9
6	Ledgewood Baptist Church, 233 Main Street, Ledgewood NJ 07852	19.3
7	Ledgewood Historic Park, 211-209 East Main Street, Ledgewood NJ 07852	19.9
8	Roxbury Township Court Clerk and Police Department, 1715 US-46, Ledgewood NJ 07852	81.2
9	St. Dunstan’s Episcopal Church, 179 South Hillside Avenue, Succasunna NJ 07876	106.5
10	The Church of Jesus Christ of Latter-Day Saints, 156 Mountain Road, Ledgewood NJ 07852	63.3
11	Calvary Bible Chapel, 76 Main Street, Flanders NJ 07836	16.8

12	Chabad Jewish Center of Mount. Olive, 58 Pleasant Hill Road, Flanders NJ 07836	62.2
13	Flanders Park, 40 Flanders-Bartley Road, Flanders NJ 07836	36.3
14	Flanders United Methodist Church & Thrift Shop, 4 Park Place, Flanders NJ 07836	219.9
15	Kiwanis Park, 9 Makin Lane, Succasunna NJ 07876	129.8
16	Mountain View Elementary School, 118 Clover Hill Drive, Flanders NJ 07836	186.1
17	Roxbury Community Garden, 281 Eyland Avenue, Succasunna NJ 07876	230.9
18	St. Thomas Orthodox Church, 50 Flanders-Bartley Road, Flanders NJ 07836	239.4
19	Temple Shalom, 215 South Hillside Avenue, Succasunna NJ 07876	817.6
20	Tinc Road School, 24 Tinc Road, Flanders NJ 07836	49.6
21	Drakestown United Methodist Church, 6 Church Road, Hackettstown NJ 0784	1,157.7
22	Mount Olive High School, 18 Corey Road, Flanders NJ 07836	287.2
23	Sandshore Elementary School, 498 Sand Shore Road, Hackettstown NJ 07840	42.6
24	Turkey Brook Park, 30 Flanders Road, Budd Lake NJ 07828	16.2
25	Benedict A. Cucinella School, 470 Naughright Road, Long Valley NJ 07853	11.5
26	Immanuel Lutheran Church, 40 Coleman Road, Long Valley NJ 07853	12.3
27	Long Valley Presbyterian Church, 39 Bartley Road, Long Valley NJ 07853	48.3
28	Old Farmers Road Elementary School, 51 Old Farmers Road, Long Valley NJ 07853	20.2

29	Schooleys Mountain Park Parking, 91 East Springtown Road, Long Valley NJ 07853	166.8
30	St. Mark the Evangelist Roman Catholic Church, 59 Spring Lane, Long Valley NJ 07853	29.9
31	Washington Township Department of Public Works, 54 Rock Road, Long Valley NJ 07853	194.9
32	Washington Township Police Department, 1 East Springtown Road, Long Valley NJ 07853	51.5
33	Washington Township Public Library and Senior Citizen Center, 35 & 37 East Springtown Road, Long Valley NJ 07853	508.0
34	West Morris Central High School, 259 Bartley Road, Chester NJ 07930	255.9
35	Zion Lutheran Church and Parish Center, 11 Schooleys Mountain Road, Long Valley NJ 07853	33.5
36	Califon Borough Elementary School, 6 School Street, Califon NJ 07830	2,589.8
37	Califon First Aid Squad, 107 Bank Street, Califon NJ 07830	249.1
38	Califon Island Park, 111 Bank Street, Califon NJ 07830	228.1
39	Long Valley Middle School, 51 West Mill Road, Long Valley NJ 07853	69.4
40	St. Luke Parish, 265 West Mill Road, Long Valley NJ 07853	170.9
41	Washington Township Municipal Building, 43 Schooleys Mountain Road, Long Valley NJ 07853	451.2
42	Body of Christ Ministries, 101 Voorhees Road, Glen Gardner NJ 08826	121.2
43	Bunnyvale Library, 7 Bunnvale Road, Califon NJ 07830	364.1
44	Califon General Store, 75 Main Street, Califon NJ 07830	982.0
45	Califon Municipal Office, Allentown Bypass, Allentown NJ 08501	66.9

46	Califon Train Station, 15 Center Street, Califon NJ 07830	68.0
47	Califon United Methodist Church, 15 Raritan River Road, Califon NJ 07830	3,997.8
48	Califon Wine and Spirits, 430 County Road 513, Califon NJ 07830	913.2
49	Coughlin Funeral Home, 15 Academy Street, Califon NJ 07830	113.3
50	Groendyke Associates, 295 County Road 513, Califon NJ 07830	794.6
51	James M. Murray CPA, 37 School Street, Califon NJ 07830	41.0
52	Lower Valley Presbyterian Church, 445 County Road 513, Califon NJ 07830	237.0
53	Oldwick Village Auto Body, 363 County Road 513, Califon NJ 07830	37.5
54	St. John Neumann Roman Catholic Church, 398 County Road 513, Califon NJ 07830	519.6
55	Staianos Furniture, 442 County Road 513, Califon NJ 07830	170.3
56	United States Postal Service, 53 Main Street, Califon NJ 07830	408.2
57	Borough of High Bridge Municipal Buildings, 97 West Main Street, High Bridge NJ 08829	185.8
58	Clinton Presbyterian Church, 91 Center Street, Clinton NJ 08809	427.3
59	Clinton United Methodist Church, 12 Halstead Street, Clinton NJ 08809	906.7
60	East Main Street Alley, Washington Avenue, High Bridge NJ 08829	3,586.2
61	High Bridge Department of Works, 26 Main Street, High Bridge NJ 08829	1,189.1
62	High Bridge Elementary School, 40 Fairview Avenue, High Bridge NJ 08829	140.0

63	High Bridge Fire Department, 7 Maryland Avenue, High Bridge NJ 08829	296.8
64	High Bridge Golf Club, 203 Cregar Road, High Bridge NJ 08829	626.1
65	High Bridge Middle School, 50 Thomas Street, High Bridge NJ 08829	852.6
66	High Bridge Public Library, 71 Main Street, High Bridge NJ 08829	654.8
67	High Bridge Reformed Church, 23 Church Street, High Bridge NJ 08829	1,362.1
68	High Bridge United Methodist Church, 36 Church Street, High Bridge NJ 08829	287.6
69	Hilltop Deli & Catering, 115 Fairview Avenue, High Bridge NJ 08829	1,210.1
70	Hunterdon Art Museum, 7 Lower Center Street, Clinton NJ 08809	3,034.4
71	St. Jospeh Church, 59 Main Street, High Bridge NJ 08829	260.8
72	Union Forge Park, 16-34 Washington Avenue, High Bridge NJ 08829	1,445.5
73	United States Postal Service, 10 McDonald Street, High Bridge NJ 08829	564.0
74	Voorhees Residential Community Home, 201 County Road 513, Glen Gardner NJ 08826	198.0
	TOTALS:	**35,806.2**

Recommendation for Rain Gardens to Manage Rooftop Runoff

Empowering and engaging the community to implement stormwater management practices on their properties can have a positive cumulative impact on the health of local waterways and can help reduce localized flooding from small storm events. Property owners typically are willing to implement two practices to address stormwater runoff: 1) rainwater harvesting with rain barrels and 2) rain gardens to intercept rooftop or driveway runoff. While rain barrels are a great tool to promote environmental stewardship and to raise awareness about the need for more stormwater management, the rain barrel, due to its small storage capacity, does not have a significant impact on reducing stormwater runoff. The rain garden is a more significant practice that can be designed to capture, treat, and infiltrate stormwater runoff from up to the two-year design storm. Educational programs have been somewhat effective at encouraging homeowners to install rain gardens. When these educational programs are coupled with rebates for installing rain gardens, the adoption rate of property owners increases. Described below is an evaluation of the opportunities for rain gardens implemented by property owners.

According to the 2015 NJDEP impervious cover GIS layer, there are 16,092 buildings in the study area, which total 799.7 acres (from Table 17) of rooftop. If 25% of the building owners construct rain gardens to manage 25% of their rooftops, a significant reduction in total phosphorus load can be obtained. This would manage 50 acres of rooftop and provide a TP, TN, and TSS reduction of 99.8 lbs/yr, 1,045 lbs/yr, and 9,500 lbs/yr, respectively.

Recommendations for Structural Practices to Manage Roadway Runoff

A large portion of pollutant loading comes from streets. Sartor and Gaboury studied the issue in 1984 stating that based upon an analysis of runoff samples collected from streets, parking lots, roofs, lawns, sidewalks, and driveways, these samples indicated that nearly 92 percent of the bacteria originated from streets in the residential-institutional land-use site, whereas only about 33 and 19 percent of the bacteria originated from streets in the industrial and commercial land-use sites, respectively (Sartor and Gaboury, 1984). While Bannerman, one of the leading researchers in roadway runoff and street sweeping, reported that 78% of the fecal coliform bacteria load for one of the same residential land-use study subbasins studied by Waschbusch in 1999 originated from streets. Bannerman and others (1993) report that for most constituents, 75 percent or more of the total residential basin loads originate from street surfaces; total phosphorus was one of the exceptions, which originated mostly from driveways and lawns. This study also concluded that streets and parking lots are a critical source area for many contaminants in the commercial and industrial land-use areas (Bannerman, et al., 1993). Waschbusch collected runoff samples from two predominantly residential land-use subbasins. Sample analysis indicated that streets were the source of most suspended solids (73% and 81% of the total load for the two study sites), which is about twice the percentage of the runoff volume from streets (37% and 38% of the total basin runoff). Total phosphorus loads were proportional to the percentage of runoff at one site (37% of the total) and about half of the percentage of runoff at the other site (14%) (Waschbusch, et al., 1999). All these studies support that roadway runoff is very important to manage. According to the 2015 NJDEP impervious cover GIS layer, there are 1,116.1 acres (from Table 17) of roadways in the study area.

It is important to note that Interstate Highway 80 and State Highways 46 and 206 all traverse the study area. Additionally, county roads such as 512, 513, 517, 619, and 631 also traverse the study area. The State of New Jersey Department of Transportation (DOT) and the Hunterdon County

DOT have a municipal separate storm sewer system (MS4) permit for their roadways. A new MS4 permit for New Jersey's Highway Agency MS4s will be issued on January 1, 2025 and will require the state and county DOTs to develop a watershed improvement plan that identifies watershed improvement projects. There are many opportunities throughout the study area for these projects to treat stormwater runoff from the state highways and county roadways. This watershed restoration and protection plan recommends that the New Jersey DOT and the Hunterdon County DOT focus on developing this watershed improvement plan as soon as possible and engage the local stakeholders and municipalities in the study area.

There are several methods to manage roadway runoff. The first is to eliminate the source of pollution by street sweeping and leaf collection. This was discussed earlier in the plan. The second is to capture and treat the roadway runoff before it enters the local waterways. This can be accomplished by several methods. One is to filter the stormwater runoff in roadside ditches or bioswales. The second method is to divert roadway runoff to rain gardens.

