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The Assiscunk Creek
Watershed Restoration and Protection Plan

Developed by the Rutgers Cooperative Extension Water Resources Program

Funded by the Burlington County Board of Chosen Freeholders
and the
NJDEP 319(h) Program
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1. Acknowledgements

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2. Executive Summary

The Assiscunk Creek Watershed Restoration and Protection Plan characterizes the watershed and provides insight into the problems facing the waterway and potential solutions. Due to its valuable wetland vegetation and rich farmlands, a large portion of this watershed has been classified as a Category One (C1) waterway, providing the highest level of protection that can be given by the State of New Jersey. This watershed also has many waterways that are impaired by excess phosphorus and excess bacteria, creating problems for designated water uses.

Land use in the watershed is predominantly agricultural, providing rich landscapes and productive output. Well managed, this watershed can continue these land use practices while achieving sustainability and ensuring a stable, healthy waterway. To do this, management measures that will minimize stormwater runoff will be essential to reducing contaminants that now impair the designated uses of the waters within the watershed.

Working with the Burlington County Department of Resource Conservation and the Burlington County Soil Conservation District, the Rutgers Cooperative Extension Water Resources Program has created this plan to provide recommended implementation projects, measureable milestones and suggestions for technical assistance and funding. Along with site specific projects, watershed wide educational components will be essential for obtaining fishable/swimmable goals for the future.

3.0 Introduction

The purpose of creating this Watershed Restoration and Protection Plan for the Assiscunk Creek Watershed is to ensure that the valuable uses that this freshwater system has provided the area in the past continue into the future. These uses include irrigation for agriculture and the ability of the river to provide a healthy ecosystem for aquatic species and surrounding habitat and wildlife. The Rutgers Cooperative Extension (RCE) Water Resources Program has undertaken the task of performing water quality testing, land surveillance, geographic information systems (GIS) analyses, and watershed modeling to provide stakeholders within the Assiscunk Creek Watershed with a Watershed Restoration and Protection Plan to ensure the quality of the watershed for the future.

The Assiscunk Creek Watershed is affected by the creation of two total maximum daily loads (TMDLs). A TMDL to address the fecal coliform contamination levels in the Annaricken Brook and Barkers Brook was approved in September of 2003 and requires a reduction in load allocation of 95% for the Annaricken and 96% for Barkers Brook. A second TMDL addressing phosphorus levels was approved in October of 2007 and requires a load allocation reduction of 54.6% for the Annaricken and 66% for Barkers Brook. Also, close to forty miles of streams in the Upper Assiscunk and the Annaricken Watersheds are classified as Category One (C1) waterways, an Antidegradation Designation that provides special protection under New Jersey’s Stormwater Rules (NJAC 7:8, 2004).

This plan will synthesize available data on the Assiscunk Creek Watershed and determine the potential sources and extent of any water quality problems within the watershed. Solutions to these problems will then be discussed with examples of such solutions for specific areas of the watershed.

The RCE Water Resources Program has coordinated efforts for this Watershed Restoration and Protection Plan with the Burlington County Department of Resource Conservation Water Resources Program and the Farmland Preservation Program. The Burlington County Soil Conservation District has also provided assistance.

3.1 Watershed Overview

The project area for this planning initiative consists of the headwaters of the Assiscunk Creek, a 14.6 square mile drainage area including the Annaricken Brook and the 4.8 square mile North Branch of Barkers Brook (Henceforth, "The Assiscunk Creek Watershed"). Land use is dominated by agricultural uses, including row crops, field nurseries, container nurseries and animal farming. The primary streams within the planning watershed are the Assiscunk Creek (headwaters), the North Branch of Barkers Brook, and the Annaricken Brook (entire reach), with main stem lengths of 7.3 miles long, 4.8 miles long, and 3.9 miles long, respectively. Within this planning area, there are approximately 40 miles of mapped streams designated Category One, with the exception of Barkers Brook. While there are no major lakes in the subwatersheds, there are three small impoundments that make up a total lake area of 2.8 acres within the project area. The project area is completely within Burlington County and is predominantly comprised of sections of of Mansfield Township and Springfield Township (Figure 1).

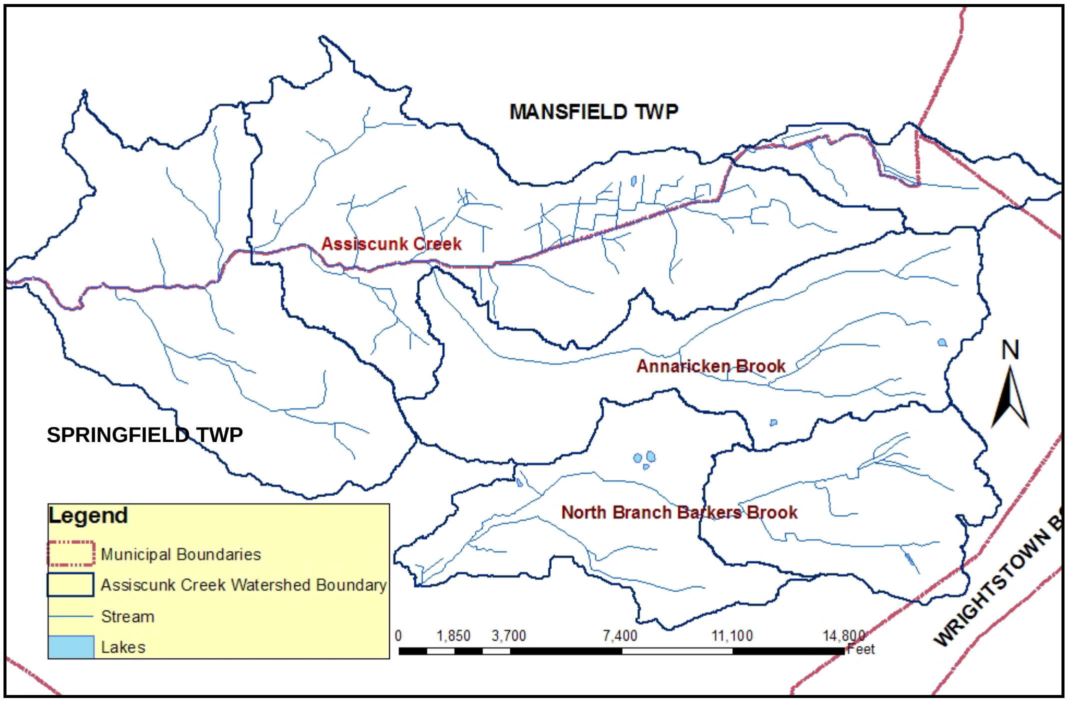

Figure 1: Municipalities and Stream Network of the Assiscunk Creek Watershed (NJDEP GIS)

Of the land uses within the subject watershed, approximately 70 percent is designated as agricultural and agricultural wetlands. Other land uses include forested areas and some suburban and typical small village development (*NJDEP 2002 Land use/Land cover Update, Assiscunk, Crosswicks and Doctors Watershed Management Area, WMA-20).*

3.2 TMDL Development Process

Section 303 of the Federal Clean Water Act (CWA) requires New Jersey to prepare and submit to the USEPA a report that identifies waters that do not meet or are not expected to meet state surface water quality standards. This report is commonly referred to as the 303(d) list. Those waterbodies, which are listed on the 303(d) list, are water quality limited waterbodies and therefore a TMDL must be developed for each individual pollutant in these water bodies based on an agreed upon schedule between the state and USEPA.

A TMDL is a calculation of the maximum amount of a single pollutant that a waterbody can receive and still meet state water quality standards. It quantitatively assesses water quality problems, contributing sources, and load reductions or control actions needed to restore and protect individual water bodies. The ultimate goal of the TMDL process is to meet the water quality standards and ultimately improve the water resources within a watershed.

A TMDL establishes waste load allocations and load allocations for point and nonpoint sources (NPS), respectively. These allocations together, with a margin of safety (MOS), are used to calculate the TMDL value. Point source pollution can come from the wastewater of various industries, federal, state, county, and municipal facilities, private companies, private residential developments, hospitals, and schools. These point sources are all regulated. NPS pollution, on the other hand, comes from many diffuse sources that enter waterways from stormwater runoff. Some sources of NPS pollution are excess fertilizers, sediment from streets or land that is not stable, and bacteria from pet wastes or faulty septic systems.

Within the Integrated List of Waterbodies (NJDEP, 2008) for New Jersey are lists that indicate the presence and level of impairment for each waterbody monitored. The lists are defined as follows:

- **Sublist 1** suggests that the waterbody is meeting water quality standards.
- **Sublist 2** states that a waterbody is attaining some of the designated uses, and no use is threatened. Furthermore, Sublist 2 suggests that data are insufficient to declare if other uses are being met.
- **Sublist 3** maintains a list of waterbodies where no data or information are available to support an attainment determination.
- **Sublist 4** lists waterbodies where use attainment is threatened and/or a waterbody is impaired; however, a TMDL will not be required to restore the waterbody to meet its use designation.
    - ➢**Sublist 4a** includes waterbodies that have a TMDL developed and approved by the USEPA, that when implemented, will result in the waterbody reaching its designated use.

  - ➢**Sublist 4b** establishes that the impaired reach will require pollutant control measurements taken by local, state, or federal authorities that will result in full attainment of designated use.
  - ➢**Sublist 4c** states that the impairment is not caused by a pollutant, but is due to factors such as instream channel condition and so forth. It is recommended by the USEPA that this list be a guideline for water quality management actions that will address the cause of impairment.
- **Sublist 5** clearly states that the water quality standard is not being attained and requires a TMDL.

3.3 Assiscunk Creek TMDL

Based on water quality testing and subsequent data analysis performed under the Integrated Water Quality Monitoring and Assessment Methods Document (NJDEP, 2006), several sections of the Assiscunk Creek Watershed have been categorized as being impaired for various parameters and uses (NJDEP, 2006; NJDEP, 2008). In the 2006 and 2008 reports, all areas within the boundaries of the delineated Assiscunk Creek Watershed were listed on Sublist 5 for the impairment of aquatic life (general), thereby requiring a TMDL.

The Assiscunk Creek Watershed is affected by the creation of two TMDLs. A TMDL to address the fecal coliform contamination levels in the Annaricken Brook and Barkers Brook was approved in September of 2003 (NJDEP, 2003b) and requires a reduction in load allocation of 95% for the Annaricken and 96% for Barkers Brook (Table 1).

A second TMDL addressing phosphorus levels was approved in October of 2007 (NJDEP, 2007b) and requires a load allocation reduction of 54.6% for the Annaricken and 66% for Barkers Brook (Table 1).

Table 1: Integrated Listing and TMDLs in the Assiscunk Creek Watershed

	Station Name	Use Impairment	Parameter	Percent Reduction (with MOS)
Approved (by EPA Region 2) 9/29/03	Annaricken Brook near Jobstown	Primary Contact	Fecal Coliform	95%
	North Branch Barkers Brook near Jobstown	Primary Contact	Fecal Coliform	96%
Approved (by EPA Region 2) 10/1/07	Annaricken Brook near Jobstown	Aquatic Life (Gen)	Phosphorus	54.6%
	Barkers Brook near Jobstown	Aquatic Life (Gen)	Phosphorus	66%

4.0 Assiscunk Creek Watershed

4.1 Physical Characteristics

4.1.1 Geography and Topography

The Assiscunk Creek watershed is located in the northern section of Burlington County, New Jersey and contains portions of Springfield, Mansfield, and Chesterfield Townships. The designation of Assiscunk Creek as a C1 waterway is due to the geographical characteristics of the stream. These characteristics include the wealth of farmland surrounding the stream, the border of a rich floodplain containing oak and maple forested wetlands, vernal pools, and marshes all being important wildlife habitat.

The topography of the watershed is generally defined by mild elevation changes along the courses of the flow paths of the streams. These gentle slopes range from 0.5% in the uppermost Assiscunk Watershed to a very gentle 0.01% in the outlet subwatershed along the main branch. These mild slopes make for reduced momentum in flooding situations while creating many areas of wetlands.

The project area for this planning initiative consists of the headwaters of the Assiscunk Creek, a 11.15 square mile drainage area including the Annaricken Brook and the 3.43 square mile North Branch of Barkers Brook (Henceforth, “The Assiscunk Creek

Watershed”). Land use is dominated by agricultural uses, including row crops, field nurseries, container nurseries and animal farming. The primary streams within the planning watershed are the Assiscunk Creek (headwaters), the North Branch of Barkers Brook, and the Annaricken Brook (entire reach), with main stem lengths of 7.3 miles long, 4.8 miles long, and 3.9 miles long, respectively.

4.1.2 Delineation

The total planning area for the Assiscunk Creek Watershed Restoration and Protection Plan is approximately 14.6 square miles, containing one full HUC14 watershed and the upper portions of two other HUC14 watersheds. The full HUC 14 watershed is 02040201100010, and the two upper portions of HUC 14 watersheds come from 020402011000-40 and 02040201100020-01. These include the eastern section of the Assiscunk Creek (Route 206 to drainage divide west of Petticoat Bridge Road) and the North Branch of Barkers Brook. (See Figure 2)

The six subwatersheds of the Assiscunk Creek Watershed were delineated within the boundaries of three HUC14 watersheds, allowing an analysis of the greatest areas of concern. The boundaries of the Assiscunk Creek Watershed and the subwatersheds of the Assiscunk Creek Watershed can be viewed within the boundaries of the HUC14s in Figure 2.

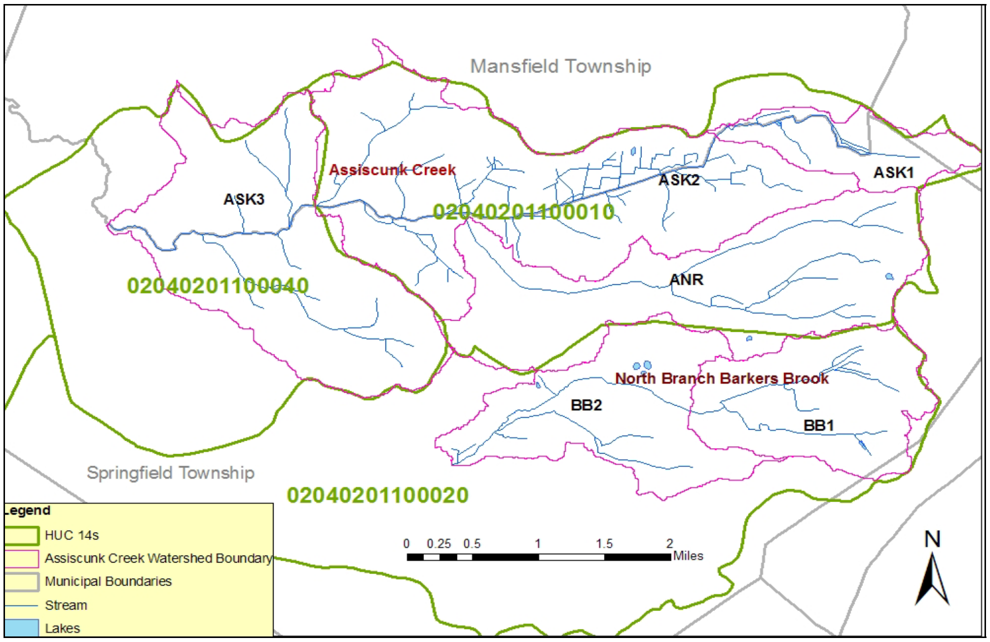

Figure 2: Limits of Assiscunk Creek Watershed Boundary within HUC14 Boundaries

The HUC14 name and number can be identified as to its related Assiscunk Creek Watershed subwatershed in Table 2.

Table 2: HUC14 and Corresponding Assiscunk Creek Watershed Boundaries

HUC14	Name	Subwatersheds from Assiscunk Creek Watershed Contained in HUC14
2040201100010	Assiscunk Creek (above Route 206)	ASK2, ASK1, ANR
2040201100020	Barkers Brook (above 40d02m30s)	BB1, BB2
2040201100040	Assiscunk Creek (Jacksonville Road to Route 206)	ASK3

4.1.3 Demographics

The population of Mansfield Township in 1987 was 3,000. Sources of income have changed from predominantly farming and trades to earning an income in the manufacturing centers nearby (Mansfield, 2010). Similar sources of income and changes in trades are surmised for the area of Springfield within the Assiscunk Creek Watershed, given the adjacent location and highly similar land use and development.

The 2000 Census reports a population of 5,090 for Mansfield Township and 3,227 for Springfield Township, providing an average of 232 and 111 people per square mile respectively (Table 3). These numbers can be compared with the Burlington County average of 526 people per square mile or the overall New Jersey population density of 1,134 people per square mile.

Table 3: Assiscunk Creek Watershed Estimated Population Density

Municipality	Area within Watershed Boundary		Population Density 2000	
	acres	square miles	per sq mile	estimated within watershed
Mansfield Twp.	2233.65	3.49	232	810
Springfield Twp.	6995.21	10.93	110	1202

4.1.4 Climate

The Assiscunk Watershed is located within the Pine Barrens Climate Zone in New Jersey. This climate is typical of that found in the mid-Atlantic region, with warm, humid summers and cold winters. Average annual precipitation is generally between 43 and 47 inches (ONJSC, 2010).

4.1.5 Geology

The Assiscunk Creek Watershed is contained within the Inner Coastal Plain Physiographic Province in New Jersey. This area is characterized by relatively flat terrain that is underlain with sands and gravels of Cretaceous origin (Anderson, 2010).

4.1.6 Soils

Several areas within the watershed contain acid soils (NJDEP and NJGS, 2009), including a portion of the Englishtown Formation in the northwest section of the watershed of the watershed. Sulfide containing soils from Cretaceous sediments, as shown in Figure 3, are potential acid producing soil.