As discussed earlier in this plan, each municipality in the study area has an MS4 permit. The roadside erosion control MS4 permit requirement makes the municipality develop a program to detect and repair erosion along the roads owned or operated by the permittee and to inspect and maintain the stability of shoulders, embankments, ditches, and soils along these roads to ensure that they are not eroding and contributing to the sedimentation of receiving waters or stormwater infrastructure. Inspections of municipal roads shall occur at least once per year, and any repairs shall be completed as soon as practicable, but no later than 90 days from discovery. This is a great opportunity for the municipality to identify roadside ditches that can be transformed into bioretention bioswales. The bioswale will remove 90% of the TSS load, 60% of the TP load, and 30% of the TN load (NJDEP, 2004). Also, bioretention systems have been shown to reduce fecal coliform concentrations by 95% (Rusciano and Obropta, 2007).

Since the MS4 permit requires Highway DOTs, County DOTs, and municipalities to develop a program to detect and repair erosion along the roads, roadside erosion sites were not identified as part of this project.

Farms or Agricultural Land Uses

Above we discussed urban land uses which are residential, commercial, and industrial properties. These urban land uses contribute 12,633 pounds of total phosphorus per year to the South Branch Raritan River (See Table 5), which is the largest contributor of TP to the waterway. The second largest contributor of total phosphorus is agricultural land uses, which contribute 6,253 pounds of total phosphorus per year to the South Branch Raritan River. The total phosphorus loading discussed above for urban and agricultural land uses assumes that stormwater management practices are not being used to treat runoff from these properties, when in fact, some of the urban and agricultural land uses already have stormwater management systems.

The NJDEP GIS parcel data contains “property classifications” for each individual lot. Property Classification 3A and 3B are considered “Farm Property.” Additionally, some parcels are qualified for farm taxes. These parcels are identified as “Q-Farms.” An analysis of the parcel data available for the South Branch Raritan River Watershed study area indicates there are 524 parcels classified as 3A or 3B or Q-Farms (See Figure 11) for a total of 11,194 acres (versus the 4,810 acres identified in the land use/land cover data). The list of 524 farm parcels is provided in Appendix G. It is important to note that many of these farm parcels are owned by the same company or the same family.

A land cover analysis was completed (See Table 35) for all parcels that are classified as “farm property.” While the total of the parcel area for all the farms parcels totaled 11,194 acres, the actual agricultural land use on these 524 parcels only totals 3,096 acres, which is 64.4% of the total agricultural land use identified in the land use/land cover data for the watershed. The total phosphorus load attributed from the agricultural land use of all 524 farms parcels is 6,341 lbs/year, based on the land cover analysis. The total phosphorus load attributed to agricultural land uses based upon the 2020 data is 6,253 lbs/year from Table 5.

The South Branch Raritan River Watershed study area contains 4,810 acres of agricultural land use based upon the 2020 land use data from NJDEP. The tax parcel data for the watershed identifies 11,194 acres of “farm property;” however, these acres contain 3,096 acres of actual agricultural land use based upon the 2020 land use database. The remaining 1,084 acres of agricultural land use can be attributed to farmers leasing parcels that have not been classified as “farm property” or parcels that have no property classification. Figures 12 and 13 provide an example of farm parcels versus agricultural land use for HUC 02030105010020 – Drakes Brook (below Eyland Avenue). Figure 14 shows an example of agricultural land use on non-farm parcels. Lot 1 is classified as 15C, which is classified as “tax-exempt property.” Lot 2 is classified as 4A, which is classified as “commercial.”

There are 15,820 parcels in the South Branch Raritan River Watershed study area (See Table 36). Of the 15,820 parcels, 808 do not have a property classification. Of these 808 parcels, 41 are qualified for farm taxes (Q-Farms). These non-classified Q-Farm parcels total 514 acres of which 145 acres are agricultural land uses, which contribute 188 pounds of total phosphorus per year.

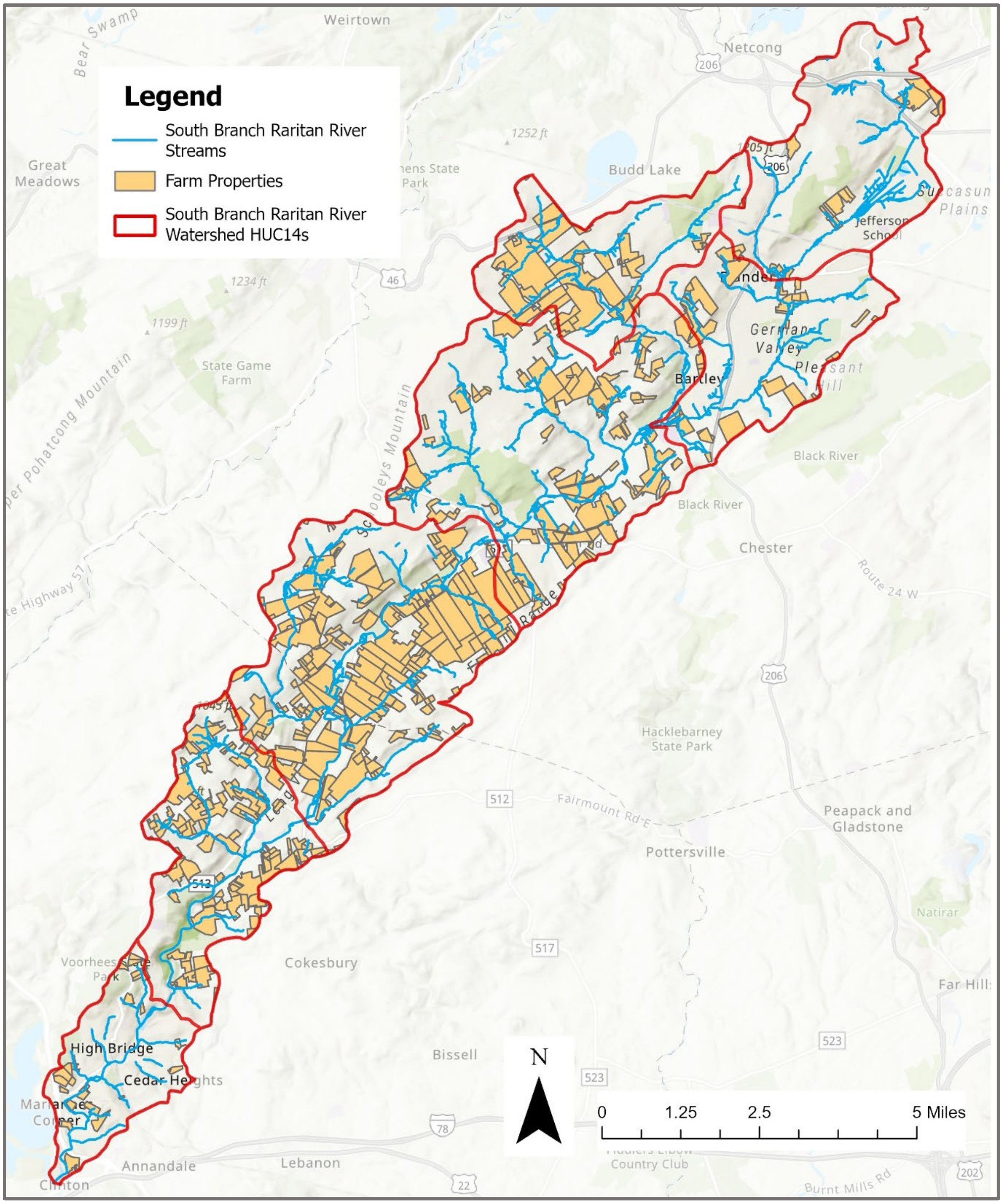

Figure 12: Parcels in the South Branch Raritan River Watershed study area that are classified as "Farm Property" (3A or 3B or Q-Farms)

Table 35: Land use analysis of all farm parcels in the study area

Land Use 2020	Area (acres)	TP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr)
Agriculture	3,906	5,078	39,061	105,900
Barren Land	47	23	235	1,320
Forest	4,656	466	13,965	24,320
Urban	743	590	5,458	81,140
Water	113	11	338	6,240
Wetlands	1,729	173	5,186	15,760
TOTAL	11,194	6,341	64,243	234,680

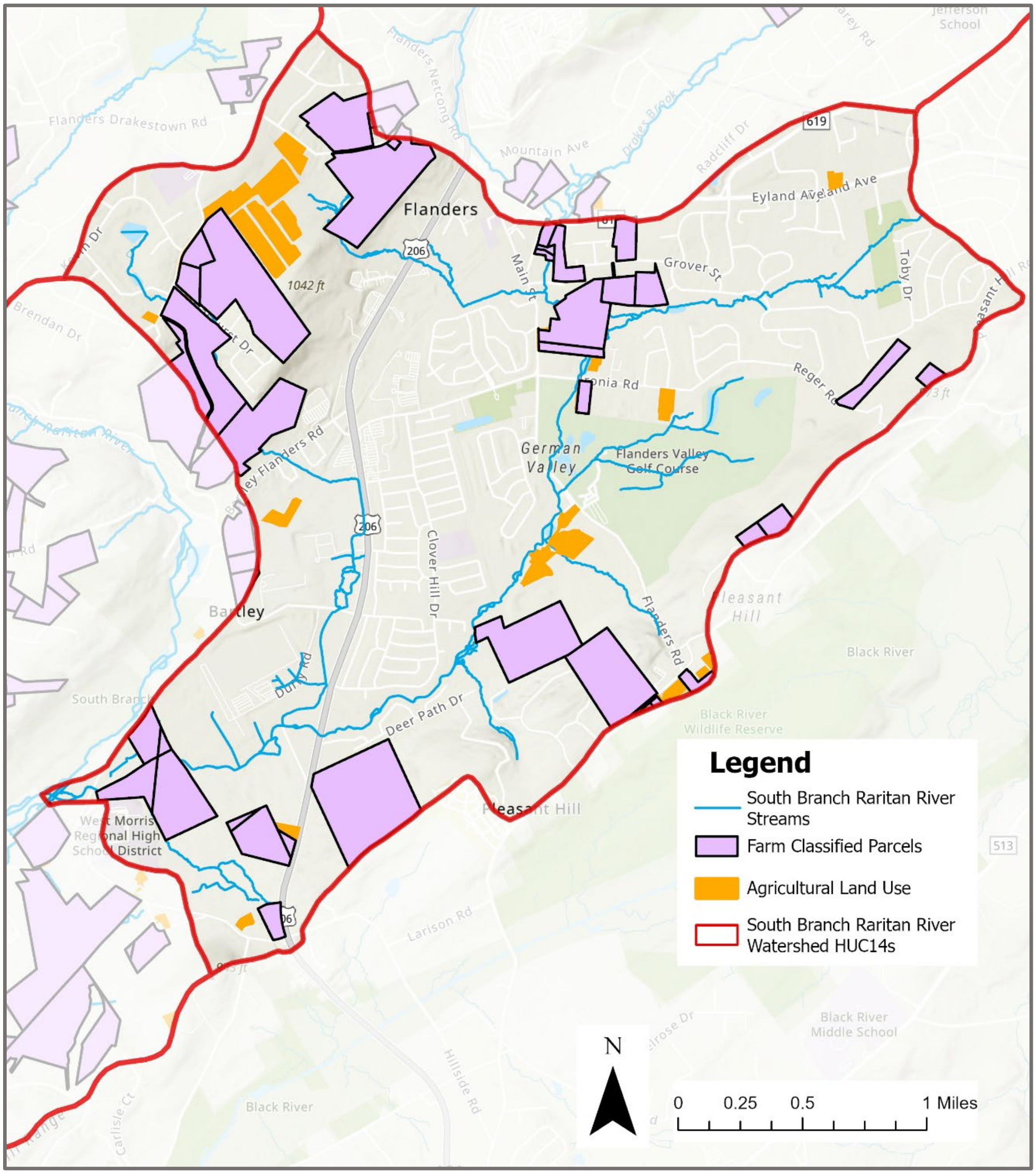

Figure 13: An example of farm parcels versus agricultural land use for HUC 02030105010020 – Drakes Brook (farm parcels are shown in purple) (2023 Parcel Data and 2020 Land Use Data, NJDEP GIS)

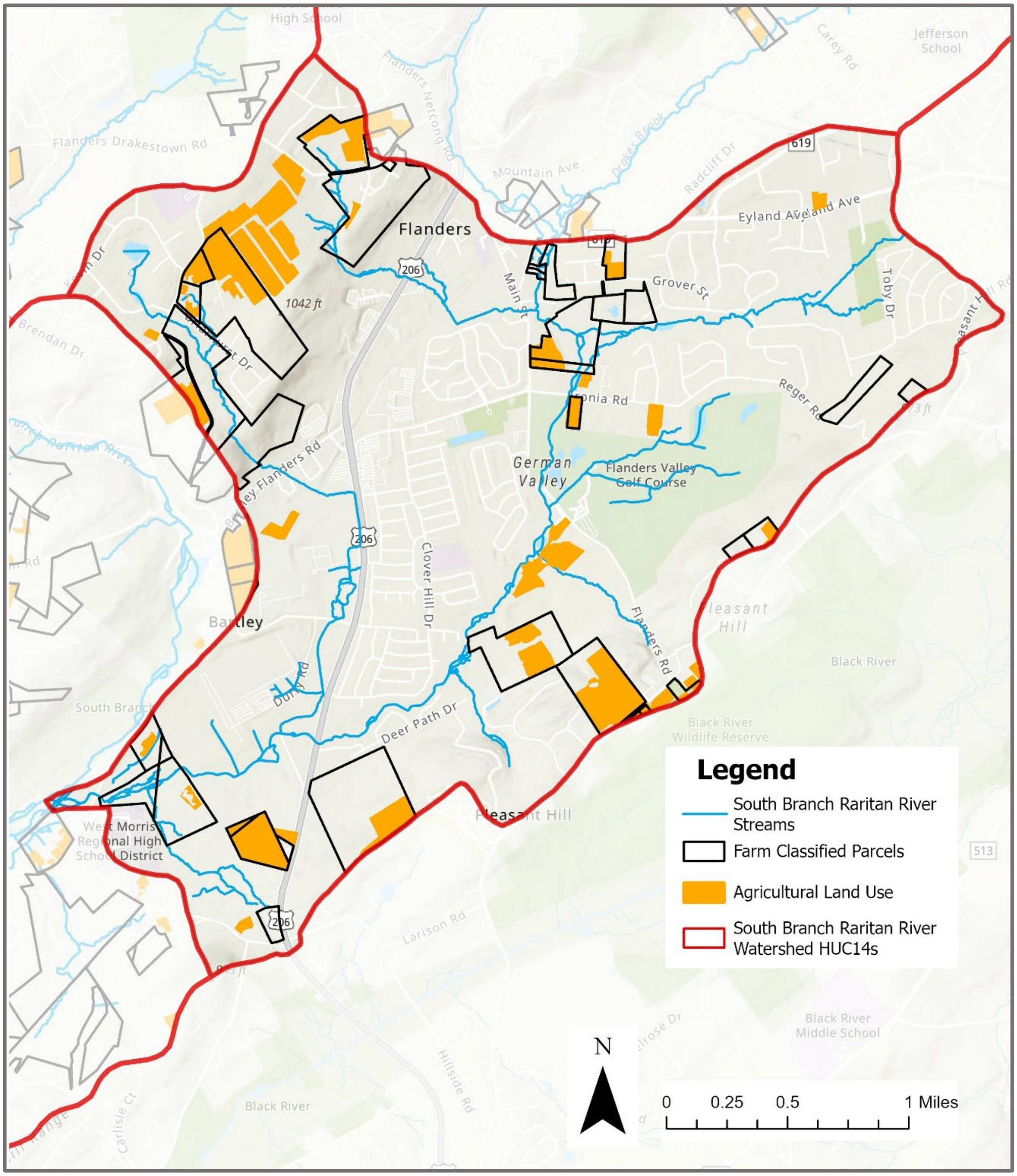

Figure 14: An example of farm parcels versus agricultural land use for HUC 02030105010020 – Drakes Brook (farm parcels are outlined in black)

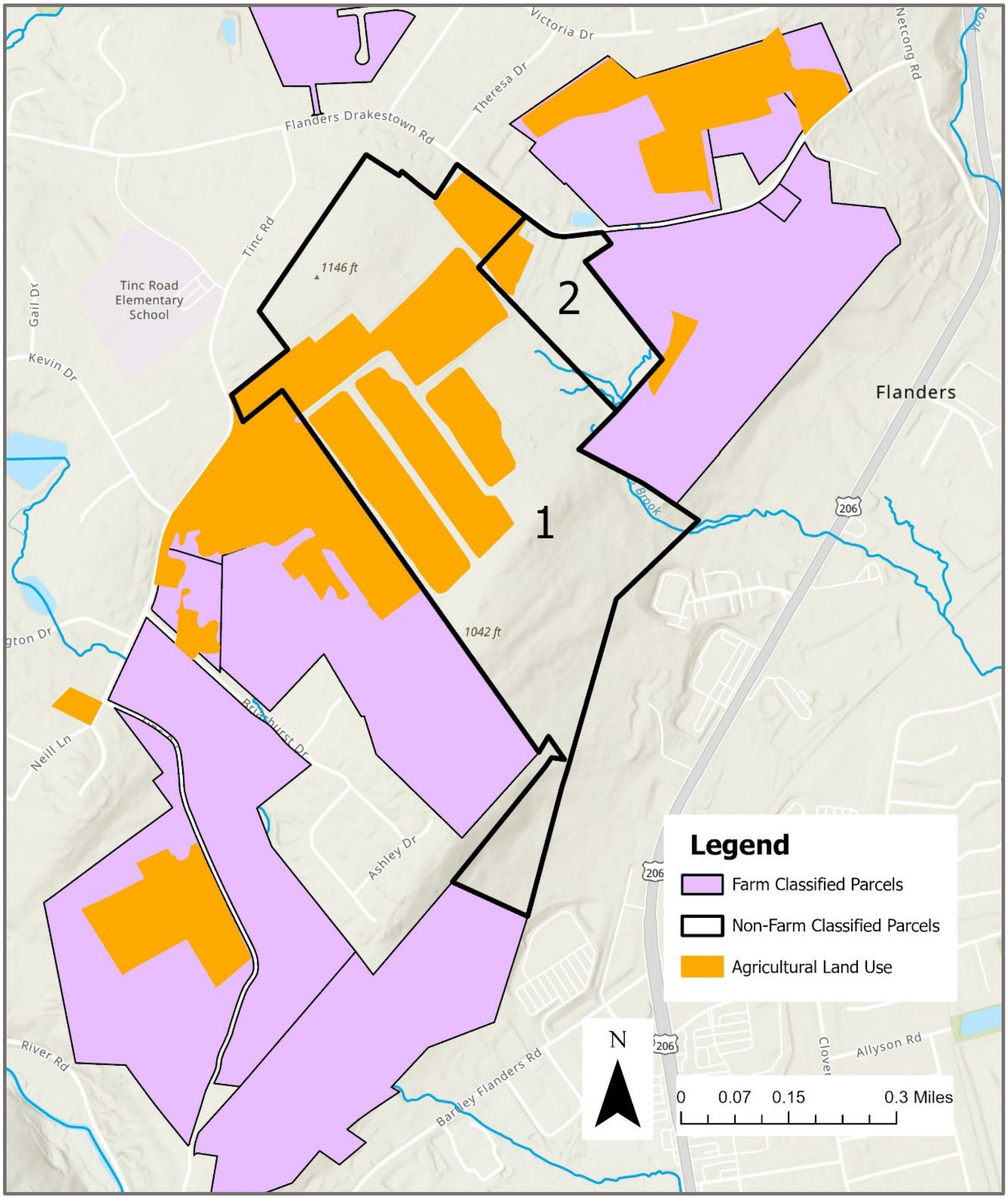

Figure 15: An example of agricultural land use on non-farm classified property

Table 36: Summary of agricultural land use analysis

Description	Ag LU (acres)	TP Load (lbs/yr)	TSS Load (lbs/yr)	No. of Parcels
Total for Farm Property (3A, 3B, and/or Q-Farm)	3,906	5,078	105,900	524
Total for entire study area (all seven HUC14s)	4,810	6,253	1,443,063	15,820*
Remaining	904	1,175	1,337,163	15,296

* Total number of parcels in study area

Recommendations for Management Practices for Specific Farms

There are 524 parcels that have been identified as farm property within the study area. Many of these parcels are completely wooded. Some are farmed with row crops such as corn, while others contain livestock (e.g., horses or cows). Many are used to grow hay or simply left as meadow. Out of these 524 parcels identified as farm property, 506 are classified as Q-Farms. These Q-Farm parcels were overlaid on the aerial photograph coupled with the stream network within the study area. Q-Farm parcels that appeared to be actively farmed within proximity of a stream were identified and further evaluated. A total of 206 Q-Farm parcels were identified to intersect the South Branch Raritan River and its tributaries within the study area. Out of the 206 Q-Farm parcels, site visits were conducted for the 91 parcels that intersected the main branch of the South Branch Raritan River to assess what type of farming was occurring on the parcels of land (See Figure 15). Four categories were considered: 1) row crops, 2) livestock/horses, 3) hay/grass, 4) wooded. One site was identified as a tree farm. Three sites (one of the sites includes two parcels) were identified as nursery/greenhouse operations. At these sites, impervious cover management practices could be installed to capture and treat stormwater runoff. Additionally, a rainwater harvesting system could be installed to reuse rooftop runoff in the nursey operations. For four parcels, the stream buffers could be enhanced to help filter runoff from the farming operations. For 16 parcels, row crops are being produced, therefore, cover crop is recommended to help retain soil and nutrients during the non-growing season. Finally, 22 parcels were identified as animal farm operations. Typically, a manure management program could be considered at these sites to reduce the impact of stormwater runoff. Table 37 lists the sites and the recommendations.