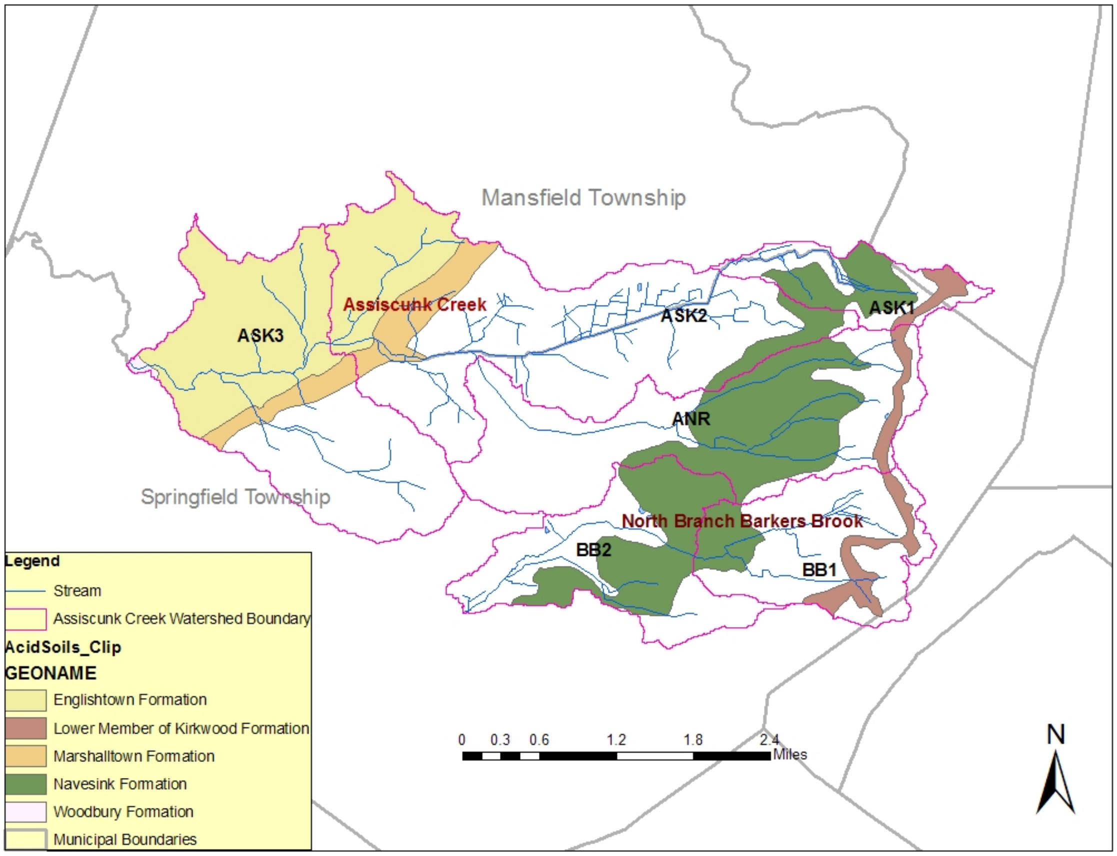

Figure 3: Potential Acid Producing Soils

4.2 Critical Source Areas

A critical source area is the intersection of the site of a pollutant source and a hydrologic transport pathway. Identification of these areas will allow the watershed manager to select management options from affecting the source to altering the pathway.

4.2.1 Wetlands

The Assiscunk Creek Watershed contains 3,520 acres of land use described in the 2002 NJDEP Land Use Land Cover GIS layer as “Wetlands.” These wetlands provide the rich floodplains of oak and maple forested swamp, vernal pools, and marshes (NJDEP, 2002) that have allowed this waterway to be designated a C1 waterway, the highest level of protection in the State. However, even though wetlands account for 46% of the land use in the watershed, 52% of this land is considered "agricultural wetlands," and this land has been modified to be farmed as such (Figure 4).

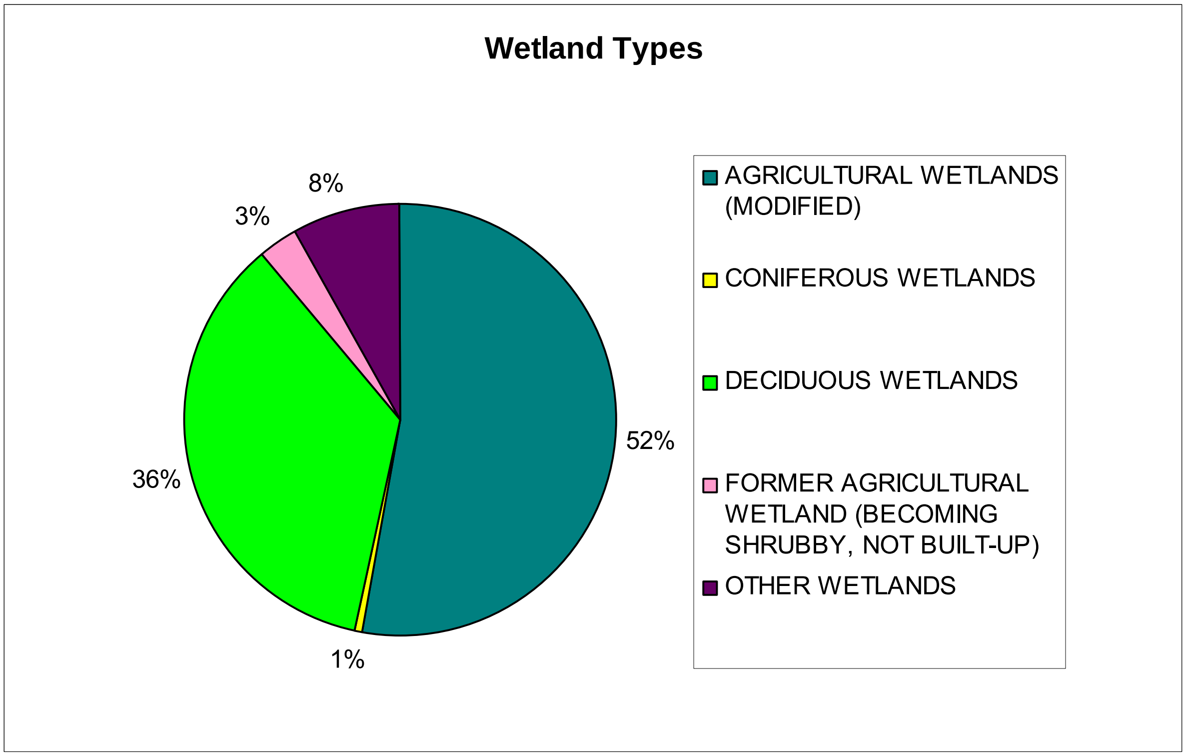

Figure 4: Assiscunk Creek Watershed Wetland Types (NJDEP, 2007)

4.2.2 Floodplain

Burlington County is currently expecting a new delineation of the floodplains that will be determined from updated topographic data recently collected. Current available digital data depicting the floodplain extent is taken from the Federal Emergency Management Agency (FEMA) Q3 data layer (FEMA, 1996).

Zone A, the area inundated by 100 year flooding (no Base Flood Elevations have been established) is shown in cross hatching in Figure 5. Aerial analysis shows that there is very little development within the boundaries of Zone A. Sparse commercial buildings in are located in ASK3 where the main stem Assiscunk crosses Route 206 in Springfield and in subwatershed ANR where aerials show a potential farm building in the flood zone.

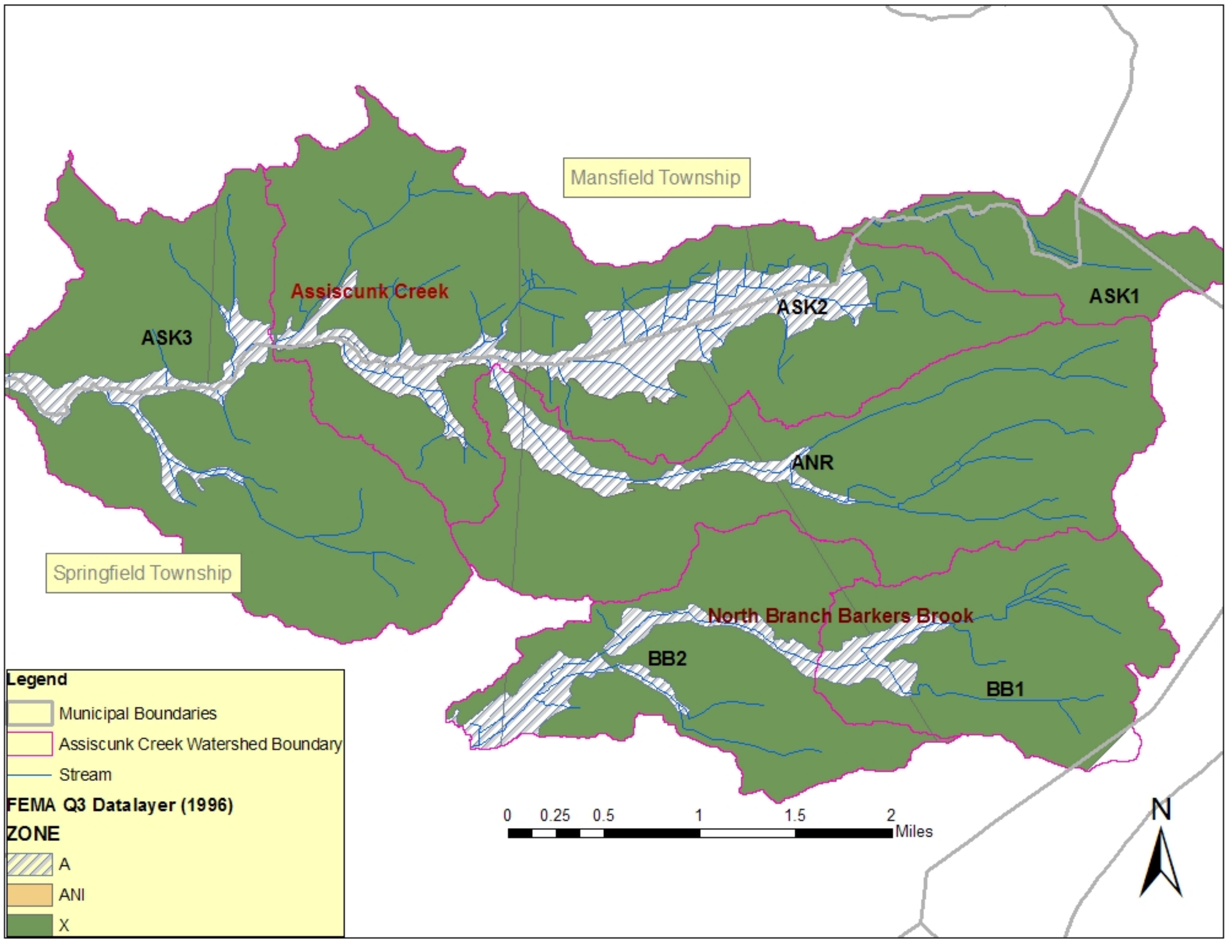

Figure 5: FEMA Q3 Datalayer (1996)

4.2.3 Riparian Areas

The functions of a healthy riparian area include stream bank stabilization, water storage and release, aquifer recharge and sediment filtering. This interface between the stream and the land should contain vegetation and roots that protect and stabilize banks as well as filter the overland flow of stormwater runoff. This interface should also promote high wildlife diversity and contain a high water table and increased storage capacity. The vegetation in the riparian area in the Assiscunk Creek Watershed has often been disrupted by land use practices. The extent of the lack of vegetation will be addressed in the sections addressing pollutant sources and recommendations for restoration strategies.

4.3 Land Use

Of the land uses within the subject watershed, approximately 70% is designated as agricultural and agricultural wetlands. Other land uses include forested areas and some suburban and typical small village development (*NJDEP 2007 Land use/Land cover Update, Assiscunk, Crosswicks and Doctors Watershed Management Area, WMA-20)* (Table 4 and Figure 6 and 7).

Table 4: 2007 Land Use Type Distribution per Subwatershed

2007 Land Use							
	AGRICULTURE	**BARREN LAND**	**FOREST**	**URBAN**	**WATER**	**WETLANDS**	**Total**
Subwatershed	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
ASK3	973.5	30.7	66.7	378.1	6.2	552.7	2007.9
ASK2	914.5	8.2	84.4	272.9	4.9	1408.0	2692.8
ANR	880.5	10.8	190.6	230.2	4.8	616.4	1933.3
ASK1	107.6	0.0	94.2	118.8	0.7	176.3	497.5
BB2	655.0	0.0	55.9	68.5	6.6	353.5	1139.4
BB1	279.6	77.6	233.7	54.2	0.7	412.1	1057.8
							9328.5

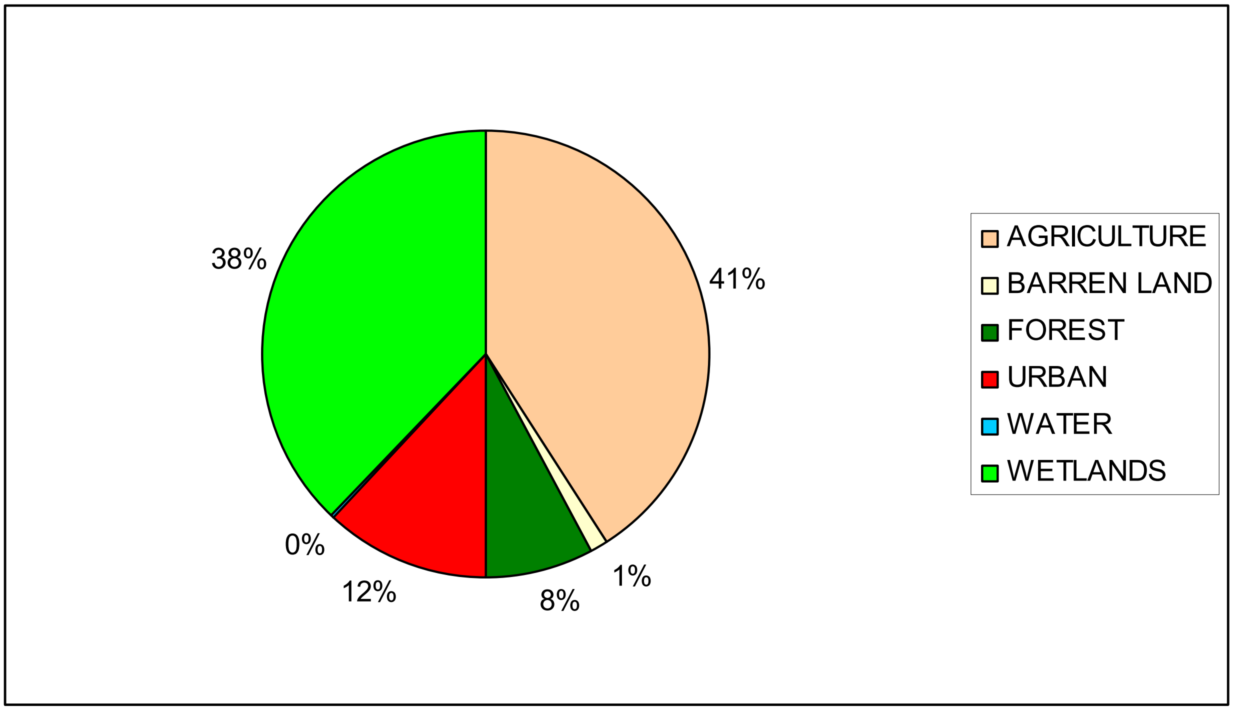

Figure 6: Assiscunk Creek Watershed Land Use (NJDEP, 2007)

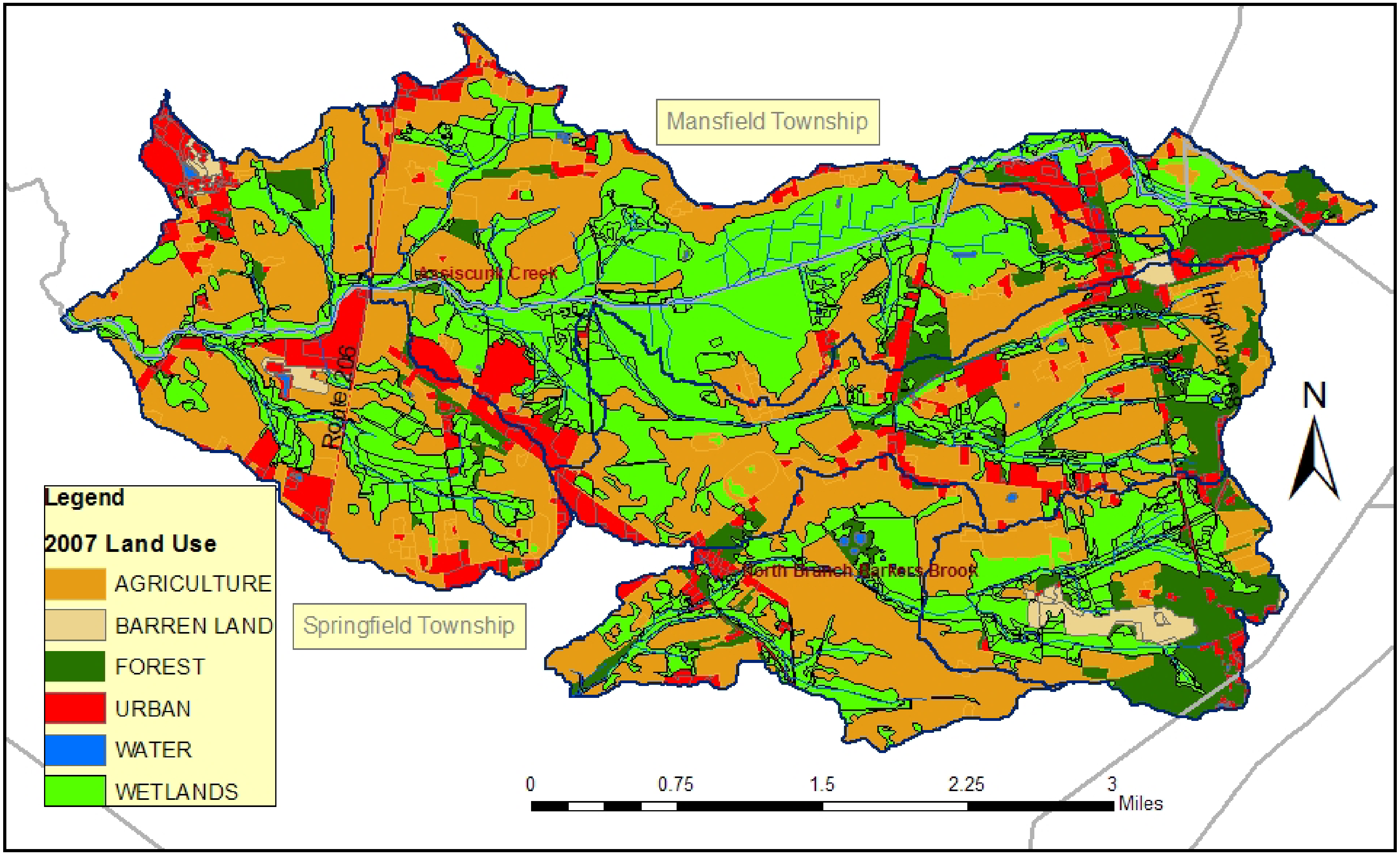

Figure 7: NJDEP 2007 Land Use of the Assiscunk Watershed

4.4 Preserved Farmland and Open Space

The Farmland Preservation Program has preserved close to 2,500 acres of farmland within the Assiscunk Creek Watershed. The locations of these parcels of land can be seen in Figure 8 below.

Open space preservation has affected only approximately 95 acres of land within the watershed. Three areas of open space preservation can be seen on Figure 8 below.

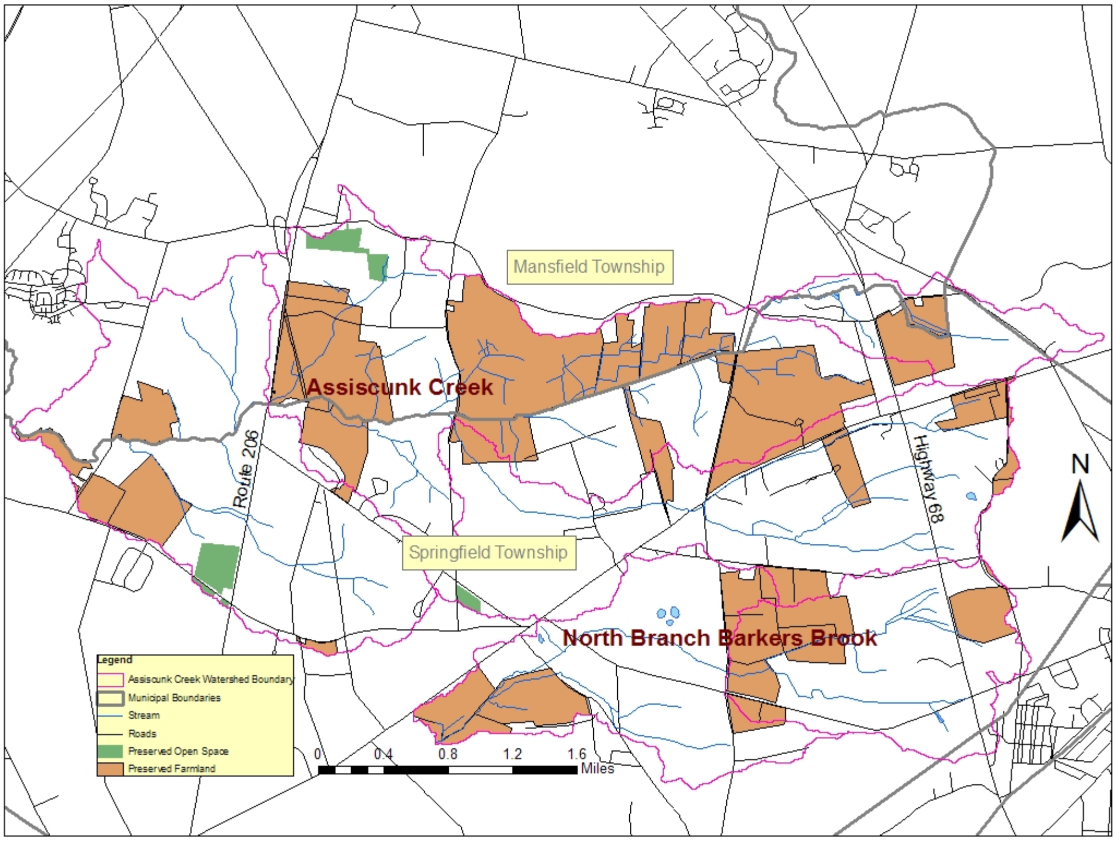

Figure 8: Preserved Farmland and Open Space

5.0 Causes and Sources of Pollution

5.1 Land Use Change

The Assiscunk Creek Watershed has experienced land use changes in the last two decades. These changes have not been as dramatic as seen elsewhere in New Jersey, with the agricultural lands being preserved at a higher rate. Aerial photography of the watershed in the 1930's shows a very similar agriculturally dominated watershed with similar drainage patterns. Fringe residential areas and additional pockets of forested lands are noted to be more extensive currently than seen in these older photos.

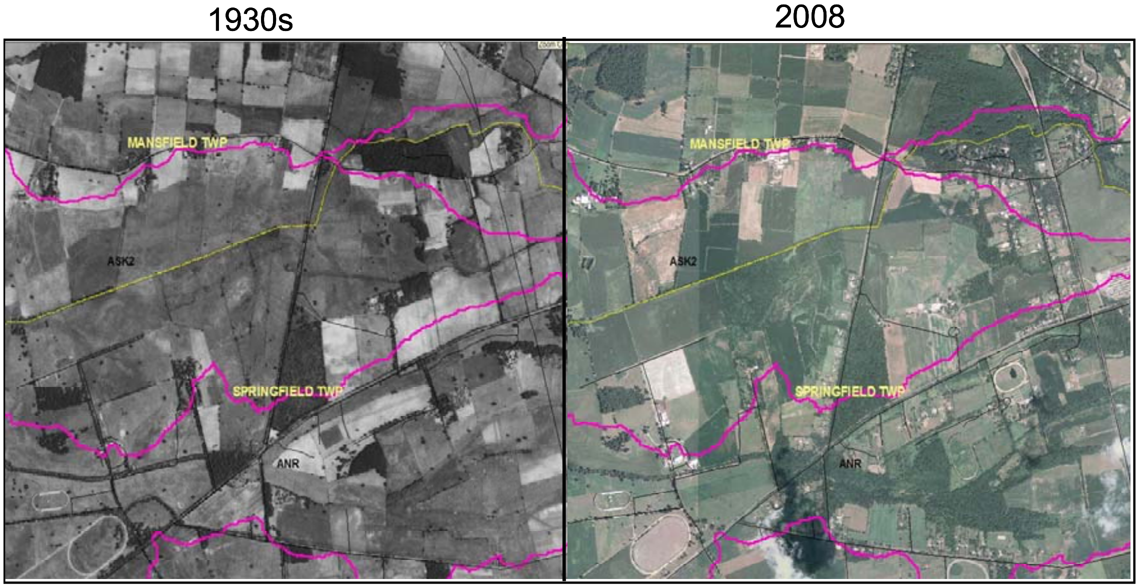

Figure 9: Aerial photos from the 1930's and 2008

In more recent land use changes, the limited urban development has resulted in increased impervious areas. Impervious acres have increased from 571 acres in 1995 to 622 acres in 2002 (Table 5). These impervious areas are primarily residential lands whose stormwater is managed close to the site of development.

Table 5: Impervious Area Change in the Assiscunk Creek Watershed

Impervious area 2002	Impervious area 1995
621.8 acres	571. 3 acres
0.97 sq miles	0.89 sq. miles
6.66 %of watershed	6.12 % of watershed

Understanding the land use dynamics between the agricultural wetlands and other agricultural uses is difficult due to the inconsistency in the classification of these types of land uses. In evaluating total watershed land use percentages from the 1986 land use files to the 2007 land use files (Figure 10), it appears that agricultural lands have transformed to wetlands.

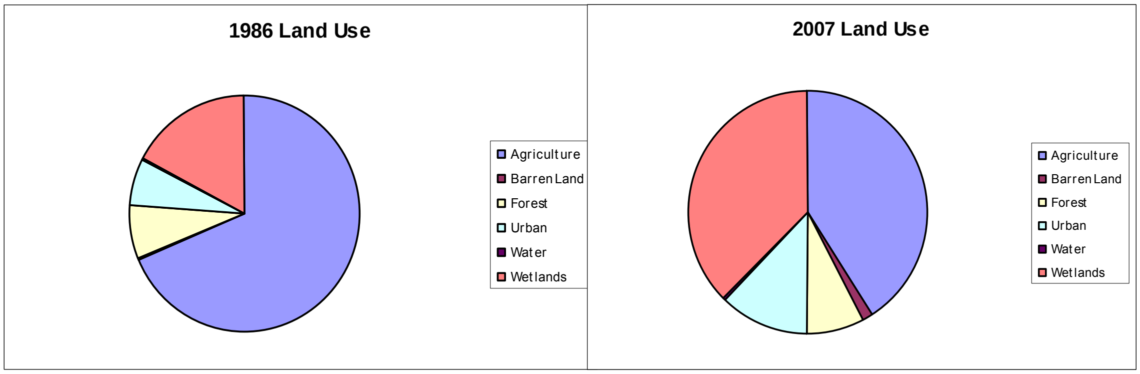

Figure 10: Total Watershed Landuse Types, 1986 and 2007 (NJDEP, 1986 and NJDEP, 2007)

However, the means of classifying the wetlands has undergone changes since 1986 and cannot be used to determine the loss of agricultural lands. In the Assiscunk Creek Watershed, analysis of these land use categories indicate that land that was in use as agriculture in 1986 was classified as "Agriculture," whereas in 2007, the land use classification was more refined and reclassified some land that was previously "Agriculture" as "Wetlands" and subcategorized as "agricultural wetlands" or "former agricultural wetlands" (Table 6). These labels allow a greater understanding of the land on an ecological basis, as the soils and hydrology indicate natural wetland components.

Table 6: Wetland Classification Division, 1986 and 2007

1986 Wetlands Type Breakdown	**acres**	**sq miles**
DECIDUOUS SCRUB/SHRUB WETLANDS	430.69	0.6732
DECIDUOUS WOODED WETLANDS	594.11	0.9282
HERBACEOUS WETLANDS	579.09	0.9047
MANAGED WETLANDS (MODIFIED)	9.41	0.0147
total:	1613.3	2.5208
2007 Wetlands Type Breakdown	**acres**	**sq miles**
AGRICULTURAL WETLANDS (MODIFIED)	1878.3	2.9352
CONIFEROUS SCRUB/SHRUB WETLANDS	8.83	0.0137
CONIFEROUS WOODED WETLANDS	5.16	0.0081
DECIDUOUS SCRUB/SHRUB WETLANDS	245.28	0.3836
DECIDUOUS WOODED WETLANDS	1024.86	1.6008
DISTURBED WETLANDS (MODIFIED)	16.63	0.026
FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)	33.8	0.0529
HERBACEOUS WETLANDS	228.75	0.3574
MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	10.46	0.016
MIXED SCRUB/SHRUB WETLANDS (CONIFEROUS DOM.)	8.85	0.0138
MIXED SCRUB/SHRUB WETLANDS (DECIDUOUS DOM.)	37.11	0.0579
MIXED WOODED WETLANDS (CONIFEROUS DOM.)	3.44	0.0054
MIXED WOODED WETLANDS (DECIDUOUS DOM.)	2.34	0.0036
WETLAND RIGHTS-OF-WAY	15.11	0.0236
total:	3518.92	5.498

From 1995 to 2002 there was 2.92 square miles of land use, or 20% of the total watershed, that was reclassified to “agricultural wetlands” which previously had been functioning natural wetlands. The different land uses are expected to have different pollutant loading and drainage characteristics. Examples of changes in pollutant loading estimates from this change of land use can be seen in Table 7.

Table 7: Wetlands and Agriculture Aerial Loading Coefficients

NJDEP 1995/97 Land Use Type	**Aerial Loading Source Analysis: Loading Rate Coefficients**				
	TP (lbs/ac/yr)	*TN (lbs/ac/yr)*	*TSS (lbs/ac/yr)*	*NH3-N (lbs/ac/yr)*	*NO2+NO3 (lbs/ac/yr)*
Agriculture	1.3	10	300	N/A	N/A
Forest, Water, Wetlands	0.1	3	40	N/A	0.3
The loading coefficients used in this table have been provided by the NJDEP in the "New Jersey Stormwater Best Management Practices Manual," February 2009.					

5.2 Hydrological Alteration

Lands used for agricultural purposes require a balance of proper drainage and access to water. Farming in areas of previously documented wetlands and floodplains provides rich soils for optimal vegetative growth. However, the hydrologic modifications necessary can have an impact on the quality of the freshwater systems that surround the farms. These impacts can include both water quality and water quantity.

The Assiscunk Creek Watershed is generally a low gradient watershed, so man-made drainage routes have been carved into the landscape throughout the watershed (Figure 11). These drainage swales route overland flow and near surface flow to the edges of the farmed field for quicker water removal. If these drainage swales do not contain sufficient vegetation in or around them, the flows leaving the area are generally of higher velocity and lower water quality.

Figure 11: Drainage Swale

The agricultural fields have also been modified for optimal farming drainage by the implementation of tile drains. These tile drains have most likely been in place for many decades, but will continue to divert flows to drainage swales or streams close to the field. These drains will decrease the infiltration recharge to the groundwater, which would lower the groundwater table. However, since this area may have been primarily wetlands in the distant past, this modification does enhance the ability to properly farm these lands, as they have done much of the last century.

Irrigation for agricultural purposes has also modified the hydrologic cycle in this watershed. Irrigation pipes pulling freshwater from the streams of the Assiscunk Creek, Annaricken and Upper Barkers Brook are ubiquitous (Figure 12). The change in irrigation needs over time could be a significant factor not only in the water quantity of the stream, but also the water quality, although many factors will play a role in reduced baseflow and reduced groundwater recharge. Site surveillance has frequently found sampling sites in this watershed having little to no flow. In September of 2010, three of the headwater sampling sites (ASK1, ANR and BB1) were found to have no flow. This occurred after an unusually dry summer season.

Figure 12: Irrigation Pipes

5.3 Surface Water Quality

5.3.1 Designated uses and impairments

Water quality standards are developed according to the designated use of the waterbody (NJDEP, 2009). The streams within the Upper Barkers Brook subwatershed are classified as FW2-NT, or freshwater (FW) non-trout (NT). The Assiscunk Creek and the Annaricken Brook are classified as FW2-NTC1, C1 being Category 1, a higher level of anti-degradation protection for the stream. “FW2” refers to those waterbodies that are used for primary and secondary contact recreation; industrial and agricultural water supply; maintenance, migration, and propagation of natural and established biota; public potable water supply after conventional filtration treatment and disinfection; and any other reasonable uses. “NT” means those freshwaters that have not been designated as trout production or trout maintenance. NT waters are not suitable for trout due to physical, chemical, or biological characteristics, but can support other fish species. Category One designated waters are protected from any measurable change in water quality because of their exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resources (N.J.A.C. 7:9). The applicable water quality standards for this project are detailed in Table 8.

Table 8: Surface Water Quality Standards (SWQS) according to N.J.A.C. 7:9B (NJDEP, 2009)

Substance	Surface Water Classification	Criteria
pH (S.U.)	FW2 (listed at 1.15 (e) in SWQS)	4.5-7.5
Total Phosphorus (mg/L)	FW2 Streams	Except as necessary to satisfy the more stringent criteria in accordance with "Lakes" (above) or where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3, phosphorus as total P shall not exceed 0.1 in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.
Total Suspended Solids (mg/L)	FW2-NT	Non-filterable residue/suspended solids shall not exceed 40.
Bacterial counts (col/100ml):	FW2	*E. coli*: Shall not exceed a geometric mean of 126/100 ml or a single sample maximum of 235/100 ml.
		Fecal Coliform*: Shall not exceed geometric average of 200/100ml, nor should more than 10% of the total samples taken during any 30-day period exceed 400/100ml
Temperature (degrees Celcius)	FW2-NT	Temperatures shall not exceed a daily maximum of 31 degrees Celsius or rolling seven-day average of the daily maximum of 28 degrees Celsius, unless due to natural conditions.
Dissolved Oxygen (mg/L)	FW2	24 hour average not less than 5.0, but not less than 4.0 at any time

**Fecal coliform was the indicator organism used during the compilation of the TMDL. This standard has since been replaced by E. coli.*

A numeric criterion for total nitrogen in FW2-NT waters does not currently exist in New Jersey. Nitrate-nitrogen has a human health surface water quality criterion of 10 mg/L. A key comment added to the New Jersey Nutrient Criteria Enhancement Plan is that a nutrient criterion is needed for freshwater systems, with the NJDEP noting in the future schedule that NJDEP will evaluate the need (NJDEP, 2009b). Other input information regarding nitrogen levels are that reference conditions in Nutrient Ecoregion VIII (Upper Midwest and Northeast U.S) are reported as 0.38 mg/L (USEPA, 2000) and New Jersey Pinelands waters have a nitrate-nitrogen surface water quality criteria of 2 mg/L (NJDEP, 2009).