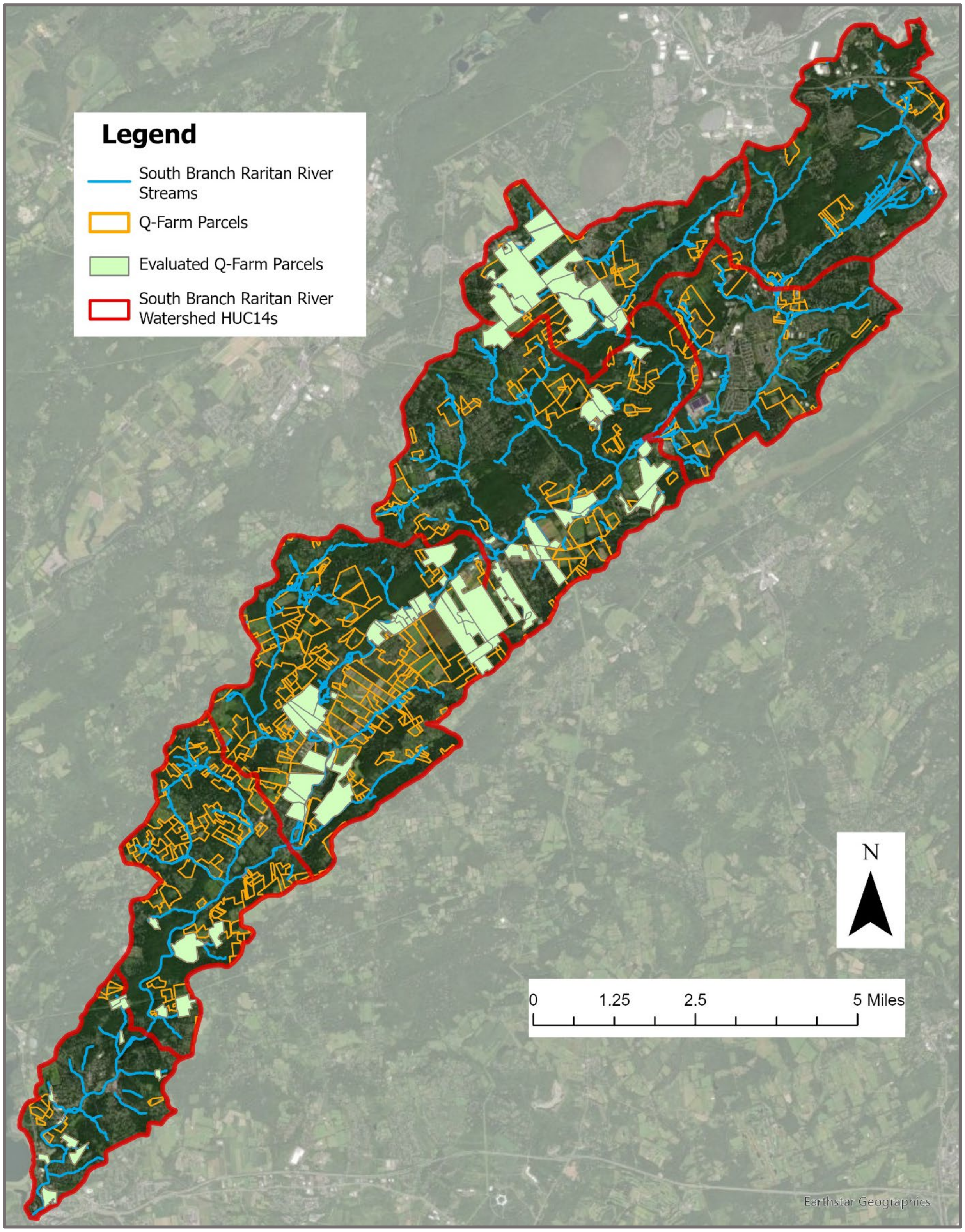

Figure 16: Q-Farms in the study area and the 91 Q-Farms evaluated for recommendations

Table 37: Recommendations for specific farms

Block	Lot	Q-Farm Code	Municipality	Cover Crop	Enhanced Stream Buffer	Impervious Cover Mgt.	Rainwater Harvesting	Livestock Exclusion	Manure Mgt.
12	3	Q0015	Lebanon Twp				X		X
12	5	Q0017	Lebanon Twp				X		
16	20	Q0024	Lebanon Twp			X	X		
18	49.03	Q0035	Lebanon Twp						X
41	11.01	Q0097	Lebanon Twp	X		X	X		
41	10	Q0113	Lebanon Twp				X		X
41	11	Q0115	Lebanon Twp	X	X				
41	13	Q0116	Lebanon Twp	X					
44	19	Q0118	Lebanon Twp				X		X
8000	6	QFARM	Mount Olive Twp	X					
8100	10	QFARM	Mount Olive Twp	X					
8100	47	QFARM	Mount Olive Twp				X		X
8200	1	QFARM	Mount Olive Twp	X					
3	4.01	Q0002	Tewksbury Twp						X
12	4	QFARM	Washington Twp	X					
12	37.03	QFARM	Washington Twp		X				X
16	14	QFARM	Washington Twp				X		X
28	4.01	QFARM	Washington Twp						X
28	14	QFARM	Washington Twp	X		X	X		
28	16	QFARM	Washington Twp	X					
28	16.01	QFARM	Washington Twp						X
28	18	QFARM	Washington Twp	X					
33	61	QFARM	Washington Twp						X
33	66	QFARM	Washington Twp		X	X	X		X
33	67	QFARM	Washington Twp						X
33	69	QFARM	Washington Twp						X

33	69.02	QFARM	Washington Twp		X				X
33	70.02	QFARM	Washington Twp	X			X		X
33	71.02	QFARM	Washington Twp			X	X		X
34	1.01	QFARM	Washington Twp						X
34	13	QFARM	Washington Twp	X					
34	42	QFARM	Washington Twp	X		X	X		
34	43	QFARM	Washington Twp	X					
34	46	QFARM	Washington Twp	X		X	X		X
35	6	QFARM	Washington Twp			X	X		X
54	26	QFARM	Washington Twp			X	X		X
54	29	QFARM	Washington Twp						X
54	30	QFARM	Washington Twp	X					

Of the 91 Q-Farm parcels that were evaluated, agricultural management practices were recommended for 38 of them. Among these 38 parcels, cover crops were recommended for 671.2 acres of agricultural lands, on 16 parcels. The existing load from these 671.2 acres is shown in Table 38. Assuming the load reduction for cover crop is the same as a vegetative buffer, 60%, 30%, and 80% removal for TP, TN, and TSS, respectively is expected. Table 39 shows the load reduction that can be obtained using cover crops on these Q-Farms.

Table 38: Existing load from 16 Q-Farms recommended for cover crop

Area (ac)	TP Load (lbs/yr)	TN Load (lbs/yr)	TSS Load (lbs/yr)
671.2	873	6,712	201,370

Table 39: Load reduction for cover crop on recommended 16 Q-Farms

Area (ac)	TP Load (lbs/yr)	TN Load (lbs/yr)	TSS Load (lbs/yr)
671.2	524	2,014	161,096

Watershed-Wide Septic Management

As discussed in the previous section, a watershed-wide septic system education program should help reduce phosphorus loads as much as 20% due to an increase in phosphate-free detergents and the reduction in the use of garbage disposals. The municipalities should adopt a homeowner requirement that all septic systems are regularly inspected and pumped with proof of inspection and pumping provided to the municipality. Regular inspections will result in problems being identified that can be repaired or failing systems that can be replaced. Several states like Rhode Island and Alabama have successfully used EPA's Clean Water State Revolving Fund for septic system repairs and replacement (See Fact Sheets in Appendix E). For example, the Rhode Island Clean Water State Revolving Fund has made loans totaling $2.95 million to repair and/or replace 400 septic systems to improve water quality in the waters of the state (USEPA, 2016). Based upon the Rhode Island example, to repair and/or replace 88 septic systems would cost approximately $800,000.

Wildlife Management

As part of the MS4 permits, the municipalities are required to adopt a wildlife feeding ordinance, which prohibits the feeding of Canada geese and other waterfowl. The enforcement of this ordinance could reduce the goose population. Additionally, educational programming is needed to encourage property owners to stop mowing lawns to the water's edge and to allow a vegetative buffer to become established along the waterway. This will decrease the Canada goose habitat in the watershed, which should reduce total phosphorus loads to the South Branch Raritan River.

Summary

Several stormwater management strategies were discussed for reducing total phosphorus loads to the South Branch Raritan River. Table 40 lists the strategies and the TP reduction for each strategy. Table 41 provides an overall summary of load reductions based upon recommendations in this plan.

Table 40: Load reductions for proposed management strategies*

Management Strategy	TP Reduction (lb/yr)	TSS Reduction (lb/yr)
Leaf collection and additional street sweeping (Option #4 – Table 26)	775.8	754,416
Green infrastructure for proposed retrofit sites	375.9	35,806
Rain gardens for ¼ rooftops for ¼ of buildings	99.8	9,500

Converting 52 existing detention basins to bioretention basins	415.2	55,701
Agricultural management practices on specific farms	524.0	161,096
Septic system replacement	6,566.3	0
TOTAL =	**8,757.0**	**1,016,519**

*** Load reductions for some recommended actions are not quantified (e.g., wildlife management and riparian buffers)**

Table 41: Existing loads and proposed load reduction

	TP (lbs/yr)	TSS (lbs/yr)
Existing Load	35,106	3,766,977
Load Reduction	8,757	1,016,519
% Load Reduction	24.9%	27.0%

Analysis by Municipality

For each municipality that has a major portion of its land in the study area, a detailed analysis was performed on a municipal basis. For each municipality, a land use, nonpoint source loading, and impervious cover analysis was completed on a HUC14 basis. Stormwater management facilities within the study area were summarized for each municipality. Farm properties and tax-exempt parcels were summarized for each municipality. Green infrastructure projects identified for each municipality were also summarized. These data are presented in Appendix F.

Criteria #4: Estimation of the amounts of technical and financial assistance needed

For each of the recommended management strategies in Table 40, construction cost estimates and annual maintenance cost estimates are provided in Table 42. The construction cost estimates include engineering design costs, permitting costs, and construction costs. Although grant funding may be available to purchase advanced street sweeping equipment, the leaf collection and street sweeping cost will most likely have to be funded by the municipality. There are federal and state funding sources that could support the remainder of these management strategies such as the Section 319 grant programs, State Revolving Funds, National Fish and Wildlife Foundation grants, Federal American Rescue Plan Act, and the Federal Infrastructure Investment and Jobs Act. Some of these strategies have co-benefits that might be more attractive to various funders. The conversion of traditional detention basins to bioretention basins creates wildlife habitat; such projects are often funded by the National Fish and Wildlife Foundation. The program to install rain gardens to manage stormwater runoff from building rooftops requires an intensive educational and outreach program. These types of efforts are often funded by private foundations.