Based on water quality testing and subsequent data analysis performed under the Integrated Water Quality Monitoring and Assessment Methods Document (NJDEP, 2006), several sections of the Assiscunk Creek Watershed have been categorized as being impaired for various parameters and uses (NJDEP, 2006b; NJDEP, 2008). In the 2006 and 2008 reports, all areas within the boundaries of the delineated Assiscunk Creek Watershed were listed on Sublist 5 for the impairment of aquatic life (general), thereby requiring a TMDL.

The Assiscunk Creek Watershed is affected by the creation of two TMDLs. A TMDL to address the fecal coliform contamination levels in the Annaricken Brook and Barkers Brook was approved in September of 2003 and requires a reduction in load allocation of 95% for the Annaricken and 96% for Barkers Brook (Table 9).

A second TMDL addressing phosphorus levels was approved in October of 2007 and requires a load allocation reduction of 54.6% for the Annaricken and 66% for Barkers Brook (Table 9). Watershed assessment units noted in the 2006 Integrated Listing for water quality impairments are compiled in Table 10.

Table 9: TMDLs in the Assiscunk Creek Watershed

	Station Name	Use Impairment	Parameter	% (with MOS)
Approved (by EPA Region 2) 9/29/03	Annaricken Brook near Jobstown	Primary Contact	Fecal Coliform	95%
	North Branch Barkers Brook near Jobstown	Primary Contact	Fecal Coliform	96%
Approved (by EPA Region 2) 10/1/07	Annaricken Brook near Jobstown	Aquatic Life (Gen)	Phosphorus	54.6%
	Barkers Brook near Jobstown	Aquatic Life (Gen)	Phosphorus	66%

Table 10: 2006 Integrated Listings for the Assiscunk Creek Watershed

Assessment Unit ID	Assessment Unit Name	Parameter	Ranking	Subwatersheds of the Assiscunk Creek Watershed
02040201100010-01	Assiscunk Creek (above Rt 206)	pH	M	ASK1, ASK2 and ANR
02040201100010-01	Assiscunk Creek (above Rt 206)	Phosphorus	M	ASK1, ASK2 and ANR
02040201100020-01	Barkers Brook (above 40d02m30s)	pH	M	includes BB1 and BB2
02040201100020-01	Barkers Brook (above 40d02m30s)	Phosphorus	H	includes BB1 and BB2
02040201100040-01	Assiscunk Creek (Jacksonville rd to Rt 206)	Arsenic	M	ASK3
02040201100040-01	Assiscunk Creek (Jacksonville rd to Rt 206)	Mercury	M	ASK3
02040201100040-01	Assiscunk Creek (Jacksonville rd to Rt 206)	pH	M	ASK3

5.3.2 Monitoring Stations

Surface water quality samples were collected from six (6) water quality monitoring stations (Table 11) over a fifteen (15) month sampling time frame. Three stations are located on the main stem Assiscunk Creek, one station is located on the Annaricken, a tributary to the Assiscunk Creek, and two stations are on the North Branch of the Barkers Brook. The stations were placed in accessible sites located at the outlet of the hydrologically delineated subwatersheds of the Assiscunk Creek Watershed. Stations are identified in Table 11 and Figure 13.

Table 11: Water Quality Monitoring Location IDs and Descriptions

Site ID	Site Description	HUC14	Coordinates
ASK3	Assiscunk Creek at Petticoat Bridge Road	2040201100040	40˚03′13.91″N, -74˚44′35.70″W
ASK2	Assiscunk Creek at United States Highway 206	2040201100010	40˚03′24.91″N, -74˚43′25.96″W
ANR	Annaricken Brook at Island Road (also AN0139)	2040201100010	40˚03′18.91″N, -74˚42′08.19″W
ASK1	Assiscunk Creek at Columbus-Georgetown Road (also AN0138)	2040201100010	40˚03′55.35″N, -74˚40′01.00″W
BB2	Barkers Brook North at Juliustown Road (also AN0140)	2040201100020	40˚01′38.85″N, -74˚42′05.52″W
BB1	Barkers Brook North southeast of Monmouth Road	2040201100020	40˚01′57.83″N, -74˚40′12.48″W

Figure 13: Assiscunk Creek Watershed Water Quality Sampling Site Locations

5.3.3 Monitoring Events

The monitoring of the water quality included three different types of sampling events as presented in Table 12. Regular monitoring occurred from April 9, 2008 to September 23, 2008. These events were monitored for all *in situ* parameters, velocity and depth, and fecal coliform (FC), *E. coli*, ammonia-nitrogen (NH_3-N), nitrate-nitrogen (NO3-N), nitrite-nitrogen (NO_2-N), total phosphorus (TP), phosphate-phosphorus (PO_4^{3-}-P), total Kjeldahl nitrogen (TKN), total suspended solids (TSS). Bacteria only monitoring was conducted in the summer months of June through August of 2008. This entailed collecting three additional samples in each of those months for fecal coliform and *E. coli* analyses, as well as *in situ* parameters (pH, temperature, dissolved oxygen), velocity and depth. In addition, surface water quality samples from three storm events were collected between July of 2008 and July of 2009. Three samples were collected over the course of each storm event, and samples were analyzed for all parameter at all six (6) monitoring sites.

Table 12: Assiscunk Creek Watershed Water Quality Monitoring Events

Date	Regular Monitoring for all Parameters	Bacteria Only Monitoring	Storm Event Monitoring
04/09/08	X		
04/24/08	X		
05/20/08	X		
05/22/08	X		
06/04/08	X		
06/10/08		X	
06/12/08		X	
06/18/08	X		
06/24/08		X	
7/2/2008	X		
07/08/08		X	
07/10/08		X	
07/15/08	X		
07/22/08		X	
07/23/08			X
07/24/08			X
07/24/08			X
08/05/08		X	
08/07/08	X		
08/13/08		X	
08/19/08	X		
08/21/08		X	
09/09/08	X		
09/23/08	X		
09/26/08			X
09/26/08			X
09/29/08			X
07/21/09			X
07/21/09			X
07/22/09			X

5.3.4 Summary of Water Quality Data

The quality of a waterway may be considered compromised if analytical results exceed the water quality criteria twice within a five-year period, according to the NJDEP Integrated Water Quality Monitoring and Assessment Methods (NJDEP, 2006). NJDEP has further stated that a minimum of eight samples collected quarterly over a two-year period are required to confirm the quality of waters (NJDEP, 2010). Therefore, if a waterbody has a minimum of eight samples collected quarterly over a two-year period and samples exceed the water quality criteria for a certain parameter twice, the waterbody is considered “impaired” for that parameter. By applying this rule to the Assiscunk Creek Watershed water quality data, it is possible to identify which stations are impaired for each parameter that has been identified as a concern for this project (i.e., pH, TP, TSS, and bacteria). The number of samples exceeding these standards is given in Table 13.

Table 13: Percentage of Samples that Exceeded Surface Water Quality Standards (SWQS)

Station	SWQS	Count	Minimum	Maximum	Mean	# of exceedances	% not satisfying SWQS
pH (SU)							
ASK3	min 4.5 max 7.5	30	5.2	7.5	6.0	0	0.0
ASK2		29	4.7	6.3	5.4	0	0.0
ANR		29	5.4	7.5	5.9	0	0.0
ASK1		30	5.3	7.0	5.9	0	0.0
BB2		27	5.3	7.0	6.1	0	0.0
BB1		29	4.1	6.7	6.0	0	0.0
Dissolved Oxygen (mg/L)							
ASK3	Not less than 4.0 at any time	30	3.5	9.3	5.9	2	6.7
ASK2		30	4.1	9.4	5.7	0	0.0
ANR		29	3.6	10.9	7.4	1	3.4
ASK1		30	2.2	10.7	7.1	1	3.3
BB2		27	3.9	11.0	7.3	1	3.7
BB1		29	4.2	11.3	7.5	0	0.0
E. coli (org./100ml)							
ASK3	235 (max single sample)	30	4	2700	415.0	10	33.3
ASK2		30	2	3300	504.3	10	33.3
ANR		30	4	3500	735.0	17	56.7
ASK1		30	2	15000	1178.6	17	56.7
BB2		30	10	3000	640.0	17	56.7
BB1		29	18	1500	326.6	12	41.4
Fecal Coliform (org./100ml)							
ASK3	Max 770 (Geo-metric mean)	30	1	22000	2201.0	17	56.7
ASK2		30	10	27000	2516.5	12	40.0
ANR		30	2	25000	2376.0	19	63.3
ASK1		30	4	39000	3281.9	21	70.0
BB2		60	4	20000	1824.0	19	63.3
BB1		29	4	9400	935.9	14	48.3
Total Phosphorus (mg/L)							
ASK3	Max 0.1	21	0.0	0.5	0.1	11	52.4
ASK2		21	0.0	0.2	0.1	7	33.3
ANR		21	0.0	0.4	0.1	13	61.9
ASK1		21	0.0	0.4	0.1	14	66.7
BB2		21	0.0	0.4	0.2	14	66.7
BB1		20	0.0	0.4	0.2	11	55.0
Total Suspended Solids (mg/L)							
ASK3	Max 40.0	21	2.0	72.0	13.0	1	4.8
ASK2		21	2.5	94.0	16.0	2	9.5
ANR		21	1.3	42.0	14.4	1	4.8
ASK1		21	1.0	43.0	11.2	1	4.8
BB2		21	2.5	180.0	19.4	3	14.3
BB1		20	1.25	38.0	8.3	0	0.0

Note: SWQS=Surface Water Quality Standards

At the time of this project's initiation and during the time of data collection, fecal coliform was the accepted measure indicating pathogen pollution for New Jersey freshwaters. Standards in place at that time were that fecal coliform should not exceed a (five samples over thirty days) geometric mean of 200 colonies/100ml or a maximum count of 400 colonies/100mL in no more than 10% of samples taken within a 30-day period. Since then, the fecal coliform standard has been replaced by the measure of *Escherichia coli* (*E. coli*). For New Jersey freshwaters, *E. coli* shall not exceed a (five samples over thirty days) geometric mean of 126 colonies/100mL or a maximum count of 235 col/100mL in a single sample (NJAC 7:9, 2010). At the time of this study, both fecal coliform data and *E. coli* data were collected. This was performed to conform to the TMDL and to provide an analysis of how the watershed may conform to the revised standard.

Tabulated water quality monitoring results are provided in the attached data report (Appendix A). Water quality monitoring data have also been graphed with surface water quality criteria, and these are available in the appendices of this report.

5.3.5 Biological Monitoring Data

Biological monitoring data is available for the watershed as part of the **Am**bient Biological Monitoring **Net**work (AMNET), which is administered by the NJDEP. The NJDEP has been monitoring the biological communities of the State's waterways since the early 1970's, specifically the benthic macroinvertebrate communities. Benthic macroinvertebrates are primarily bottom-dwelling (benthic) organisms that are generally ubiquitous in freshwater and are macroscopic. Due to their important role in the food web, macroinvertebrate communities reflect current perturbations in the environment. There are several advantages to using macroinvertebrates to gauge the health of a stream. First, macroinvertebrates have limited mobility, and thus, are good indicators of site-specific water conditions. Also, macroinvertebrates are sensitive to pollution, both point and nonpoint sources; they can be impacted by short-term environmental impacts such as intermittent discharges and contaminated spills. In addition to indicating chemical impacts to stream quality, macroinvertebrates can gauge non-chemical issues of a stream such as turbidity and siltation, eutrophication, and thermal stresses. Finally, macroinvertebrate communities are a holistic overall indicator of water quality health, which is consistent with the goals of the Clean Water Act (CWA, 2002). These organisms are normally abundant in New Jersey freshwaters and are relatively inexpensive to sample.

New Jersey Impairment Score (NJIS)

The AMNET program began in 1992 and is currently comprised of more than 800 stream sites with approximately 200 monitoring locations in each of the five major drainage basins of New Jersey (i.e., Upper and Lower Delaware, Northeast, Raritan, and Atlantic). These sites are sampled once every five years using a modified version of the USEPA Rapid Bioassessment Protocol (RBP) II. To evaluate the biological condition of the sampling locations, several community measures are calculated by the NJDEP from the data collected and include the following:

1. Taxa Richness: Taxa richness is a measure of the total number of benthic macroinvertebrate families identified. A reduction in taxa richness typically indicates the presence of organic enrichment, toxics, sedimentation, or other factors.
2. EPT (Ephemeroptera, Plecoptera, Trichoptera) Index: The EPT Index is a measure of the total number of Ephemeroptera, Plecoptera, and Trichoptera families (i.e., mayflies, stoneflies, and caddisflies) in a sample. These organisms typically require clear moving water habitats.
3. %EPT: Percent EPT measures the numeric abundance of the mayflies, stoneflies, and caddisflies within a sample. A high percentage of EPT taxa is associated with good water quality.
4. %CDF (percent contribution of the dominant family): Percent CDF measures the relative balance within the benthic macroinvertebrate community. A healthy community is characterized by a diverse number of taxa that have abundances somewhat proportional to each other.
5. Family Biotic Index: The Family Biotic Index measures the relative tolerances of benthic macroinvertebrates to organic enrichment based on tolerance scores assigned to families ranging from 0 (intolerant) to 10 (tolerant).

This analysis integrates several community parameters into one easily comprehended evaluation of biological integrity referred to as the New Jersey Impairment Score (NJIS). The NJIS has been established for three categories of water quality bioassessment for New Jersey streams: non-impaired, moderately impaired, and severely impaired. A non-impaired site has a benthic community comparable to other high quality "reference" streams within the region. The community is characterized by maximum taxa richness, balanced taxa groups, and a good representation of intolerant individuals. A moderately impaired site is characterized by reduced macroinvertebrate taxa richness, in particular the EPT taxa. Changes in taxa composition result in reduced community balance and intolerant taxa become absent. A severely impaired site is one in which the benthic community is significantly different from that of the reference streams. The macroinvertebrates are dominated by a few taxa which are often very abundant. Tolerant taxa are typically the only taxa present.

The scoring criteria currently used by the NJDEP are as follows:

- Non-impaired sites have total scores ranging from 24 to 30,
- Moderately impaired sites have total scores ranging from 9 to 21, and
- Severely impaired sites have total scores ranging from 0 to 6.

It is important to note that the entire scoring system is based on comparisons with reference streams in a related EcoRegion and a historical database consisting of 200 benthic macroinvertebrate samples collected from New Jersey streams. While a low score indicates "impairment," the score may actually be a consequence of habitat or other natural differences between the subject stream and the reference stream.

Starting with the second round of sampling under the AMNET program held between 2000 and 2001 for the Lower Delaware River region, habitat assessments were conducted in conjunction with the biological assessments. The first round of sampling under the AMNET program did not include habitat assessments. The habitat assessment, which was designed to provide a measure of habitat quality, involves a visually based technique for assessing stream habitat structure. The habitat assessment is designed to provide an estimate of habitat quality based upon qualitative estimates of selected habitat attributes. The assessment involves the numerical scoring of ten habitat parameters to evaluate instream substrate, channel morphology, bank structural features, and riparian vegetation. Each parameter is scored and summed to produce a total score which is assigned a habitat quality category of optimal, sub-optimal, marginal, or poor. Sites with optimal/excellent habitat conditions have total scores ranging from 160 to 200; sites with suboptimal/good habitat conditions have total scores ranging from 110 to 159; sites with marginal/fair habitat conditions have total scores ranging from 60 to 109, and sites with poor habitat conditions have total scores less than 60. The findings from the habitat assessment are used to interpret survey results and identify obvious constraints on the attainable biological potential within the study area.

AMNET and the Assiscunk Creek Watershed

The NJDEP Bureau of Biological & Freshwater Monitoring maintains three AMNET stations within the delineation of the Assiscunk Creek Watershed (Stations AN0138, AN0139 and AN0140) (See Figure 14).