An additional funding mechanism would be a stormwater utility. New Jersey passed legislation to enable the formation of stormwater utilities. A stormwater utility would charge property owners a fee based upon their impervious cover. Creation of either a regional stormwater utility or municipal stormwater utilities should be considered to fund the implementation and maintenance of stormwater infrastructure in the South Branch Raritan River Watershed.

Table 42: Costs for proposed management strategies for the South Branch Raritan River Watershed study area

Action	Management Strategy	Cost
1	Leaf collection and additional street sweeping (Option #4 – Table 28) ($10,000 per town to conduct enhanced street sweeping – annual cost)	$110,000
2	Green infrastructure for proposed retrofit sites – construction costs	$9,415,125
3	Rain gardens for ¼ rooftops for ¼ of buildings – construction costs	$5,445,000
4	Converting 52 existing detention basins to bioretention basins – construction costs	$2,600,000
5	Agricultural management practices on specific farms (providing cover crop for 671.2 acres of farmland [$100 per acre] – annual cost)	$67,120
6	Septic system replacement (replacing 716 septic systems at $30,000 per system) – construction costs	$21,390,000
	Total construction cost estimate =	$38,850,125
	Annual cost estimate =	$177,120

Criteria #5: Information and Education Program

The goal of the watershed restoration and protection plan is to reduce pollutant loading to the South Branch Raritan River. The goal of this Information and Education Program is to: 1) increase overall awareness among the stakeholders in the watershed, 2) engage municipal governments to act in adopting practices to reduce pollutant loading to the South Branch Raritan River, and 3) encourage action among residents, businesses, and farmers to implement stormwater management and nutrient management practices.

Audiences

There are three main audiences that will be targeted by the information and education program: 1) municipal officials and staff, 2) farmers, and 3) residents and other property owners.

Messaging for each audience

The initial message for all audiences focuses on providing information on the water quality problems and methods for addressing these problems. The second part of the message needs to convey the action that each audience can take to reduce the pollutant loads to the water bodies.

Municipal officials and staff

This target audience is often very busy with their daily duties and are hesitant to take on new activities unless it helps them address a permit requirement or saves them money. The first step is to get this audience to an educational session. One of the requirements of the municipal separate storm sewer (MS4) permit is for this audience to attend stormwater training. This educational session can satisfy this requirement. The MS4 permit also requires the municipalities to conduct education and outreach activities. The need to satisfy this requirement could encourage towns to support rain garden and rain barrel programs for homeowners and businesses. Once this audience awareness has been raised around the issues, the municipalities can apply for grants or partner on grants to implement the actions outlined in the plan such as building bioswales along roadways, enhanced street sweeping and leaf collection, and installation of green infrastructure on publicly owned property. Finally, the MS4 permit requires municipalities to develop Watershed Improvement Plans in three phases. Information in this watershed restoration and protection plan should be incorporated into the Watershed Inventory Report, Watershed Assessment Report, and Watershed Improvement Plan. This should save the municipalities significant costs in developing the Watershed Improvement Plan.

The first educational program offered to this audience would be *Stormwater Management for MS4 Communities.* The goal of this program will be to increase the awareness of the municipal officials and staff on the issues associated with stormwater runoff, particularly runoff laden with phosphorus and sediment that enters the South Branch Raritan River. The importance of good housekeeping practices such as street sweeping, catch basin cleaning, and leaf collection will be discussed. Additionally, this presentation will discuss the potential use of green infrastructure to decrease stormwater runoff from existing developed lands. To evaluate the effectiveness of this project, the participants will be surveyed to determine their increase in knowledge on various topics discussed in the program.

The second educational program for this audience will focus on the Watershed Improvement Plan that is an MS4 permit requirement. The Watershed Improvement Plan will identify stormwater management practices that can be implemented to protect the health of the waterway and reduce localized flooding. The program will focus on providing information on the green infrastructure practices that can be used to reduce pollution to the waterway and capture stormwater runoff to address localized flooding. The opportunities already identified in the watershed restoration and protection plan will be highlighted in the presentation as well as protocols for identifying additional projects. The production of a comprehensive Watershed Improvement Plan that is accepted by NJDEP will be an indication of success of this program along with the number of additional sites that have been incorporated into the plan.

Residents and other property owners
The major obstacle to reaching this audience is their lack of knowledge and awareness. The educational program must raise their awareness and empower this audience to action. The second obstacle for this group is the lack of available technical expertise to support their efforts and funding to help implement various stormwater management strategies. The process will be to first increase the audience's knowledge and awareness, empower them to act by providing them technical support and funding, and evaluate their success through surveys and documentation of practices installed.

The first program will be *Stormwater Management for Homeowners and Businesses.* There are two marketing strategies to encourage people to attend this program. The first is that many property owners have drainage problems, and this program could provide them with solutions to these problems through the implementation of green infrastructure practices. The second is to take advantage of the fact that many people want to help improve the environment and protect local waterways. These people should be easy to encourage to attend this program. This program will provide education on water quality issues particularly related to the South Branch Raritan River. It will emphasize how individual actions can help address the problem, empowering people to do their part. The program will identify and describe green infrastructure practices that property owners can implement. A survey will be conducted to evaluate the success of this program by measuring increases in knowledge and awareness along with the increase in willingness to implement a stormwater management strategy.

The second program would be a green infrastructure rebate program. This will need to be supported with grant funding. A *Landscape Makeover Program* has been offered in various watersheds throughout New Jersey over the last several years. This program provides technical support to the property owner to design green infrastructure practices and provide the owner rebates when the practice is installed. Approximately 25% of the property owners implement the practices to get the rebates. This program can easily be evaluated by the number of practices implemented.

Farmers
A few major obstacles to reaching out to farmers is getting them to 1) attend meetings, 2) acknowledge that they are contributing to the water pollution problem, 3) be willing to take land out of production to create agricultural management practices, and 4) pay the cost share to install practices. The Natural Resources Conservation Service (NRCS) offers several programs in New Jersey for farmers.

1. Agricultural Management Assistance (AMA)

   For this program, producers may construct or improve water management structures or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices, including soil erosion control, integrated pest management, or transition to organic farming. AMA provides financial assistance to up to 75 percent of the cost of installing conservation practices.

2. Conservation Stewardship Program (CSP)

   For this program, NRCS works one-on-one with producers to develop a conservation plan that outlines and enhances existing efforts, using new conservation practices or activities, based on management objectives for the operation. Producers implement practices and activities in their conservation plan that expands on the benefits of cleaner water and air, healthier soil, and better wildlife habitat, all while improving their agricultural operations.

   For example, if you have been planting a cover crop, you may decide to try an enhancement for a multi-species cover crop or implement a deep-rooted cover crop to break up soil compaction and further improve the health of the soil.

   CSP offers annual payments for implementing these practices and operating and maintaining existing conservation efforts.

3. Environmental Quality Incentives Program (EQIP)

   EQIP delivers environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, improved or created wildlife habitat, and mitigation against drought and increasing weather volatility. This voluntary conservation program helps producers make conservation work for them. Together, NRCS and producers invest in solutions that conserve natural resources for the future while also improving agricultural operations.

   Through EQIP, NRCS provides agricultural producers and non-industrial forest managers with financial resources and one-on-one help to plan and implement improvements, or what NRCS calls conservation practices. Using these practices can lead to cleaner water and air, healthier soil, and better wildlife habitat, all while improving agricultural operations. Through EQIP, conservation practices can be voluntarily implemented, and NRCS co-invests in these practices.

4. Regional Conservation Partnership Program (RCPP)

   By leveraging collective resources and collaborating on common goals, RCPP demonstrates the power of public-private partnerships in delivering results for agriculture and conservation.

   RCPP projects fall under two different categories: RCPP Classic and RCPP Alternative Funding Agreement (AFA). RCPP Classic projects are implemented using NRCS contracts and easements with producers, landowners, and communities, in collaboration with project partners. Through RCPP AFA, the lead partner must work directly with agricultural producers to support the development of new conservation structures and approaches that would not otherwise be available under RCPP Classic.

For this education and information program, a workshop would be offered to farmers to outline these programs and encourage farmers to participate in these programs. This educational program could be offered by any of the local NGOs but should be offered jointly with NRCS and the Morris County Soil Conservation District. The main method to evaluate this program is a post-program survey that determines if the program has convinced farmers to participate in the NRCS programs.

Program Delivery by Raritan Headwater Association and their Partners

The best method for delivering these programs is in-person at local venues, possibly as an extension of existing programs that each audience is attending. The watershed is small, so these programs could be offered regionally or possibly at two locations throughout the watershed. All the programs would be delivered as PowerPoint presentations with the slides made available to the attendees as handouts. Additionally, one-page information sheets would be developed that discuss the water quality impairments in the watershed, green infrastructure, and NRCS programs. It is important to provide short, concise documents to the audience that they can share with others in their community.

Additional opportunities for education include installation of educational signage at selected locations, tabling at events, and use of social media and websites. Arranging group visits to successful best management practice installation sites is a more interactive alternative to PowerPoints.

Criteria #6: Development of a schedule for implementing nonpoint source controls

A schedule for implementing the management strategies will be highly dependent on funding. The first step is to prepare shovel-ready designs for projects that have been identified in this plan. Shovel-ready designs will help the South Branch Raritan River communities more easily secure state and federal funds. Often grant applications with shovel-ready designs are the first to be funded. Table 43 is a step-by-step timeline for implementing the recommended management strategies.

Table 43: Management strategy implementation schedule

Step	Management Strategy	Time Frame
1	Municipalities should review their leaf collection and street sweeping program. Since on average 43% of the annual phosphorus load is discharged during the fall, the street sweeping program should be adopted to address this issue. The municipalities should begin soliciting grant funding for an additional advanced street sweeper.	0 to 6 months
2	Develop and deliver the educational programming, particularly focusing on encouraging residents to adopt pollution reduction strategies, build rain gardens, and install rainwater harvesting systems to help reduce stormwater flows to the South Branch Raritan River; seek funding to support rain garden installation by private property owners; Raritan Headwaters Association can be the lead on this effort with support from Rutgers Cooperative Extension and Morris County Soil Conservation District	6 to 18 months
3	Develop detention basin retrofit designs that can be submitted for grant funding to implement	6 to 18 months
4	Prepare designs for green infrastructure projects and submit these designs for funding	6 to 24 months
5	Adopt a septic system registration program where homeowners must inspect and pump their systems on a regular basis (once every three years)	12 to 24 months
6	Install agricultural management practices using agricultural technical support program funding	2 to 10+ years
7	Implement the above BMPs as funding is obtained	1 to 10+ years

Criteria #7: Development of interim, measurable milestones

There are short-term milestones (0 to 3 years), mid-term milestones (4 to 9 years), and long-term milestones (10+ years). Each of these milestones are discussed below.