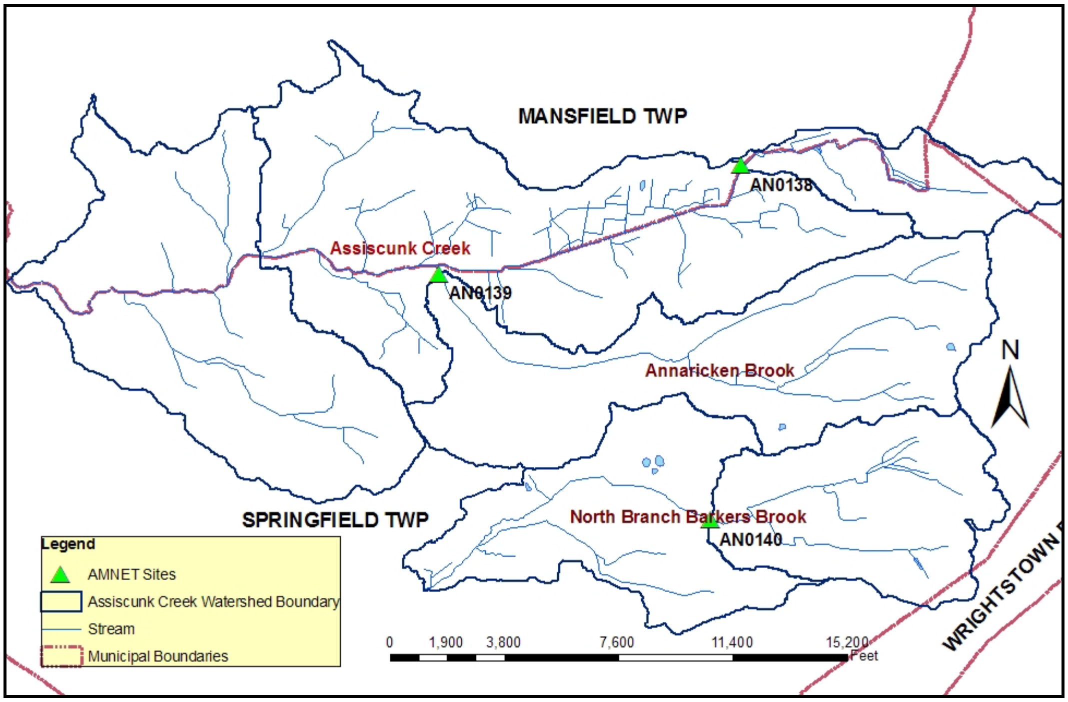

Figure 14: Location of AMNET Stations within the Assiscunk Creek Watershed

All three stations were sampled in AMNET rounds in 1993, 1998, 2001, and 2006. Findings from the AMNET program for the stations located within the project area are summarized in Table 14. The biological condition over the years has ranged from severely to moderately impaired, and the habitat has ranged from marginal to sub-optimal conditions within the Assiscunk Creek Watershed.

Table 14: Summary of NJDEP Ambient Biological Monitoring Network (AMNET)

AMNET Station (RCE Location)	Location	1993 - Round 1		1998 - Supplemental Sampling			2001 - Round 2			2006 - Round 3		
		Date Sampled	Impairment Status	Date Sampled	Impairment Status	Habitat Analysis Result	Date Sampled	Impairment Status	Habitat Analysis Result	Date Sampled	Impairment Status	Habitat Analysis Result
AN0138 (ASK1)	Assiscunk Ck., Columbus-Georgetown Rd., Mansfield Twp.	1/25/93	severely impaired	1/8/98	moderately impaired	sub-optimal	1/16/01	moderately impaired	marginal	6/6/06	moderately impaired	sub-optimal
AN0139 (ANR)	Annaricken Bk., Island Rd., Springfield Twp.	1/25/93	moderately impaired	1/8/98	moderately impaired	sub-optimal	1/16/01	moderately impaired	sub-optimal	6/15/06	moderately Impaired	sub-optimal
AN0140 (BB1)	North Br. Barkers Bk., Georgetown-Juliustown Rd., Springfield Twp.	1/25/93	severely impaired	1/13/98	moderately impaired	sub-optimal	1/17/01	severely impaired	marginal	6/15/06	severely impaired	sub-optimal

Results (NJDEP, 1994; NJDEP, 1999; NJDEP, 2003; NJDEP, 2010b)

5.3.6 Rutgers Biological Monitoring

Given these aquatic life impairments, an additional biological assessment was proposed as part of the development of the Watershed Restoration and Protection Plan for the Assiscunk Creek Watershed. A biological assessment was conducted by the RCE Water Resources Program in July 2008 at Station BB1 (i.e., AN0140), Station ANR (i.e., AN0139), Station ASK1 (i.e., AN0138), and Station ASK3. Station ASK3 is approximately 1.5 miles upstream from AMNET Station AN0141 on the Assiscunk Creek, which is just outside of the study area but within the Assiscunk Creek Watershed. The NJDEP under the AMNET program has assessed AN0141 as being moderately impaired and having sub-optimal habitat conditions. The 2008 biological assessment conducted by the Water Resources Program is summarized in Appendix A.

The 2008 assessment by the Water Resources Program at Station BB1 demonstrates that the biological condition improved to a moderately impaired status since 2006, but with a score of 9, the biological condition at BB1 borders on being severely impaired. The habitat condition in 2008 was downgraded to marginal. The 2008 assessment at Station ANR and ASK1 demonstrates that the biological condition remained at a moderately impaired status, and the habitat condition remained as sub-optimal. Furthermore, the 2008 assessment at Station ASK3 demonstrates that the biological condition in the vicinity of AMNET Station AN0141 remained as moderately impaired, and the habitat conditions remained as sub-optimal.

Coastal Plain Macroinvertebrate Index (CPMI)

New Jersey’s benthic macroinvertebrate communities can be grouped into three distinct groupings based on geographical regions: high gradient (above the Fall Line), low gradient (Coastal Plain excluding the Pinelands), and Pinelands. A multimetric index has been developed, using genus level taxonomic identifications, for each distinct region. The NJIS described and presented above is a single index used statewide that is based on family level taxonomic identifications. The NJDEP, in 2009, began using the multimetric indices for each distinct region. The index appropriate to use within the Assiscunk Creek Watershed is the Coastal Plain Macroinvertebrate Index (CPMI). The CPMI is comprised of the following metrics: total number of genera, total number of EPT genera, percent Ephemeroptera genera, Hilsenhoff Biotic Index, and percent clinger genera ("Clinger" describes a habitat and behavior designation for how the organism functions in the stream. Clingers are able to remain stationery on the bottom substrates in flowing waters.).

The scoring criteria used by the NJDEP Bureau of Freshwater & Biological Monitoring for the CPMI are outlined in Table 15. Excellent sites have total scores ranging from 22-30 and are characterized as having minimal changes in the structure of biological community and having minimal changes in ecosystem function. Good sites have total scores ranging from 12-20 and are characterized as having some evident changes in the structure of the biological community and having minimal changes in ecosystem function. Fair sites have total scores ranging from 10-6 and are characterized as having moderate to major changes in the structure of the biological community and having moderate changes in ecosystem function. Poor sites have total scores of < 6 and are characterized by extreme changes in the structure of the biological community and a major loss of ecosystem function. CPMI scores for Stations BB1, ANR, ASK3, and ASK1 are provided in Tables 16-19, respectively. All the stations were assessed as being fair. A fair assessment under the CPMI falls below the acceptable regulatory range, and a site assessed as fair using the CPMI would be considered impaired from a Federal Clean Water Act perspective and not attaining the aquatic life use.

Table 15: Scoring Criteria for Coastal Plain Macroinvertebrate Index (CPMI)

Score:	***Excellent***	***Good***	***Fair***	***Poor***
	6	***4***	***2***	***0***
Index Metrics:				
1. Number of genera	>25	17-25	9-16	<9
2. Number of EPT genera	>9	7-9	4-6	<4
3. % of Ephemeroptera	>29	20-29	10-19	<10
4. Hilsenhoff Biotic Index	<4.9	4.9-6.0	6.1-7.3	>7.3
5. % Clinger genera	>51	34-51	17-33	<17
Assessment Rating:	Total Score			
Excellent	22-30			
Good	12-20			
Fair	10-6			
Poor	<6			

Table 16: Calculation of Coastal Plain Macroinvertebrate Index for Station BB1

Taxa	***Tolerance Value***	***Station BB1 Number of Individuals***
Gammarus sp.	6	85
Calopteryx sp.	6	2
Enallagma sp.	8	3
Ischnura sp.	9	1
Belostoma sp.	5	2
Trichocorixa sp.	5	3
Stenelmis sp.	5	2
Sialis sp.	4	4
Tanypodinae	7	2
Total Number of Genera		9
Number of EPT Genera		0
% of Ephemeroptera		0%
Hilsenhoff Biotic Index		5.96 (Fair - fairly significant organic pollution)
% Clinger Genera		2%
Coastal Plain Macroinvertebrate Index (CPMI)		6
Assessment Rating		***Fair***

Table 17: Calculation of Coastal Plain Macroinvertebrate Index for Station ANR

Taxa	***Tolerance Value***	***Station ANR Number of Individuals***
Physa sp.	8	2
Orconectes sp.	6	2
Gammarus sp.	6	5
Baetis sp.	6	4
Gomphus sp.	5	2
Microvelia sp.	5	9
Rhagovelia sp.	5	1
Stenelmis sp.	5	18
Sialis sp.	4	1
Hydropsyche sp.	4	15
Cheumatopsyche sp.	5	28
Dicranota sp.	3	2
Tipula sp.	6	1
Simulium sp.	5	10
Chironominae	6	1
Tanypodinae	7	3
Total Number of Genera		16
Number of EPT Genera		3
% of Ephemeroptera		4%
Hilsenhoff Biotic Index		5.05 (Good - some organic pollution)
% Clinger Genera		51%
Coastal Plain Macroinvertebrate Index (CPMI)		10
Assessment Rating		***Fair***

Table 18: Calculation of Coastal Plain Macroinvertebrate Index for Station ASK3

Taxa	***Tolerance Value***	***Station ASK3 Number of Individuals***
Physa sp.	8	3
Pisidium sp.	6	2
Gammarus sp.	6	3
Orconectes sp.	6	4
Isotomurus sp.	5	1
Argia sp.	6	1
Enallagma sp.	8	1
Sigara sp.	3	49
Pelocoris sp.	5	1
Notonecta sp.	5	3
Chauliodes sp.	4	1
Sialis sp.	4	7
Polycentropus sp.	6	5
Chironominae	6	7
Tanypodinae	7	10
Bittacomorpha sp.	9	2
Total Number of Genera		16
Number of EPT Genera		1
% of Ephemeroptera		0%
Hilsenhoff Biotic Index		4.56 (Good - some organic pollution)
% Clinger Genera		7%
Coastal Plain Macroinvertebrate Index (CPMI)		8
Assessment Rating		***Fair***

Table 19: Calculation of Coastal Plain Macroinvertebrate Index for Station ASK1

Taxa	***Tolerance Value***	***Station ASK1 Number of Individuals***
Dina sp.	8	2
Erpobdella sp.	8	1
Placobdella sp.	8	1
Physa sp.	8	6
Caecidotea sp.	8	4
Gammarus sp.	6	24
Cordulegaster sp.	3	5
Sigara sp.	3	7
Microvelia sp.	6	6
Promoresia sp.	2	2
Stenelmis sp.	5	2
Cheumatopsyche sp.	5	19
Hydropsyche sp.	4	7
Chironominae	6	4
Tanypodinae	7	13
Diacranota sp.	3	1
Total Number of Genera		16
Number of EPT Genera		2
% of Ephemeroptera		0%
Hilsenhoff Biotic Index		5.61 (Fair - fairly significant organic pollution)
% Clinger Genera		29%
Coastal Plain Macroinvertebrate Index (CPMI)		8
Assessment Rating		***Fair***

5.3.7 Stressor Identification

Biological assessments have become an important tool for managing water quality to meet the goal of the Clean Water Act (i.e., to maintain the chemical, physical, and biological integrity of the nation's water). However, although biological assessments are a critical tool for detecting impairment, they do not identify the cause or causes of the impairment. The USEPA developed a process, known as the Stressor Identification (SI) process, to accurately identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000b). The SI process involves the critical review of available information, the formation of possible stressor scenarios that may explain the observed impairment, the analysis of these possible scenarios, and the formation of conclusions about which stressor or combination of stressors are causing the impairment. The SI process is iterative, and in some cases additional data may be needed to identify the stressor(s). In addition, the SI process provides a structure or a method for assembling the scientific evidence needed to support any conclusions made about the stressor(s). When the cause of a biological impairment is identified, stakeholders are then in a better position to locate the source(s) of the stressor(s) and are better prepared to implement the appropriate management actions to improve the biological condition of the impaired waterway.

The benthic macroinvertebrate community occurring within the Assiscunk Creek Watershed is apparently under some type of stress as evidenced by sensitive taxa (i.e., EPT taxa) being markedly diminished and by a conspicuously unbalanced distribution of major groups (i.e, relatively high percent dominance). Based on the calculated family level and generic level Hilsenhoff Biotic Index, the types of organisms found within the study area are indicative of some organic pollution to fairly substantial levels of organic pollution (Hilsenhoff, 1988). In addition, the habitat assessment revealed sub-optimal to marginal habitat conditions which may also account for the impaired condition of the community within the study area.

Candidate causes of impairment within the Assiscunk Creek Watershed include:

1. Elevated nutrient levels (i.e., total phosphorus)

2. Elevated bacteria levels (i.e., fecal coliform and *E. coli*)
3. Degraded instream habitat
4. Altered hydrology
5. Toxicants.

Analysis/Evaluation of Candidate Causes:

Elevated nutrient levels and elevated bacteria levels: The role of elevated nutrients and elevated bacteria levels in impairing the biological community was indicated by continual and persistent exceedances of the surface water quality criteria for phosphorus and bacteria throughout the watershed during the surface water quality monitoring portion of this study. Surface water quality samples were collected from stations within the Assiscunk Creek Watershed over a six month sampling time frame from April 2008 to September 2008, demonstrating a co-occurrence of these candidate causes within the watershed. Approximately 70% of the designated land use within the watershed is agricultural/agricultural wetlands. Stormwater runoff from these agricultural land uses is a likely source of elevated nutrients. In addition, visual assessments (i.e., SVAP) were conducted in the Assiscunk Creek Watershed as part of this study. Manure was observed in the proximity of several assessed locations which may be a source of the elevated bacteria levels observed within the watershed.

Degraded habitat: The role of degraded habitat in impairing the biological community within the watershed was indicated by the assessed sub-optimal to marginal habitat conditions within the watershed. A potential source for degraded habitat conditions within this watershed includes channelization, which reduces channel diversity and promotes a uniform flow regime and ultimately reduces habitat diversity. Another likely source is stormwater outfalls which can increase erosion and scour leading to reduced channel diversity, homogenous flow regime, and unstable habitat. An additional source observed within the watershed is a decreased riparian vegetative zone (i.e., riparian buffer) which leads to increased stream temperatures, depressed dissolved oxygen levels, unstable banks, and an overall reduction in habitat complexity.

Altered hydrology: The role of altered hydrology in impairing the biological community within the watershed was indicated by reduced channel and habitat diversity, a slow and homogenous flow regime, and a potential reduction in baseflow. Stations BB1, ANR, and ASK1 were observed to have low baseflow in the summer of 2008 during the biological assessment portion of the study, especially Station ASK1. A likely source for altered hydrology observed within the watershed includes channelization, which reduces channel diversity and therefore promotes a uniform flow regime. Another likely source for altered hydrology observed within the watershed would include stormwater outfalls. Stormwater outfalls can increase erosion and scour leading to reduced channel diversity and homogenous flow regime.

Toxicants: The role of toxicants in impairing the biological community was indicated by the observation of water odors and surface oils at ASK3 and BB1, as well as the observation of sediment odors and oils at BB1. Additional monitoring for toxics, especially petroleum hydrocarbons, is warranted at these locations and within the watershed. Monitoring for pesticides and herbicides as possible toxicants is warranted given the agricultural nature of the watershed, as well.

5.4 Nonpoint Sources

In this watershed, the pollutant sources to the waterway are predominantly nonpoint source pollution. The main source of this pollution is the excess precipitation that runs off or is drained off of the land. Stormwater is considered a nonpoint source pollutant before it gets routed into a storm drainage system, where it is then considered a point source, and is regulated by the Municipal Separate Storm Sewer System (MS4) rules (N.J.A.C. 7:8).

A hydrologic and pollutant fate and transport model, the Soil, Water Assessment Tool (SWAT), was created for use in identifying primary nonpoint source pollutant sources. This model was also used to identify best management practices implementation scenarios and potential pollutant reduction that would accompany these scenarios. This information has been incorporated into the recommendations made by this plan. The full modeling report can be found in Appendix B.

5.5 Point Sources

One point discharge is permitted by the State for discharge into receiving waters within the boundary of this watershed restoration and protection plan. The Springfield Board of Education is permitted for the discharge of a publicly owned sewage treatment plant at the Springfield Elementary School which discharges less than 1 million gallons per day. This pipe discharges downstream of sampling site BB1, approximately 2,000 feet upstream of sampling site BB2 on Barkers Brook.

Upon evaluation of the total phosphorus and phosphate-phosphorus (PO_4^{3-}-P) data, several sampling events have higher concentrations at the downstream site when compared with the upstream site (Figures 15 and 16). Orthophosphate is that portion of the total phosphorus that is readily available for plant uptake. Upon evaluation of the data collected at these two sites for this study, there appears to be no trend that allows a correlation of phosphorus concentrations to the location of the point source discharge.

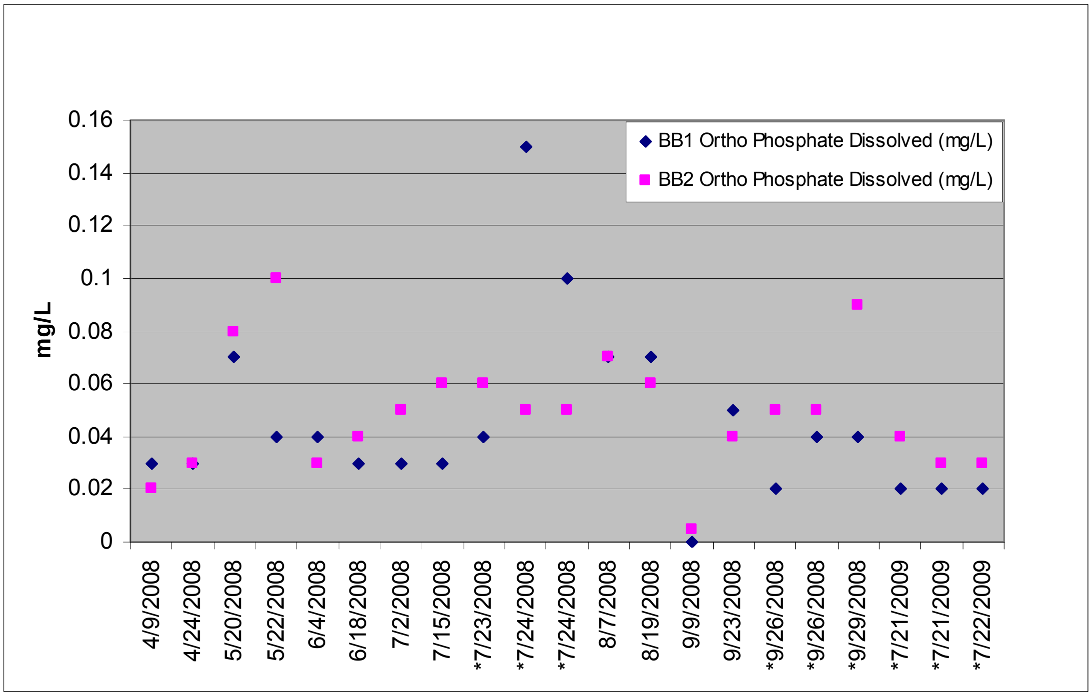

Figure 15: Barkers Brook Orthophosphate (*Storm Event)

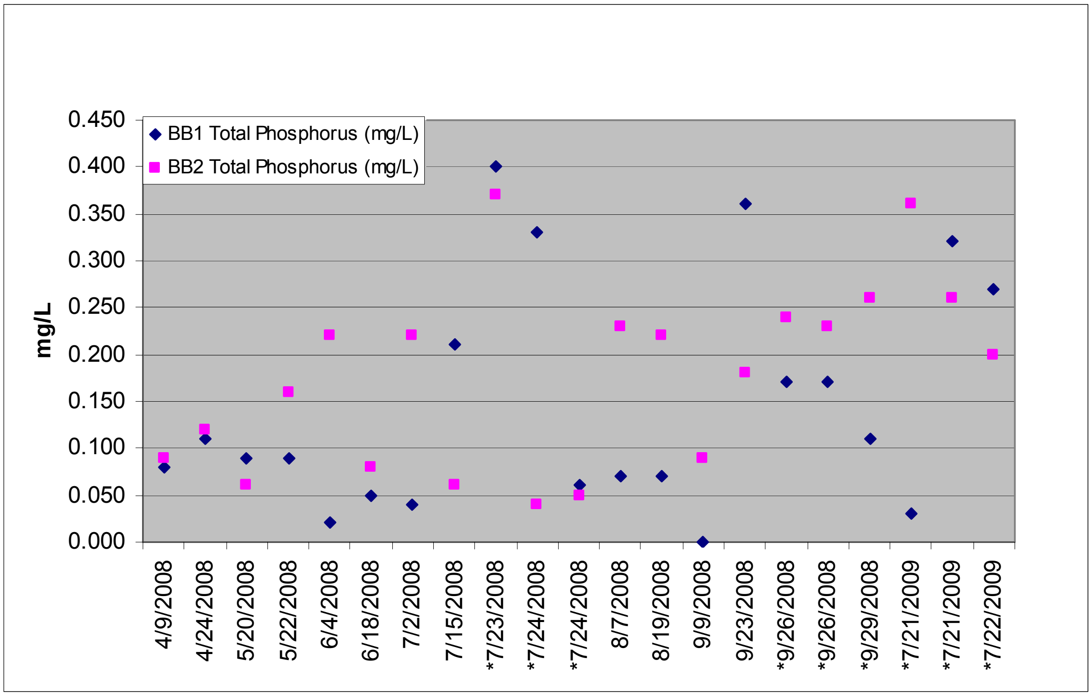

Figure 16: Barkers Brook Total Phosphorus (*Storm Event)

5.6 Erosion and Sedimentation

The water quality analysis of the Assiscunk Creek did not raise concerns regarding high levels of total suspended solids. Soil types and water chemistry in the area are thought to play a role in the coloration of the water. However, fine sediments covering the bed of the stream have been noted in potentially playing a role in reduced macroinvertebrate habitat. These fine sediments may be due to stream bank erosion of fine sediments that settle out early in their flow and are therefore not included in the total suspended solids quantification. This may be correlated to reduced riparian buffer vegetation and/or invasive species with shallow root systems. It is also possible that the sampling events taken for this study did not capture events that were significant in solids loading to the waterway.

5.7 SVAP Data

Fifty-two stream reaches were evaluated in the Assiscunk Creek Watershed (Figure 17; Appendix A). The overall SVAP score for all 52 reaches was 6.0, a resulting watershed quality of “fair” (Table 20). There were five areas where the presence of manure was observed and assessed. Pastures were noted along the banks of eleven of the fifty-two sites evaluated, but no access to the stream was noted. Observations were made regarding the rust colored water and rust colored algae or floc at distributed sites throughout the watershed and were attributed to sulfur and iron containing substrates. Riffles were present at sixteen locations and received an average score of poor, which means that riffles were on average 30-40% embedded. The average for canopy cover, described as the percent of water surface that is shaded, was also rated as poor.

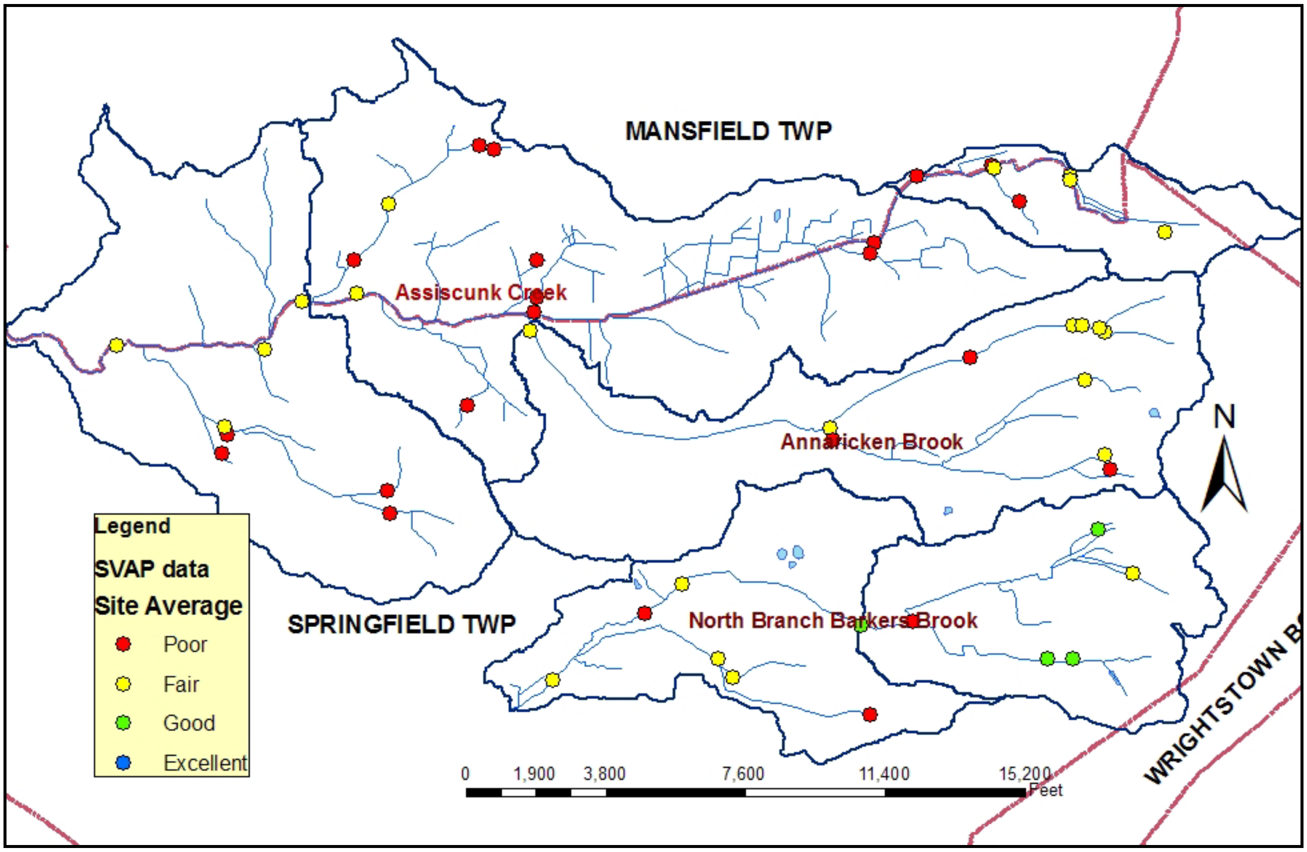

Figure 17: Stream Visual Assessment Reaches with Scores in the Assiscunk Creek Watershed

Table 20: SVAP Assessment Elements and Data

	Hydrologic Alteration	Channel Condition	Riparian Zone - left bank	Riparian Zone - right bank	Bank Stability - left bank	Bank Stability - right bank	Water Appearance	Nutrient Enrichment	Barriers to Fish Movement
# of scores	52	52	52	52	52	52	52	52	52
minimum value	1	2	1	1	2	1	1	1	1
maximum value	10	10	10	10	9	9	10	10	10
average	6.23	6.44	6.31	6.46	5.85	5.73	5.60	6.48	6.29
	Instream Fish Cover	Pools	Invertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embedded-ness	Water Appearance & Nutrient Enrichment Averages		Tiered Assessment Averages
# of scores	52	52	52	52	5	16	52		52
minimum value	1	1	2	0	5	1	1		1
maximum value	9	10	10	10	7	10	10		10
average	5.38	4.29	7.31	5.88	6.20	5.44	6.04		6.14
	Overall Average - left bank		**Overall Average - right bank**		**Overall Site Average**				
# of scores	52		52		52				
minimum value	3.82		3.55		3.68				
maximum value	7.92		7.92		7.92				
average	6.00		6		6.00				

5.7.1 Using the SVAP Data

SVAP scores have been evaluated as individual assessment elements and combined with other data collected as part of this restoration planning effort. The SVAP results will be compared to land use, soil characteristics, slope and stream gradient, and water quality monitoring results to determine the quality of waters within the Assiscunk Creek Watershed. The SVAP scores, information on pipes, ditches, photos, and remediation notes have been used to identify sources of pollution and potential opportunities for improved management.

6.0 Estimated Loading Targets/Priorities

6.1 Loading Targets

Load reduction targets will adhere to the TMDL approved by the USEPA. These targets will dictate the plans in the Annaricken subwatershed (ANR) and the Upper Barkers Brook subwatersheds (BB1 and BB2).

As stated previously, the Assiscunk Creek Watershed is affected by the creation of two TMDLs. A TMDL to address the fecal coliform contamination levels in the Annaricken Brook and Barkers Brook was approved in September of 2003 and requires a reduction in load allocation of 95% for the Annaricken and 96% for Barkers Brook (Table 9). A second TMDL addressing phosphorus levels was approved in October of 2007 and requires a load allocation reduction of 54.6% for the Annaricken and 66% for Barkers Brook (Table 9).

The Assiscunk Creek HUC 02040201100010-01 (above Rt. 206) includes subwatersheds ANR, ASK1 and ASK2. The NJDEP/USGS ambient water quality sampling site for “Annaricken Brook near Jobstown” is located at the outlet of subwatershed ANR. On the NJDEP 2006 Integrated Report GIS layer and the 2008 (305(b)) Integrated List, the drainage area of the Assiscunk Creek (above Rt. 206) is noted as being listed on Sublist

4a for primary recreation/pathogens. The TMDL for the Annaricken pathogens, which denotes a 3.7 mile long stretch of stream, does not contain the areas covered by ASK1 and ASK2, which are above Rt. 206, but not above the Ambient Stream Monitoring locationWater quality samples taken as a part of this plan show that these two additional subwatersheds not noted in the TMDL (ASK1 and ASK2) were also impaired by pathogen contamination (as stated in the Integrated Report). Therefore, this plan will include the entirety of the area above Rt. 206 in the bacterial reduction requirements assigned to the Annaricken Brook.

Phosphorus levels are also addressed in the TMDL, with a mandated reduction of 66% in the two Barkers Brook subwatersheds and a 54% reduction in the ANR subwatershed. Current loading of phosphorus in the Annaricken Brook is calculated in the TMDL as being 1279.3 lbs/yr, with a proposed load capacity including a margin of safety of 762.85 lbs/yr. The proposed maximum capacity of the Barkers Brook with the margin of safety is calculated to be 900 lbs/yr, with a current loading of 1635.9 lbs/yr. The 303(d) list includes the entire subwatershed of the Assiscunk Creek above Rt. 206 for a "Medium Priority" for the phosphorus impairment. Water quality samples taken as a part of this plan show that ASK1 did not meet water quality standards 67% of the time, and ASK2 did not achieve water quality standards 33% of the time.

Water quality samples collected during the Assiscunk Creek Watershed Restoration and Protection Plan survey indicated similar phosphorus and bacteria concentration sampled at ASK 3 as exist in the upstream tributaries. The water quality samples collected for this plan did not meet water quality standards for fecal coliform in 57% of samples and for phosphorus in 52% of the samples for the ASK3 subwatershed, although the aerial loading analysis found that ASK3 land use may act as a contaminant sink, or an area where contaminants are removed, due to the low gradient wetlands. Since water quality monitoring at this outlet site has had many exceedances, this may indicate that the storage in ASK3 has hit a maximum level and needs to be managed. Therefore, this plan will include the recommendation for nonpoint source load reduction in this subwatershed to proceed in a similar manner as the upstream subwatersheds (Table 21).

Table 21: Load Reduction Plan Recommendations

	Bacteria Load Reduction		Phosphorus Load Reduction	
Subwatershed	TMDL	Plan Recommendation	TMDL	Plan Recommendation
ASK3		95%		54%
ASK2		95%		54%
ANR	95%	95%	54%	54%
ASK1		95%		54%
BB2	96%	96%	66%	66%
BB1	96%	96%	66%	66%

6.2 Allocation among Nonpoint Sources

Since there are not significant point sources identified as contributing to the overall water quality exceedances in this watershed (See Section 5.5), source reduction needs to be allocated to nonpoint sources. Stormwater is considered a nonpoint source, although MS4s are a regulated point source for both the Tier A municipalities (Mansfield) and the Tier B municipalities (Springfield). Due to the fact that the origin of stormwater is from diffuse sources that run off of the land area, solutions will be determined while the pollutant is still considered nonpoint. Also, there are no known water quality samples taken at the point of a stormwater pipe discharge to the stream. Land use in each subwatershed (Table 4) has been evaluated for aerial loading and is a key determinant of recommended best management practices (BMP) types.

The approved pathogen TMDL for the Annaricken Brook near Jobstown notes that a source of potential pathogen pollution is agricultural land with poor riparian buffers. Horse farms, including smaller farms and a horseracing track located within 300 feet of the stream were specifically noted in the TMDL.

The North Branch Barkers Brook has also been identified as having large agricultural lands with cultivation and pasturing up to the water’s edge. The TMDL notes that large flocks of Canada geese and birds were observed on farm fields and in farm ponds.

6.3 Priority Ranking

One of the goals of the watershed restoration plan is to prioritize the implementation of various best management practices. For this project, water quality data and flow data were collected at six sampling locations. Each of these sampling locations represents the outlet of a subwatershed within the Assiscunk Creek Watershed. To identify which subwatershed was contributing the most pollution to the Assiscunk Creek, data from each of these sampling locations was used to determine the annual pollutant load leaving each of the subwatersheds. The subwatersheds were then ranked by their annual pollutant load.

The two primary pollutants of concern in the Assiscunk Creek Watershed are total phosphorus and fecal coliform, which is an indicator of pathogen contamination. Flow and pollutant concentration from each sampling event were used to calculate the daily load at each sampling location. The annual total load for each subwatershed was determined by averaging the daily loads and multiplying this average daily load by 365 days (number of day in a year). For total phosphorus this provides an annual load in kg/year. For fecal coliform, this calculation provided an annual load in colonies per year. These annual loads are presented in Table 22.

Table 22: Load of Individual Subwatershed Calculated

Subwatershed	Fecal Coliform (Colonies/yr)	*E. coli* (Colonies/yr)	Total Phosphorus (kg/yr)
ASK3	-2.02E+14	-5.70E+12	308.109
ASK2	3.08E+14	3.51E+13	290.183
ANR	6.61E+12	2.30E+12	57.750
ASK1	2.00E+13	3.00E+12	32.359
BB2	5.78E+13	5.96E+12	-40.003
BB1	4.00E+13	5.48E+12	169.482

*Negative numbers may indicate that the subwatershed is acting as a sink for the pollutant

Since each subwatershed is different in size, the annual loads were then normalized by dividing them by the number of acres in each subwatershed. This provides a total phosphorus loading rate in terms of kg/year/acre and a fecal coliform loading rate in terms of colonies/year/acre. These loading rates are provided in Table 23.

Table 23: Annual Loading Rates for Fecal Coliform, *E. coli* and Total Phosphorus Normalized to Basin Area

Subwatershed	Fecal Coliform (Colonies/yr/acre)	*E. coli* (Colonies/yr/acre)	Total Phosphorus (kg/yr/ac)
ASK3	-1.00E+11	-2.84E+09	0.153
ASK2	1.15E+11	1.30E+10	0.108
ANR	3.42E+09	1.19E+09	0.030
ASK1	4.02E+10	6.03E+09	0.065
BB2	5.07E+10	5.23E+09	-0.035
BB1	3.78E+10	5.18E+09	0.160

The calculated annual loads and loading rates were used to rank the subwatersheds. The subwatershed with the highest loading rate was given one (1) point, the next highest was given two (2) and so on. This method was repeated for the area normalized loading rate. The points were combined, and the subwatersheds were ranked highest to lowest according to their total points. These results are presented in Table 24 for total phosphorus and Table 25 for fecal coliform.