Short-term Milestones (0 to 3 years)

- Within six months the leaf collection and street sweeping program will be updated and funds will be sought to purchase additional equipment
- Within 18 months, four educational programs will be developed and delivered
- Within 18 months, funding will be sought to provide incentives for rain garden installations for private property owners
- Within 18 months, retrofit designs for the detention basins will be completed, and funding will be sought to retrofit these basins
- Within 24 months, the municipalities will adopt a septic system registration program that requires homeowners to regularly inspect and pump their septic systems (once every three years)
- Within 24 months, develop and deliver educational programs to farms and strongly encourage cover crop usage

Mid-term Milestones (4 to 9 years)

- Within 48 months, 2 to 4 bioswale projects will be constructed
- Within 48 months, secure New Jersey Clean Water State Revolving Fund loan to repair and replace septic systems in the watershed
- Within 60 months, nursey operations will implement stormwater management practices and/or rainwater harvesting practices
- Within 10 years, all the green infrastructure projects will be installed
- Within 10 years, one half of row crop farms will be using cover crop

Long-term Milestones (10+ years)

- The remaining bioswales will be installed as needed
- The remaining farmers will implement an agricultural management practice

Criteria #8: Development of criteria to ensure load reductions are being achieved

The intent of the plan is to identify stormwater management practices that can be implemented to achieve pollutant load reductions. A watershed stakeholder committee should be formed to advocate for implementing the strategies identified in the plan. This committee should consist of elected officials, municipal public works employees, environmental commissions, farmers, environmental advocates, staff from the Raritan Headwaters Association, staff from the Morris County Soil Conservation District, and other local stakeholders who have an interest in restoring and protecting the South Branch Raritan River. This committee should track the progress of achieving the load reductions identified in the plan and ensure the waterway is monitored so management strategies can be adapted to optimize pollutant load reductions. For all management practices that are installed, a detailed load reduction calculation should be provided based upon the drainage area being managed and the expected load reduction efficiency of the proposed practice. These load reductions should be tabulated on an annual basis for submittal to NJDEP. Additionally, the committee should issue an annual report on the progress to improve the health of the South Branch Raritan River and the efforts put in place to prevent future damage to this waterbody (e.g., number of basin retrofits, number of rain gardens installed, etc.). Furthermore, NJDEP's biennial analysis of water quality data will be evaluated and tracked to determine progress toward water quality protection and restoration.

Criteria #9: Development of a monitoring component to evaluate effectiveness

The goal of this monitoring plan is to assess the success of the South Branch Raritan River Watershed Restoration and Protection Plan (SBR WRPP) implementation in addressing stormwater inputs of nutrients, bacteria, and other pollutants as well as impacts on temperature, dissolved oxygen, pH, dissolved salts, total suspended solids, aquatic life, and stream habitat within South Branch Raritan River and its tributaries. The SBR WRPP was developed by the Rutgers Cooperative Extension Water Resources Program with funding from the New Jersey Highlands Council. Upper Raritan-Highlands Region Watershed Restoration and Protection Plans are also being developed for the North Branch Raritan River, Lamington-Black River and Spruce Run and Mulhockaway Creek, and there is a WRPP already in place for Budd Lake.

Raritan Headwaters Association (RHA), a non-profit environmental organization focused on protecting water resources of the Upper Raritan Region, is applying its expertise in water quality monitoring to assess the success of the SBR WRPP as part of a larger endeavor to understand water quality improvements in rivers because of watershed plan implementation throughout the Upper Raritan-Highlands Region of New Jersey. Learn more about RHA at www.raritanheadwaters.org.

Study Area

South Branch Raritan River

The South Branch Raritan River flows for a total of 51 miles from its headwaters in Budd Lake, a 374-acre glacial lake located in Mount Olive Township. Budd Lake has an NJDEP-approved watershed restoration and protection plan in place, and a baseline characterization study is underway by Raritan Headwaters and Mount Olive Township with funding from the NJ Highlands Council. The main stem of the Raritan River begins at the confluence of the South and North Branches of the Raritan River at the border of Branchburg, Bridgewater, and Hillsborough Townships. Sun Valley Brook, Turkey Brook, Stony Brook, Electric Brook, Turtleback Brook, Teetertown Brook, Frog Hollow Brook, Little Brook, Hickory Run, Beaver Brook, Grandin Stream, Cramers Creek, Allerton Brook, Bushkill Brook, Assicong Creek, Minneakoning Creek, Capoolong Creek, Mulhockaway Creek, Prescott Brook, Spruce Run, Willoughby Brook, Holland Brook, Pleasant Run, Drakes Brook and the Neshanic River are tributaries of the South Branch Raritan River. This subwatershed is a 276 square mile area comprised of parts of Union Township, Clinton Town, Clinton Township, Franklin Township, Raritan Township, Readington Township, Flemington Borough, Branchburg Township, Hillsborough Township, Mount Olive Township, Washington Township, Chester Township, Lebanon Township, Califon Borough, Tewksbury Township, and High Bridge Borough. The dominant land use in this subwatershed as of 2012 was urban (34.7%), followed by forest (32.7%), agriculture (18.5%), wetlands (11.1%), and barren land (0.8%).

The South Branch Raritan River is located within the Highlands Region until the river segments and flows through Franklin Township, Raritan Township, and Readington Township. The headwaters of the South Branch Raritan River until the dam near Flanders-Drakestown Road bridge are classified as FW2-NT and are designated as C1 waters. Below the dam, the South Branch Raritan River is classified as FW2-TM and continues to improve to FW2-TP below the confluence with the Turkey Brook. Below the Route 512 bridge in Califon until its confluence with the North Branch Raritan River, the South Branch Raritan River gradually degrades from a FW2-TM to FW2-NT stream classification with a C2 waters designation. The only exception is the Ken Lockwood Gorge Wildlife Management Area where the South Branch Raritan River is classified as FW2-TM and is designated as C1 waters. Based on longterm trend analyses, several sites in the Highlands Region of the South Branch Raritan River Watershed have shown improvements in biotic indicators of water quality over the past decade (MacDonald 2019; MacDonald and Harris *in prep*).

The South Branch Raritan River is part of the North and South Branch Raritan Watershed (WMA8), which is the largest watershed within the Raritan River Basin and is part of the New Jersey Highlands Region. The 470 mile^2 (1,217 km^2) watershed, which comprises the Raritan Headwaters region, provides drinking water to 300,000 watershed residents of 38 municipalities in Hunterdon, Morris, and Somerset counties and drinking water to more than 1.5 million residents that live beyond the watershed, in the state's more urban areas. The South Branch of the Raritan River is 51 miles long, from its source in Budd Lake to its confluence with the North Branch. The North Branch originates as a spring-fed stream in Morris County and flows south approximately 23 miles to its confluence with the South Branch in Branchburg. The watershed holds a rich variety of flora and fauna and contains some 1,400 miles of streams, including many wild trout production streams. Two large reservoirs, Spruce Run and Round Valley, and a variety of large protected public lands including Ken Lockwood Gorge, Hacklebarney State Park, and the Black River Wildlife Management Area are all within the Raritan Headwaters region. Under the surface are the fractured-rock aquifers of the Newark Basin including mainly the Brunswick aquifer, Lockatong and Stockton formations, along with some limestone aquifers and buried valley aquifers where glaciers deposited sand, gravel, and clay materials. These resources are threatened by continued degradation caused by numerous stressors associated with human activities. The most pressing of these are the large inputs of polluted stormwater runoff from urban and agricultural areas coupled with frequent, extreme storms due to climate change. TMDLs are in place on the South Branch Raritan River to address impairments in fecal coliform, total phosphorous, dissolved oxygen, pH, and total suspended solids.

RHA has about 80 long-term stream monitoring sites throughout the Upper Raritan, with 55 of them falling in the Highlands region of the watershed. Of these, 21 monitoring sites are located in the South Branch Raritan River drainage (Figure 16). Additional information about RHA's stream monitoring program and a link to a detailed, interactive map and information about each monitoring site are available at https://www.raritanheadwaters.org/monitoring-water/surface-water/.

Study Design

Initial sampling efforts from 2020-2026 will constitute the baseline characterization of water quality in the South Branch Raritan River watershed; samples from June 2028 through June 2038 will provide an assessment of implementation phase impacts on water quality; implementation of stormwater management projects from the SBR WRPP will determine when post-implementation data collection should begin.

Biological, chemical, and habitat parameters will be collected as outlined in the following schedule (Table 44) and will be conducted pre-project implementation as part of a baseline characterization study, which will further inform the long-term monitoring of water quality as WRPPs are implemented in the Highlands portion of the South Branch Raritan River and its tributaries. RHA's existing monitoring program forms the basis of this monitoring plan with a few additions in the area of chemical monitoring as well as inclusion of AMNET monitoring data in the baseline and final reporting.

Sampling Methods

RHA has annually collected data on benthic macroinvertebrates and habitat, and more recently chemical data, at fixed monitoring sites, some of which have been monitored since 1992. Data have typically followed protocols developed by the USEPA (Barbour et al. 1999) and later refined by NJDEP. In addition, beginning in 2017, Raritan Headwaters began collecting baseline chemical data on water quality parameters at each of its stream monitoring sites. A list of the water quality parameters used in this study and their abbreviations is provided in Table 45.

Quality Assurance Project Plan (QAPP): To assure that our methods are up to date, RHA submits a QAPP to the NJDEP Division of Water Monitoring and Standards for review and approval at least every three years, or more frequently if changes to the QAPP are made. Our current QAPP is approved at Tier 3.3, meaning the data are considered high enough quality to be used for regulatory decisions by state and federal agencies. Before the monitoring season, all monitoring equipment is inventoried, calibrated, and replaced if necessary. Detailed descriptions of RHA's stream monitoring program including volunteer training and NJDEP certification of RHA stream monitors can be found in the NJDEP-approved Quality Assurance Project Plan (Raritan Headwaters, 2024).

Citizen Science Program: Each spring, RHA holds an intensive stream monitoring training for new volunteers and a separate refresher that returning volunteers repeat every other year. Trainings review the purpose of the stream monitoring program and assure the standardization of sample and data collection by explaining and demonstrating the biological sampling and visual assessment protocols. New volunteers are required to work with either a staff member or an experienced volunteer during their first season. DEP conducts accreditation and auditing of our staff and volunteers.