Table 24: Ranking Subwatersheds by Total Phosphorus Annual Loads and Loading Normalized to Area

Subwatershed	Annual Load (kg/yr)	Ranking of Annual Load	Annual Loading, Normalized (kg/yr/ac)	Ranking of Annual Loading, Normalized	Summation of Rankings
ASK3	308.109	1	0.153	2	3
ASK2	290.183	2	0.108	3	5
ANR	57.750	4	0.03	5	9
ASK1	32.359	5	0.065	4	9
BB2	-40.003	6	-0.035	6	12
BB1	169.482	3	0.16	1	4

Table 25: Ranking Subwatersheds by Total Fecal Coliform Annual Loads and Loading Normalized to Area

Subwatershed	Annual Load (kg/yr)	Ranking of Annual Load	Annual Loading, Normalized (kg/yr/ac)	Ranking of Annual Loading, Normalized	Summation of Rankings
ASK3	-2.02E+14	6	-1.00E+11	6	12
ASK2	3.08E+14	1	1.15E+11	1	2
ANR	6.61E+12	5	3.42E+09	5	10
ASK1	2.00E+13	4	4.02E+10	3	7
BB2	5.78E+13	2	5.07E+10	2	4
BB1	4.00E+13	3	3.78E+10	4	7

The loading rates show which subwatershed is contributing the most pollutants into the stream. The area normalized loading rate show which subwatershed is contributing the most pollutant per acre. Combining both parameters ensures that the subwatersheds with the highest priority are those where the greatest impact can be had with the least amount of implementation. See Table 26 for ranking results.

Table 26: Ranking Subwatersheds by Total *E. coli* Annual Loads and Loading Normalized to Area

Subwatershed	Annual Load (kg/yr)	Ranking of Annual Load	Annual Loading, Normalized (kg/yr/ac)	Ranking of Annual Loading, Normalized	Summation of Rankings
ASK3	-5.70E+12	6	-2.84E+09	6	12
ASK2	3.51E+13	1	1.30E+10	1	2
ANR	2.30E+12	5	1.19E+09	5	10
ASK1	3.00E+12	4	6.03E+09	2	6
BB2	5.96E+12	2	5.23E+09	3	5
BB1	5.48E+12	3	5.18E+09	4	7

The final step in this analysis was to combine the priority rankings for total phosphorus, fecal coliform and *E. coli* to create an overall ranking for each subwatershed. Subwatershed ASK3 was ranked the highest overall priority for phosphorus, while ASK1 and BB2 were ranked the overall lowest priority (Table 27). ASK 2 was ranked the highest overall for both fecal coliform and *E. coli,* with BB1 and BB2 ranking high on loading capacity (Tables 28 and 29). ASK3 was calculated to be a sink for bacteria, but a source for phosphorus, potentially indicating that the low gradient, wetland characteristics of this subwatershed provide an area for die off of bacteria, but an accumulation and re-suspension of phosphorus. Similarly, BB2 was calculated to be a source for bacteria and a sink for phosphorus. BB2 also has the low gradient, wetland characteristic that would promote the detention of contaminants, but may have an accumulation of bacteria in sediments or a higher source population.

These ranking will help prioritize the implementation of stormwater best management practices and agricultural management practices. The following three tables (Table 27, 29 and 30) summarize overall rankings for total phosphorus, fecal coliform and *E. coli*.

Table 27: Priority Subwatersheds by Total Phosphorus

Subwatershed	Ranking of Annual Load	Ranking of Annual Loading, Normalized	Overall Rankings
ASK3	1	2	1
BB1	3	1	2
ASK2	2	3	3
ANR	4	5	4
ASK1	5	4	5
BB2	6	6	6

Table 28: Priority Ranking Subwatershed by Fecal Coliform

Subwatershed	Ranking of Annual Load	Ranking of Annual Loading, Normalized	Overall Rankings
ASK2	1	1	1
BB2	2	2	2
BB1	3	4	3
ASK1	4	3	4
ANR	5	5	5
ASK3	6	6	6

Table 29: Priority Ranking Subwatersheds by *E. coli*

Subwatershed	Ranking of Annual Load	Ranking of Annual Loading, Normalized	Overall Rankings
ASK2	1	1	1
BB2	2	3	2
ASK1	4	2	3
BB1	3	4	4
ANR	5	5	5
ASK3	6	6	6

7.0 Restoration Strategies and Best Management Practices (BMPs)

7.1 Watershed Restoration Strategies

7.1.1 Strategies for Controlling Pathogen Contamination

The biggest water quality issue in the Assiscunk Creek Watershed is pathogen contamination. The pathogen contamination is identified through the indicator bacteria fecal coliform and *E. coli*. The sources of these bacteria are warm blooded animals, whether domestic pets, farm animals, wildlife or humans.

SWAT modeling and aerial loading runoff coefficient analyses show that due to the large percentage of agricultural land use in the watershed, the sources of bacterial contamination is allocated to farm animals and manure application. Wildlife is also considered a significant source.

7.1.1.1 Agricultural Practices

Animal Manure Management

The Assiscunk Creek Watershed contains both “larger” animal facilities and many smaller “backyard” animal farms. Proper management of animal manure from both types of farms is essential to control pathogen contamination in the watershed. Techniques to encourage optimal disposal of animal waste will differ according to the size of the farm and the options available.

The New Jersey Department of Agriculture (NJDA) has developed and adopted the Animal Waste Management rules effective on August 2, 2010 (N.J.A.C. 2:91, Appendix C). The rules require all farms with livestock will have to follow the General Requirements of the rules and the operations with eight (8) or more Animal Units (AU) [1 AU= 1000 pounds of live animal weight] or those receiving or applying 142 or more tons of animal waste per year will be required to develop and implement a self-certified Animal Waste Management Plan. These new rules include requirements to mitigate the proliferation of pathogens to state waters. These requirements include:

- Manure storage areas must be at least 100 feet away from state waters
- Animals in confined areas shall not have uncontrolled access to waters of the state, and
- Land application of animal waste shall be performed in accordance with the principles of the NJDA BMP Manual and the USDA-NRCS Field Office Technical Guide (USDA, 2004; Appendix C)

The Department has developed a program that provides technical assistance tools, including a template for Animal Waste Management Programs, education and outreach programs in each county and a tiered Animal Waste Management Plan (AWMP) approval process that would rely on self-certification for those operations with eight to 299 AU's with an animal density of less than one AU per acre. These AWMPs should include details describing how the generated manure will be collected, stored and dispersed. The dispersion could include well timed and integrated application in row-crop, hay and pasture lands.

> ***Recommendation 1: Animal Waste Management Plans should be comprehensive and include all aspects of keeping waste from becoming nonpoint source pollution to the waterways.***

> ***Recommendation 2: A manure management outreach program should be created that is targeted at the smaller farms and the cooperation between these farms. This could include regional composting for smaller operations.***

Livestock Exclusion

Grazing livestock that have direct access to streams not only damages stream banks and causes soil erosion, but also contributes manure directly into the streams and causes pathogen contamination. The new rules state that no animal should have access to state waters unless such access is controlled in accordance with the NJDA Best Management

Practices Manual (NJDA, 2009). Although it is not required, it is highly recommended that animals in areas that are not "confined" be fenced from adjacent water bodies. The Natural Resource Conservation Service (NRCS) has been implementing exclusion fencing education, outreach and implementation projects that can be used to create a watershed wide livestock exclusion practice.

Stream visual assessments did not identify specific animals in streams, however aerial analysis indicates areas that have the potential for farm animals to have access to the streams. Site location should be confirmed for maximal benefit.

> ***Recommendation: Waterways should be fenced in areas of potential animal access. (For an example of such a project, refer to Appendix D, Sheet 7 and Appendix E, Animal Management BMP Information Sheet)***

7.1.1.2 General Land Use Practices

Wildlife Management

Wildlife such as deer and geese can contribute pathogen contamination in the watershed. This contribution could be heavy during the winter season when vegetation is down, allowing areas of bird foraging. This reduction in vegetation also plays a role in the ease of contaminant runoff.

The resident population of Canada geese in New Jersey has become a focus of several pathogen management programs. In the Assiscunk Creek Watershed, both Canada geese and Snow geese have been identified in fields (particularly fallowed fields) and parks. Potential solutions include the planting of dense ground cover crops, noise devices, dogs and mylar tape. The ground cover will also serve to stabilize the soil and the nutrients that the soil may carry if it erodes. The installation of conservation buffers will also serve to reduce the direct runoff of pathogens into the waterway.

> ***Recommendation: Nuisance wildlife should be identified and discouraged from becoming residents of the area's surrounding streams.***

Detention Basin Retrofitting

There are a scattering of detention/infiltration basins in recently developed areas of the Assiscunk Creek Watershed. Small basins (approximately five) have been found in the residential development area by the intersection of ASK3, ANR and ASK2. Some of these detention basins may present an opportunity for upgrading or retrofitting to reduce the pathogen loads and improving water quality in the watershed, but practices such as minimizing mowing seem already to be in place. There is no empirical study on how much retrofitting a detention basin would reduce the pathogen loads. Depending on the final design of the detention basin, a retrofitted detention basin will function like a bioretention basin or a wetland. The removal rates of bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007 and Karathanasis, et al., 2003).

> ***Recommendation: Detention basins that currently require regular maintenance should be retrofitted with native vegetation to maximize pollutant removal and infiltration capacity.***

On-Site Wastewater Treatment System (OWTS) Education and Management

The majority of residential homes and businesses in the Assiscunk Creek Watershed rely on OWTS for treatment and disposal of wastewater. Functioning OWTS require regular maintenance. Failing OWTSs are often very expensive to repair and sometimes require rebuilding. Burlington County currently requires the inspection of OWTSs during a real estate transaction. Only the houses with functioning OWTSs are permitted to be sold. To help control the pathogen contamination in the Assiscunk streams, a comprehensive OWTS education and management program can be implemented. The comprehensive education and management program should include the following elements:

- An education campaign by distributing flyers, newspaper articles and regional education workshops to make the residents and businesses aware of their on-site wastewater treatment system and their functioning status
- A regular inspection program (3 or 5 years)
- A technical assistance program on OWTS inspection, operation and maintenance

- A financial incentive program combined with fines and subsidies, and public and private funds that motivate the residents and business to operate their systems at their optimal status.

Recommendation: All septic systems in the watershed should be inventoried and regularly inspected. Management plans for each system should be compiled.

7.1.2 Strategies for Controlling Nutrient Contamination

Nutrients refer to the total nitrogen (TN) and total phosphorus (TP) in stream flow. Water quality monitoring by USGS/NJDEP and the RCE Water Resources Program has identified phosphorus as a contaminant of concern. According to the calculations in the phosphorus TMDL for Annaricken and Barkers Brook, the attainment of the water quality standard for the FW2- NT streams requires a 54-66% reduction in the load of total phosphorus to these watersheds. Modeling of the land use shows that the primary source of nutrients is agriculture including row-crop and other agriculture. Due to the percentage of land in these subwatersheds that is agricultural lands, the TMDL assigned a 67% and 51% reduction of the load capacity from agricultural lands.

One source of phosphorus is animal waste and therefore can be addressed by agricultural strategies proposed in the previous section. Other sources of phosphorus include the breakdown of organic material left on the field or left to compost and fertilizers applied to crops. Fertilizers are also applied to residential developments, so strategies to address this source are included here.

7.1.2.1 Integrated Crop Management for Fertilizer Application

Excess fertilizer use and poor application methods and timing can cause fertilizer to move into ground and surface waters and contaminate the water resources. One way to eliminate the impacts of agricultural fertilizer application is to implement an integrated crop management plan for fertilizer application to optimize the fertilizer application rate, timing and methods and to achieve the best economic yield and profit. The proper amounts of fertilizers will be based on the reasonable crop yield goal and the available nutrients in the soils as determined by soil testing.

> ***Recommended: Soil test-based integrated crop management, as offered by the Rutgers Cooperative Extension and the Natural Resource Conservation Service, should be incorporated into a technical assistance program to farmers in the watershed to improve water quality.***

7.1.2.2 Fertilizer Application for Lawn

The 2011 New Jersey Fertilizer Law establishes statewide fertilizer standards that are intended to take the place of the multiple and varied municipal ordinances. This law is intended to protect all New Jersey surface and groundwaters from impairment by the excess application of fertilizers containing phosphorus and nitrogen. Both nutrients are important for plant growth, but in excess, may contribute to water quality impairments and eutrophication.

Details of the law that are pertinent to the Assiscunk Creek Watershed include:

- Professional applicators must undergo training and become certified. (Effective January 5, 2012.)
- Fertilizer application is prohibited between November 15th-March 1st for consumers and December 1st-March1st for professionals. (Effective immediately.)
- Fertilizer application is prohibited during or just before heavy rainfall, onto impervious surfaces, or onto frozen ground. (Effective immediately.)
- Restrictions on the amount and type of nitrogen (20% slow-release vs. soluble) used per application. (Effective January 5, 2012.)
- Fertilizers that contain phosphorus can not be applied to turf unless (1) a soil test indicates the need, or (2) if establishing turf and vegetation for the first time, or (3) repairing or re-establishing turf, or (4) applying liquid or granular fertilizer under the soil surface, directly to the roots; or (5) if the fertilizer consists of manipulated animal or vegetable manure (organic sources). (Effective January 5, 2012.)
- The establishment of buffers where the fertilizer can not be applied to turf within 25 feet of any waterbody, except where a drop spreader, rotary spreader with a deflector or targeted spray liquid is used, and then the buffer can be reduced to 10 feet. (Effective immediately.)
- The exemption of commercial farms and golf courses, except that no person, other than a certified professional, may apply fertilizer to a golf course. (Effective January 5, 2012.)

Labeling and content requirements will take effect January 5th, 2013 outlawing fertilizer products that do not meet the new content standards set by this law. Fines for noncompliance are $500 for the first offense and up to $1,000 for the 2nd and each subsequent offense for professional applicators.

> ***Recommendation: A public education program to inform homeowners on the proper application of fertilizer to protect water resources and to become familiar with the details of the new law.***

7.1.2.3 Conservation buffers

Conservation buffers are structuralized vegetative mixtures of trees, shrubs and grasses placed adjacent to the streams or between drainage areas to intercept overland flow and stabilize the soils in the area. There are many types of buffers such as contour buffer strips, field borders, grassed waterways, filter strips and riparian forest buffers (Bentrup, 2008). In this project, the term conservation buffer is used to refer to all types of buffer practices being used in the watershed. Different types of conservation buffer practices can be applied in different settings in the watershed to improve water quality, control soil erosion, enhance wildlife habitat. Water quality benefits of conservation buffers are well documented. As runoff goes through conservation buffers, the sediments and any pollutants attached to sediments will be filtered out by buffers. These buffers also promote ground water recharge and transpiration and therefore reduce runoff. Well designed and positioned conservation buffers can achieve at least 50% reduction of nitrogen, phosphorus, and sediment loads (Lowrance et al., 1986). In New Jersey, the vegetative filter is expected to achieve 80% reduction in TSS and 30 percent in nitrogen and phophorus from stormwater runoff (Semple, 2004). The research on the effectiveness of buffers in reducing pathogen loads is not as widely researched as for reducing total suspended solids, total nitrogen, total phosphorus and pesticides. Some research suggested the conservation buffers can remove up to 60% of pathogens in runoff (SWCS, 2001). Strategically locating the buffers is essential to achieve the effectiveness of the conservation buffers in improving water quality (Dillaha et al., 1989; Dosskey et al., 2002 and 2006; Qiu, 2003 and 2009).

The installation of buffers may affect the smaller farmer disproportionately, due to the amount of land that is necessary to dedicate to the buffer. An education and outreach program can be implemented that provides guidance in incorporating economically beneficial buffers. These could include buffers that would only be mowed annually for a crop, such as hay.

> ***Recommendation 1: Install conservation buffers throughout the watershed as the primary stormwater best management practice to improve water quality and address water quantity issues. (For an example of such a project, refer to Appendix D, Sheet 2 and Appendix E, Riparian Buffer and Filter Strip BMP Information Sheet).***

> ***Recommendation 2: Provide education and outreach to the many smaller farms in the watershed to provide guidance on the many benefits that can be achieved through the proper installation of stream buffers.***

7.1.2.3 Animal manure management

The animal manure management program discussed for pathogen load reduction should also help reduce total phosphorus and total nitrogen loads to the streams in the watershed. While nitrogen can be easily dissolved, phosphorus in manure usually can be more easily built up in soils where manure is applied. The accumulated phosphorus in soil can be later carried into to the streams by runoff. Cropland can be used as an application area for animal manure. Manure application can be rotated among the different fields to avoid the concentrated manure application on limited land bases. Methods of application may include injection for stabilization in the soils. Soils in croplands should be periodically tested to ensure that only proper amounts of manure can be applied to protect water resources, and promote crop growth and soil health. The animal manure management for the smaller farms will best be optimized through an outreach program that aids in coordinating waste disposal activities and provides educational opportunities. This education and outreach to the smaller animal farms may also include the benefits of buffer implementation and impervious surface disconnection.

7.1.3 Strategies for Controlling Sediment Contamination

Sediment concentrations in the Assiscunk Creek Watershed do not exceed water quality criteria. However, the unstable banks of drainage ditches, tributaries and the main stem stream will supply solids to the water system. Given the low gradient of the stream bed with its slow flow, these solids will settle to the bottom quickly and contribute to a poor macroinvertebrate habitat.