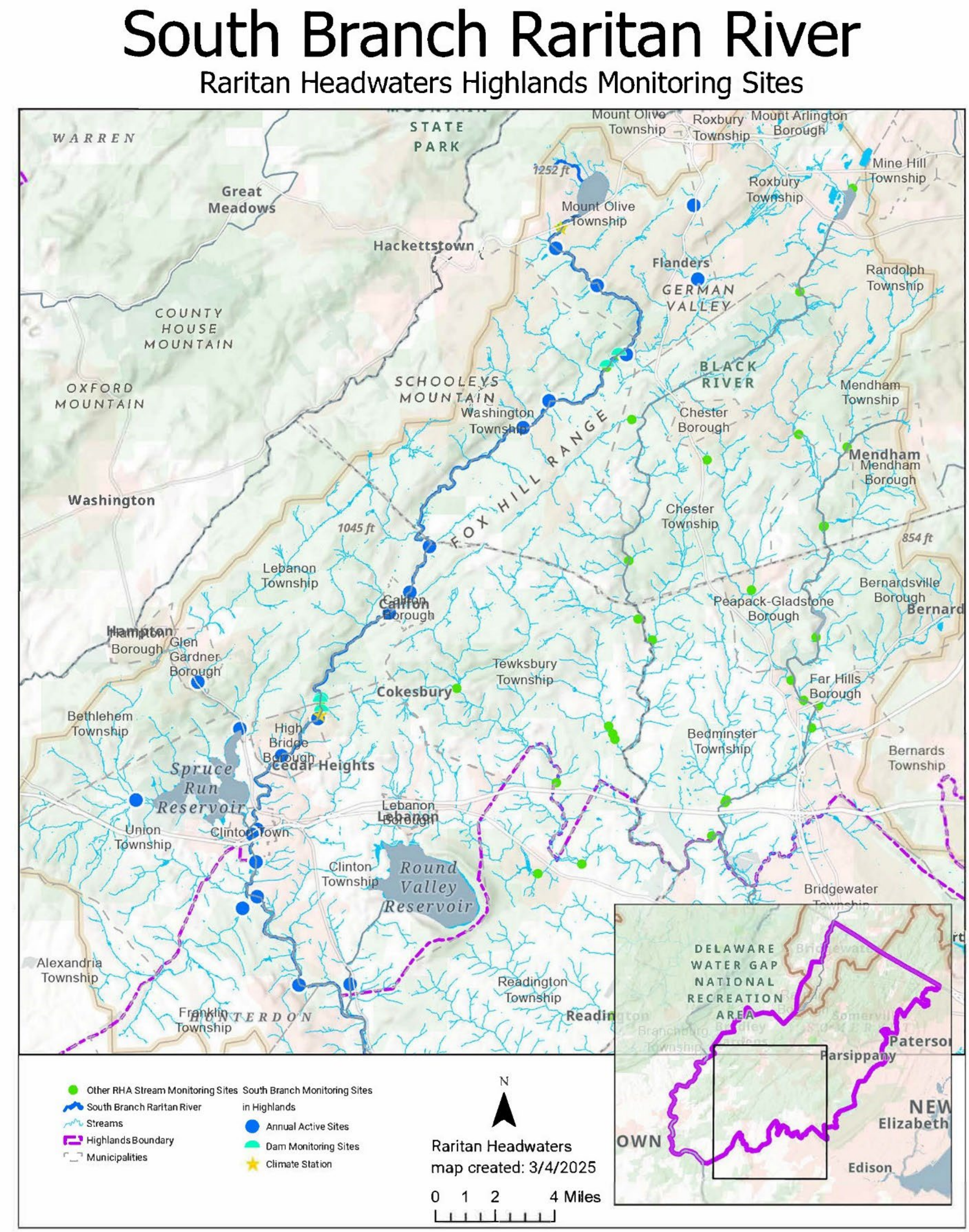

Figure 17: Map of study area indicating the 21 active monitoring sites and 2 climate station locations in the South Branch Raritan River drainage of the Highlands in New Jersey

Table 44: Project outline and timeline.

Task	Responsible Party	Time (months)	Project Deliverable	Status (start/end)	
Baseline Characterization of Water Quality in the South Branch Raritan River and its tributaries	RHA	18	Baseline Water Quality Characterization Report	Feb 2026; include all available data pre-Feb 2026	June 2027
WRPP Implementation Monitoring	RHA	132	Annual Trend Updates; Final Report	Feb 2028	Feb 2039
Data Collection	RHA	120	Data Collection and Entry in WQX, Tables, Charts, Analysis	Feb 2028	Jun 2038
Data Analysis	RHA	Annual and at conclusion of project in 132 months	Data Summary and Trend Analyses and Cumulative Annual Reports, Final Report (10 years)	June 2038	April 2039

Table 45: Water quality, biodiversity, habitat, and land use parameters and brief description or source for methods

Water Quality Parameter (Abbreviation)	Brief Description/Source
Biological (Benthic Macroinvertebrate)	Barbour et al. 1999; https://www.state.nj.us/dep/wms/bfbm/amnet.html
High Gradient Macroinvertebrate Index (HGMI)	Jessup 2007
New Jersey Impairment Score (NJIS)	Kurtenbach 1990
Family Richness (F_Rich)	No. of Families
Genus_Richness (G_Rich)	No. of Genera
Family-Level Biotic Index (FBI)	An index of pollution tolerant families
Hilsenhoff Biotic Index (HBI), Genus level	An index of pollution tolerant genera; Hilsenhoff 1987
Percent Non-Insect Genera (Non-Insect)	Percentage of the Genera that are non-insect indicating increasing pollution tolerance
Percent Ephemeroptera, Plecoptera, Trichoptera (EPT)	Percentage of pollution intolerant Genera
H2 Genera (H2)	Pollution Sensitive Uncommon Genera

H3 Genera (H3)	Pollution Sensitive Common Genera
Scrapers	A functional feeding group of sensitive species critical for nutrient capture and cycling.
Bacteria	
Escherichia coli count	Indicates fecal contamination and potential for other pathogens; EPA Method Method 1603 at state-certified lab; DEP summer sampling protocols (5 weeks), 1 site on mainstem S. Branch just before leaving Highlands Region; include at least 1 stormwater sample.
Chemical	
Temperature (Temp)	*In situ* probe; pendant loggers; continuous at 4 sites using Mayfly Enviro-DIY climate stations
TSS	State-certified lab
pH	Handheld meter
Dissolved Oxygen (DO)	Handheld meter
Total Phosphorus (TP)	State-certified Lab
Total Nitrogen (TN)	Handheld meter
Chloride	State-certified Lab
Specific Conductance (SPC)	Handheld meter; Continuous at 4 sites using Mayfly Enviro-DIY climate stations
Total Dissolved Solids (TDS)	Handheld meter
Total Suspended Solids (TSS)	State-certified Lab
Surfactants	State-certified Lab
Habitat Quality and other environmental variables	
Total Habitat Score (THS)	Habitat Score: Ratings of embeddedness, bank structure, stream bottom, woody debris, periphyton, and vegetated buffer are combined into a habitat score and may also be used as individual habitat variables (Barbour et al. 1999; NJDEP 2015)
Depth	Continuous at 4 sites using Mayfly Enviro-DIY climate stations
Flow	Flow meter reading
Rainfall data	nearest CoCoRaHS station (https://www.cocorahs.org/

Land Use Land Cover, Catchment (2012)	NJDEP 2012 Land Use Land Cover GIS data used to calculate the percentage of major habitat categories standardized per unit area (acres)
Total Catchment Area	
% Forest (FOR)	1986 to 2026; 2026 to 2038
% Wetland (WET)	1986 to 2026; 2026 to 2038
% Agriculture (AGR)	1986 to 2026; 2026 to 2038
% Urban (URB)	1986 to 2026; 2026 to 2038
% Water (WAT)	1986 to 2026; 2026 to 2038
% Barren (BAR)	1986 to 2026; 2026 to 2038
Impervious Surface	1986 to 2026; 2026 to 2038

For each stream monitoring site RHA provides GPS coordinates, verbal descriptions of collection (riffle) areas, and photographic records to all volunteers. This further assures that comparable data is gathered from one year to the next. GPS coordinates and site descriptions are available on RHA's website at http://www.raritanheadwaters.org/protect/stream-monitoring-program/stream-monitoring-map/, as well as the aforementioned QAPP.

Data Sharing: All chemical, biological and visual habitat data will be entered into the NJDEP stream monitoring database and subsequently uploaded to the Water Quality Data Exchange (WQX) for data sharing with the NJDEP, USEPA, and other users. In addition to this study of the impacts of watershed restoration and protection plan implementation on water quality, data from the study will be used for regulatory purposes including identifying impaired waterways under Section 303d of the Clean Water Act as well as protection of waterways of high ecological value as Category 1 designations. RHA also produces an annual Surface Water Report Card based on the monitoring results and the report card is shared via presentations and on their website.

Biological Data (Benthic Macroinvertebrates): Each year, visual and biological stream assessments have been performed at fixed sites in the Upper Raritan (WMA8) between June 1 and July 10. By using the same sampling window each year, the information gathered can be easily compared across years and among sites. Stream monitoring sites have been chosen so that they are suitable to use with the U.S. Environmental Protection Agency's Rapid Bioassessment protocol (Barbour et al. 1999).

To collect a biological sample, a D-net is used to perform a "kick" in the stream, disturbing the benthic habitat in a riffle within a 100-meter stream segment so that all cobble, sand, and debris flow into the net. Larger rocks are rubbed into the net to remove attached organisms prior to commencing each kick. Kicks are timed for one minute at each of 10 riffles or other suitable habitats in the stream. Once completed, volunteers sort through the collected debris, ensuring a minimum of 100 benthic macroinvertebrates were collected. Effort is made to retain all the benthic macroinvertebrates in the sample. The macroinvertebrates along with most of the substrate and debris are preserved in a jar of 95% ethyl alcohol. As part of Quality Assurance/Quality Control (QAQC), duplicate samples are taken from 5-10% of the sites each year. Jars are clearly labeled using stream monitoring site ID numbers. Once completed, samples are sent to Normandeau Labs (Stowe, PA), an EPA certified laboratory, where an expert taxonomist identifies all macroinvertebrates collected down to the lowest taxonomic level possible. Analysis by an independent lab assures that RHA's data is of the highest quality, allowing it to be used by state and federal agencies with the most stringent data quality requirements. As further QAQC, benthic macroinvertebrates from the 100-organism samples are returned to RHA and periodically a subsample is sent for taxonomic verification to a different certified taxonomist for verification. Using the relative abundances and pollution tolerances at the family level (Table 45; NJ Impairment Score and underlying metrics) and genus level (Table 45; High Gradient Macroinvertebrate Index and underlying metrics; Jessup 2007), the macroinvertebrate community can be characterized and compared across sites and years.

The benthic macroinvertebrate samples are scored using the New Jersey Impairment Scoring (NJIS) Criteria for Rapid Bioassessments and the more sensitive High Gradient Macroinvertebrate Index (HGMI; Jessup 2007). Both protocols evaluate a 100-organism subsample and are described in detail in Appendix A.

NJIS is based on five criteria:

- Taxa Richness
- EPT genera
- Percent Dominance
- Percent EPT
- Family Biotic Index (FBI)

Each of the five metrics is given a score of 0, 3, or 6 depending on where it falls on the scale, and then all are totaled for a final NJIS index score. The possible scores range from 0 to 30, where 30 indicates the high end of non-impaired and 0 indicates a site which is severely impaired.

HGMI is based on 7 criteria:

- Total number of genera
- Percent of genera that are not insects
- Percent of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT; three orders of aquatic insects that are common in the benthic macroinvertebrate community) individuals (excluding Hydropsychidae, including Diplectrona)
- Number of scraper genera
- Hilsenhoff Biotic Index (HBI)
- Number of attribute 2 genera (highly sensitive and uncommon taxa)
- Number of attribute 3 genera (sensitive and common taxa)

Habitat Assessment Data: The suitability of the riparian habitat is assessed through a visual site assessment and calculating stream flow. A total habitat score is calculated (Table 45; Barbour 1999; NJDEP 2015). Staff and volunteers characterize the health of the riparian habitat by completing a visual site assessment and calculating stream flow.

A habitat assessment should occur following a macroinvertebrate sampling event. The USEPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (RBP) will be utilized for a visual habitat assessment in each of the monitoring sites. The RBP is utilized by state agencies across the nation and is the standard, accepted habitat assessment method for wadable rivers and streams.

Chemical Parameters

Chemical monitoring will be conducted via both continuous and discreet sampling.

Temperature and Specific Conductance: Two types of continuous sensors will be deployed. A HOBO 8K Pendant Temperature Data Logger will be used to monitor temperature changes on the South Branch Raritan River just before it leaves the Highlands. Temperature data will be downloaded monthly in the field via USB. Data will be logged at 15-minute intervals continuously throughout the monitoring period.

RHA has 2 Mayfly Enviro-DIY continuous conductivity-depth-temperature sensors ("Climate Stations") deployed since 2022 on the South Branch Raritan River. There are two of five such sensors placed strategically throughout the Upper Raritan to measure specific conductivity, temperature, and water depth at 15-minute intervals. Locations of these stations include: (1) the headwaters of the South Branch Raritan, directly downstream of the Budd Lake outlet, (2) near the headwaters of the North Branch Raritan in Mendham Township, (3) approximately mid-way downstream/upstream of the South Branch Raritan in Ken Lockwood Gorge, (4) approximately mid-way downstream/upstream of the Black/Lamington River in Pottersville, and (5) below the confluence with the Lower Raritan River at Duke Farms. The stations transmit data via cell service to MonitorMyWatershed.org linked to the Climate Dashboard on RHA's website here https://www.raritanheadwaters.org/climate-stations/.

Both sensor types require biweekly maintenance to check for fouling, loss, or damage of equipment.

Other Chemical Parameters: Discrete chemical monitoring will begin in June 2026 and will be conducted monthly at each of the 21 stream monitoring sites.

During discreet sampling events an *in situ*-brand meter will be utilized to measure stream temperature, dissolved oxygen (concentration and percent saturation), pH, total dissolved solids (TDS) and conductivity (specific and actual). Meters are calibrated prior to field visits using NIST-certified standards. Total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), chloride, and surfactant data will be collected using a grab sample and analyzed by a state-certified lab. When collecting grab samples, sample jars should be rinsed three times with stream water before sample collection. Taking samples from the surface of the stream should be avoided. Turbidity will be measured in the field using a turbidimeter. A standard operating procedure (SOP) for collecting grab samples is in development.

Collecting both chloride and specific conductance data will allow us to understand the relationship between chloride and conductivity. Specific conductance is often used as a proxy for chloride and previous studies have shown significant relationships between chloride and conductivity (Trowbridge et al. 2010). However, specific stream sites are subject to trends outside of this typical relationship, given concentrations of other ions present. A Flinn Scientific hand-held flow meter will be used during each sampling event so that all chemical parameters can be flow-weighted for load estimates.

Bacterial Data: The current primary contact recreation use surface water quality standard (SWQS) for freshwater in New Jersey is based on *Escherichia coli* (*E. coli*) bacteria levels. Each site will be sampled five (5) times, including one stormwater sampling, over a 30-day period between July and August using NJDEP protocols

(https://www.nj.gov/dep/wms/bfbm/QAPPs/SummerAmbientBacteriology2016QAPP.pdf).

Garden State Labs (GSL), an NJDEP-certified water testing lab, determines *E. coli* count/100ml using USEPA Method 1603.

Rainfall Data: Data on monthly rainfall will use as a reference the nearest CoCoRaHS station (https://www.cocorahs.org/) and a monthly weather report from National Oceanic and Atmospheric Administration (NOAA). The amount of rainfall that occurs monthly within the sampling locations will be recorded and summarized in the final report. Volunteers will be encouraged to install a CoCoRaHS station on their property to assist with the development of the monitoring plan where gaps in rainfall data exist.

Land Use Land Cover*:* Data on land use land cover will be obtained from NJDEP (Bureau of GIS) and analyzed by catchment area for each site ArcGIS (ESRI). For each site, catchment-level variables will be calculated from the data including total area of the catchment, percent land use land cover type (forest, wetland, agriculture, urban, barren, and impervious surface), and percentage change for each land use land cover type between 1986 to 2026 and for 2026 to 2038.

Decontamination Protocols: Decontamination protocols recommended by NJDEP (2024) will be followed to prevent the spread of aquatic invasive species. Field gear should be decontaminated after each biological sampling event to prevent the spread of pathogens and invasives. Decontamination protocols must be followed even if there are no known aquatic invasive species in the restoration area. All visible debris and gear will be removed before leaving the stream. All gear holding stream water will be emptied on site to avoid transportation and all gear should be dried completely before the next sampling event. Decontamination consists of mixing a solution of water and biodegradable dish soap and scrubbing all gear thoroughly, away from the stream. In particularly sensitive areas, a 3% bleach solution should be used to ensure that pathogens specific to sensitive amphibian species are thoroughly removed. The bleach solution should not be used in the field and should be contained and treated as chemical waste. All field gear cleaned with bleach should be allowed to dry completely before being used in the field again to avoid environmental damage. Bleach may not be applicable for all field gear, as it may be damaging to some materials. Whenever possible, hot water will be utilized during decontamination for increased effectiveness.

Sampling Schedule

***In situ* monitoring (monthly):** The following *in-situ* parameters should be tested at each sampling location using hand-held meters for measurement of temperature, conductivity, dissolved oxygen (concentration and percent saturation), pH, and total dissolved solids.

Grab samples for laboratory analysis (Monthly except for bacteria): Samples will be collected monthly under baseflow conditions (except for the stormwater sample(s) for bacteria). Grab samples will be collected and sent to an NJDEP certified laboratory for analysis. At all stream sites, samples will be used for measurements of TN (including nitrate, nitrite, and Total Kjeldahl Nitrogen), TP, chloride, TSS, surfactants, and bacteria. Bacteria are sampled five (5) times during summer months.

Annual Biological and Visual Habitat Assessments (Annually from June 1-June 30): Macroinvertebrate and visual habitat assessments will occur at each longterm monitoring site. Macroinvertebrate samples are collected, and visual assessments are conducted on an annual basis between June 1st and 30th. RHA's benthic macroinvertebrate sampling and visual habitat assessments have a DEP-approved QAPP conforming to Tier 3.3 level standards and are thus used by the DEP for regulatory decision-making.

(NJDEP Water Monitoring and Standards, Volunteer Monitoring, https://njwatershedwatch.org/wp-content/uploads/2021/01/NJ-Community-Monitoring-DataQuality-Tiers.pdf).

Benthic macroinvertebrate samples are preserved and delivered to a certified taxonomist at Normandeau Labs in Stowe, Pennsylvania for identification, counts, and calculation of the High Gradient Macroinvertebrate Index (HGMI) and its submetrics.

Data Analysis and Reporting

Determination of Impairments: Water quality data will be evaluated based on whether each parameter is meeting New Jersey Surface Water Quality Standards (SWQS). A site will be considered impaired, with respect to a given parameter, if it is not meeting the Surface Water Quality Standard.

Descriptive Statistics: Descriptive statistics of water quality parameters will be summarized by site, river overall, and by year and reported as box plots and in tabular format using R and SPSS.

Before-After Comparison: A BACIP (before-after-control-impact-paired) model as described by Smith (2002) will be utilized for this study. This allows for analysis of data before and after treatment (restoration efforts). This design considers both control and treatment data. It pairs the treatment site with a control site, where restoration efforts are not being undertaken, to account for natural variations in water quality and biological community composition. BACIP model utilizes ANOVA to look for differences between control and treatment, before and after restoration, and interaction effects. Additional statistical analyses will be undertaken to explore patterns in the biological, habitat, and chemical data.

Trends over Time: Presence of significant temporal trends in water quality and land use metrics will be determined using PERMANOVA and then by assessing the significance of Spearman's rank correlation coefficients for pairings of X (Year) and Y (water quality metric) using methods described by Scarsbrook et al. (2000; SPSS Statistics 2017). In addition, the strength of significant trends will be determined using Bonferroni-corrected P-values. Spearman's rank correlation coefficient has an advantage over parametric correlation techniques in that the relationship between X and Y does not necessarily have to be linear, and data does not need to come from a normal population (Iman and Conover 1983). In the analysis, both variables are first ranked, then the correlation coefficient is calculated for the ranks. In the present study, year will be ranked, with the first year being ranked as 1 and subsequent years given sequential numbers (2, 3, 4, …). A significant relationship between year and an individual community metric indicates a trend and the sign of the relationship will indicate whether the metric increased or decreased temporally. The level of significance will be set *a priori* at $p<0.05$.

Data will be visualized on maps created using ArcGIS with trends indicated using arrows.

The RHA has provided a budget for this sampling program (see Table 46).

Budget

Table 46: Project budget broken down by baseline study and overall project

South Branch Raritan River WRPP Monitoring Budget				
Parameters	**Lab cost/sample**	**# samples /yr**	**# of sites**	**Total**
Nitrate	$20	12	21	$5,040
Total Phosphorus	$30	12	21	$7,560
Total Suspended Solids	$25	12	21	$6,300
Chloride	$25	12	21	$6,300
E coli	$20	5	21	$2,100
Surfactants	$30	12	21	$7,560
Benthic Macroinvertebrates	$300	1	21	$6,300
			Total/year 1	**$41,160**
			Total 2026-2039	**$452,760**
	Equipment and Supplies			
Hobo 8k Pendant Temperature Logger	$160	1	1	$160
Mayfly Enviro DIY - board and sensors	$1,000	1	1	$2,000
Lab Consumables - calibration standards	$800	1	1	$800
In Situ Factory Calibration	$250	1	1	$250
			Total/year 1	**$3,210**
			Total 2026-2039	**$25,310**
	Staff Time			
Baseline Study - fieldwork, analysis, report	$7,000	1		$7,000
			Total Year 1 baseline (2026)	**$50,370**
	Staff Time			
Annual Data Collection - 2028-2038	$5,000	10	2028-2039	$50,000
Final Report 2039	$5,000	1	2039	$5,000
			Total Study Cost (2026-2039)	**$550,070**

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