7.1.3.1 Drainage Ditch Retrofitting

There are extensive drainage ditch segments in the Assiscunk Creek Watershed, including roadside and agricultural drainage swales. Among these segments, many are actively eroding, thus contributing sediment to stormwater which flows through them and need urgent repair. Drainage ditch retrofitting can turn the ditches into bioretention swales that are very similar to constructed wetlands (Refer to BMP Information Sheets in Appendix D and Concept Designs in Appendix E). The removal rate for constructed wetlands is 90% for total suspended solids, 50% for total phosphorus and 30 percent for total nitrogen. According to Karathanasis (2003), the removal rate of wetlands for fecal coliform is 93 percent. The maintenance of these systems are relatively low, with once yearly mowing and sediment removal every one to three years.

The Assiscunk Creek Watershed contains many miles of drainage ditches that drain farmland, roads and residential neighborhoods. There is a need to address this altered hydrology which increases runoff, pollutant loading to the stream and peak flow during storm events. Retrofitting theses ditches is expected to yield large reductions in pollutant loads.

> ***Recommendation: Retrofit ditches to promote filtration, to slow overland flow and to stabilize soil on the banks. (For an example of such a project, refer to Appendix D, Sheets 3 and 5 and Appendix E, Naturalized Agricultural Swale and Roadside Ditch Retrofits BMP Information Sheets)***

7.1.3.2 No-till and Residue Management

Tillage is viewed as a necessary field operation to grow crops. Tilling is used to remove weeds, mix in soil amendments like fertilizers, shape the soil into rows for crop plants and furrows for irrigation, and prepare the surface for seeding. Tillage very often leads to some unfavorable effects such as soil erosion, soil compaction, loss of organic matter, degradation of soil health and disruption of soil microbes and other organisms. There are various tillage level used by farmers depending on equipments, tradition, soil conditions and crop choice. In the Assiscunk Creek Watershed, farmers often used conventional or reduced tillage practices in croplands, which have potentially contributed sediments and nutrients as soil particles are washed away during storms. NRCS has been recommending no-till, strip till, mulch till and ridge till with proper crop residue management to minimize physical disturbance of the soil and leave approximately 30% of the surface covered by residue after planting (NJACD, 20XX). This type of tillage reduces sheet and rill and wind erosion, slows down surface runoff and peak runoff, increases infiltration and reduces surface runoff by increasing land cover and surface roughness, and works to improve soil organic matter content.

> ***Recommendation: Promote no-till, strip till, mulch till and ridge till systems to reduce erosion and sedimentation. (Example program: Soil Health Workshop through Friendly Farms, Burlington County and South Jersey Resource Conservation and Development Council)***

7.1.3.3 Cover Crop

Cover crops are grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and other conservation purposes. Cover crops are usually cold season crops such as winter rye or wheat that are planted after harvesting a major crop and killed before the new growing season. Annual rye grain is among the popular choices of cover crop. Cover crops reduce soil erosion, and help maintain soil moisture and improve soil nutrients and organic matter. Proper use of cover crop also have other benefits including lower farming operation cost, reduced tillage, less herbicide uses and better overall soil health. Cover crops can be incorporated into any cropping system that has fields not in use for all or part of the year.

> ***Recommendation: An education and assistance program should be established to help farmers implement cover crops regularly.***

7.1.3.4 Streambank stabilization

Streambank erosion is a natural process that occurs in streams as water flows through the channel and wears away soil and rock. The SVAP assessment indicates that streambank erosion is a common resource concern in the Assiscunk Creek Watershed. Streambank stabilization is an important measure to reduce streambank erosion, improve water quality and enhance the stream ecology. SVAP assessments have identified potential sites for streambank stabilization. There is a wide range of streambank stabilization methods and techniques available to use. Sections of proper streambank stabilization methods and techniques should be determined according to the channel evolution stage identified through the channel evolution models. Although the streambank can be temporarily stabilized through various streambank stabilization measures, the permanent stabilization has to be achieved by controlling runoff amount and velocity in the watershed. Streambank stabilization also requires any land use activities that disrupt the streambank should be prohibited in the watershed.

> ***Recommendation: The stabilization of stream banks should be undertaken to reduce the entrance of solids, and the phosphorus adhered to those solids, into the waterway. (For an example of such a project, refer to Appendix D, Sheet 6 and Appendix E, Stream Corridor Restoration BMP Information Sheet).***

7.1.3.5 Conservation buffers

Conservation buffers have multiple water quality benefits. In fact, the most noted and well-documented water quality benefit is to reduce TSS loads to streams. As runoff enters into conservation buffers, the dense vegetation in the conservation buffers will act as a filter to block off the sediments and sediment-absorbed nutrients, pesticides and pathogens and prevent them from going into streams. (See Section 7.1.2.2.)

> ***Recommendation: Conservation buffers should be installed in proper locations to achieve their optimal effectiveness in improving water quality. (For an example of such a project, refer to Appendix D, Sheet 2 and Appendix E, Riparian Buffer and Filter Strip BMP Information Sheet).***

7.1.3.6 Livestock Exclusion Fencing

As discussed previously, livestock exclusion fencing should be installed in pastures along the streams to eliminate livestock’s direct access to streams and therefore reduce the pathogen loads into the streams in the Assiscunk Creek Watershed. The same exclusion fencing would also eliminate livestock’s disturbances to the streambank and maintain the streambank stability. The stable streambank implies less soil erosion and therefore less TSS load to the streams in the Assiscunk Creek Watershed. (See Section 7.1.1.1)

Recommendation: Waterways should be fenced in areas of potential animal access. (For an example of such a project, refer to Appendix D, Sheet 7 and Appendix E, Animal Management BMP Information Sheet)

7.1.4 Strategies for Restoring Watershed Hydrology and Streamflow

Land use changes and the associated stormwater drainage systems have significantly altered watershed hydrology. Watershed restoration has to mitigate the negative impacts of land use changes on watershed hydrology. The following BMPs are proposed to restore watershed hydrology and streamflow.

7.1.4.1 Bioretention Systems

Traditional stormwater infrastructure is designed to quickly deliver the stormwater from the sources to the streams. Bioretention systems are the BMPs that are designed to retain the stormwater first and then discharge to the stormwater systems and/or the stream if necessary. These systems are designed to capture, treat and infiltrate stormwater runoff. In areas where groundwater tables are high, underdrain systems can serve to discharge overflow after treatment. Bioretention systems in the watershed should include a series of bioretention facilities that are maintained under different situations and include:

- Rain gardens to capture, treat, and infiltrate stormwater in residential areas
- Bioretention facilities at business and corporate campus
- Constructed wetlands along roads.

Recommendation: Install bioretention systems to receive excess runoff from impervious surfaces.

7.1.4.2 Conservation buffers

Conservation buffers have not only water quality benefits as discussed previously, but also water quantity benefits. Conservation buffers could achieve runoff reduction by evapotranspiration and groundwater recharge through multiple biological and hydrological processes. (See Section 7.1.2.2.)

Recommendation: Conservation buffers should be installed in proper locations to achieve their optimal effectiveness in improving water quality. (For an example of such a project, refer to Appendix D, Sheet 2 and Appendix E, Riparian Buffer and Filter Strip BMP Information Sheet).

7.1.4.3 Conservation Planning and Ordinances

Land use changes, especially suburban development, substantially alter watershed hydrology and cause many water quality problems in the Assiscunk Creek Watershed. In respond to those water quality and quantity issues, municipalities in the watershed have developed various conservation plans and ordinances to control land use activities and protect water resources. Stream corridor protection ordinances should be enforced to restrict land use activities in the stream corridors for improving water quality, mitigating the impacts of floods and protecting the streams and their surrounding ecosystems. As suburban development continues in the watershed, conservation planning and ordinances should be reviewed, developed and implemented to help prevent harmful land use activities and protect the water resources in the watershed.

> ***Recommendation: Municipalities should develop and enforce regulations protecting water resources in the watershed.***

7.1.4.4 Farmland and Open Space Preservation

All municipalities in the Assiscunk Creek Watershed have active farmland and open space preservation programs. These programs were originally established as urban sprawl control measures to protect important natural and cultural resources from urban development and retain the amenities of traditional rural communities and improve environmental quality including water quality.

> ***Recommendation: Municipal farmland and open space preservation programs in the watershed should be continuously used and expanded to***

protect critical source areas from intensive land use activities and disturbances and prevent water resource degradation.

7.2 Agricultural Best Management Priorities and Practices

The implementation of Agricultural Best Management Practices will address many of the impairment issued currently experienced in the Assiscunk Creek Watershed. Prioritizing the implementation of these practices will need to include the extent that the practice will cover, along with the initial circumstances that are being mitigated. Site specific recommendations, as presented in Section 7.5 and 7.6 will aid in determining options for implementation.

7.2.1 Livestock Access Control – Exclusion Fencing

Direct access to streams by livestock is a threat to water quality in the Assiscunk Creek Watershed. Nutrients and pathogens from livestock manure can be transmitted to streams via direct deposit and runoff. Livestock access to streams may also damage the stream bank and causes soil erosion. Installation of exclusion fences along a stream would protect streams from such contamination. Fencing also allows for the healing of the riparian area. A fully functioning riparian buffer would further filter those pollutants from reaching the streams. The NRCS BMP Practice Manual (Appendix C) requires that livestock exclusion fencing should be installed at least 35 feet from the stream banks depending on the stream width and other site specific conditions. The 35 foot corridor allows for the establishment of a riparian zone for additional protection from pastureland runoff. The type of fencing utilized depends on livestock type and site conditions. Once installed, livestock are no longer able to directly deposit manure while watering or crossing. Additional damage that may have occurred on stream banks can be repaired, and the stream will heal to a more natural state, reducing stream bank erosion.

Exclusion fencing should be installed along all waterways which run through property with livestock that have access to the waterway. While fencing may be installed by any contractor or landowner, technical assistance should be obtained from NRCS or other support agency to ensure the effectiveness and longevity of the fence. While fencing prices can vary according to livestock type and landowners' preferences, NRCS approximates the unit cost of fencing to be $4.78 per foot for use for livestock exclusion. There is also the potential for cost sharing to help offset any expenses accrued by the landowners. Cost sharing will very often help fund the practices associated with the installation of exclusion fencing such as the installation of an alternate water source for livestock. There are currently many sources of cost share from both state and federal government including the NRCS Agricultural Water Enhancement Program (AWEP). This cost will be greatly offset if the landowner applies and qualifies for cost sharing. Currently funding can be up to 100 percent of the installation cost.

Recommendation: All farms that house any number of animal units should install fencing to deter the entrance of these animals into the waterways. (For an example of such a project, refer to Appendix D, Sheet 7 and Appendix E, Animal Management BMP Information Sheet)

7.2.2 Conservation Buffers

Conservation buffers are structural vegetative mixture of trees, shrubs and grasses placed in landscape to influence ecological processes and enhance ecosystem goods and services. There are many types of conservation buffers such as contour buffer strips, field borders, grassed waterways, filter strips and riparian forest buffers (Bentrup, 2008). People tend to use those terms interchangeably without distinction. In this project, the term conservation buffer is used to refer to all types of buffer practices being used in the watershed. Different types of conservation buffer practices can be applied in different parts of the watershed to maximize economic and environmental benefits such as water quality improvement, soil erosion control, wildlife habitat enhancement. Water quality benefits of conservation buffers are well documented. As runoff goes through conservation buffers, the sediments and any pollutants attached to sediments will be filtered out by buffers. The buffers also dissolve some of the pollutants through complicated chemical and biological processes. Conservation buffers also promote ground water recharge and transpiration and therefore reduce runoff. Well designed and positioned conservation buffers can achieve at least 50 percent reduction of nitrogen, phosphorus, and sediment loads (Lowrance et al., 1986). In New Jersey, the vegetative filter is expected to achieve 80 percent reduction in TSS and 30 percent in nitrogen and phosphorus (Semple, 2004). The research on the effectiveness of buffers in reducing pathogen loads is not as widely known as for reducing TSS, total nitrogen, total phosphorus and pesticides. Some research suggested the conservation buffers can remove up to 60 percent of pathogens in runoff (SWCS, 2001). Strategically locating the buffer is essential to achieve the effectiveness of the conservation buffers in improving water quality (Dillaha et al., 1989; Dosskey et al., 2002 and 2006; Qiu, 2003 and 2009).

Conservation buffers can be installed by any contractor or landowner. NRCS has the specific guidance for conservation buffer installation and maintenance. Technical assistance should be obtained from NRCS to ensure proper location, plant selection and buffer size being determined. If livestock are present, fencing will have to be installed to prevent damage to the buffer. The costs associated with the implementation of conservation buffers include materials and labor, maintenance, and the opportunity cost of the land taken out of production. There are various federal, state and local programs that provide cost sharing to implement conservation buffers. In New Jersey, the New Jersey Conservation Reserve Enhancement Program (NJCREP) has been the primary funding mechanism for installing conservation buffers on agricultural lands. The $100 million NJCREP offers a one-time sign-up incentive and covers 100 percent of the implementation costs of installing buffers and offers land rental payments up to 15 years. NJCREP supports four types of buffer practices in agricultural lands: grass waterways, contour grass strips, filter strips, and riparian buffers. The land rental payments offset the opportunity cost of the land being taken out of agricultural production and are determined by soil types and the annual soil rental rate set by the USDA Farm Service Agency. Some other governmental agencies and non-profit conservation groups are often interested in implementing conservation buffers and can also become involved in offering mini grants and assisting in the implementation and maintenance of conservation buffers.

Installation costs of conservation buffers vary due to site-specific conditions and choice of certain buffer practices. According to the NRCS AWEP 2010 practice catalog, the installation costs of filter strips range from $292.25 to $303.35 per acre and of riparian buffers from $1,081.56 to $2,596.56 per acre. Grassed waterway is the most expensive, but the least used buffer practice because an engineering structure is often installed at the end of the waterway to ensure the proper dispersion of the concentrated runoff into the streams. The general annual maintenance cost that includes mowing, sediment removal and debris removal is about $4 to $9 per acre.

As discussed previously, conservation buffers have multiple water quality benefits. Based on the assessment using SWAT modeling, the well implemented conservation buffer program could result in a 52 to 68% reduction of total phosphorus and 80% reduction in pathogen loads to Barkers Brook and Assiscunk Creek streams.

Recommendation: Install conservation buffers throughout the watershed as the primary stormwater best management practice to improve water quality and address water quantity issues. (For an example of such a project, refer to Appendix D, Sheet 2 and Appendix E, Riparian Buffer and Filter Strip BMP Information Sheet)

7.2.3 Composting Facility

Currently in the Assiscunk Creek Watershed, there are agricultural properties which produce manure that may not be able to be used onsite. In some cases this manure may be handled in a fashion which can potentially pose an environmental threat. Manure piled in hydrologically sensitive areas or without proper distance from streams can leak phosphorus and fecal contaminants into surface water. A remedy is to compost the raw manure to a safe and biologically stable organic material.

A composting facility can be a simple windrow or a static pile which is turned to allow for aerobic conditions. The location on the property must be at least 50 feet from the property line and 250 feet from an occupied dwelling with no part located within a flood plain unless it is protected against the 100 year flood. The facility will also be designed to manage any runoff in a safe manner.

The task of installing a composting facility varies in difficulty and should be done with assistance from the NRCS or another support agency or non-profit to help make technical decisions that will ensure the facility is sited properly and designed to deal with any runoff potential. There may also be local and state ordinances which must be met to install this practice. There is cost sharing to help offset any expenses accrued by the landowner. This practice may also require some training for the operator, as temperature and proper ratio of carbon-to-nitrogen must be maintained to encourage this biological process.

There is a range of prices for composting facilities based on the needs and preference of a land owner. The price range listed in the NRCS AWEP 2010 practice catalog ranges from $.10 to $16.73 per square foot. There is a cost share available for the construction of the facility. There is no cost share available for some of the equipment which is required to run the facility, such as a tractor or a windrow turner. If an operator does not own this equipment it will be an out of pocket expense.

Composting facilities should be considered as a possible solution for any livestock operation that cannot safely use or remove manure from the property in regards to water quality. This would include land that is overstocked. The locations can be prioritized by the subwatershed ranked according to the combined fecal coliform and total phosphorus loading.

The use of composting facilities as a means to safely manage manure generated on a farm will help to mitigate any potential phosphorus and fecal contamination generated through manure storage in the watershed. Secondary benefits are from turning manure into a safer alternative fertilizer than the spreading of raw manure.

> ***Recommendation: A composting facility for manure produced in the watershed should be made available to those farmers that require this***

> ***proper waste disposal. Those in need should check with the local Solid Waste Facility.***

7.2.4 Prescribed Grazing

Prescribed grazing is having a plan in place that manages grazing and browsing of animals to ensure there is always adequate ground cover while ensuring proper nutrition for the livestock. Overstocked or poorly managed pastures lead to less than sufficient vegetated cover required to prevent erosion and manure run-off. Generally a prescribed grazing plan will be written by a pasture professional. At times it requires temporary fencing for rotational grazing activity, pasture reseeding and a reduction in animal units.

A farmer can have a prescribed grazing plan written for him through several government agencies, including NRCS. This plan may require a farm to install fencing or provide alternate watering. In addition, a pasture might have to be reseeded, fertilized, limed or enhanced. All of these practices might not be cost shared, but there can be economic benefits to healthy pastures that can further offset costs.

The cost of implementing a prescribed grazing plan varies according to the pasture needs and existing conditions. There is also a cost associated with the learning curve of the operator. The end result is often healthier pasture, which can in return make the plan worth any cost to the landowner. The cost estimate in the AWEP 2010 practice catalog is between $241.97 and $321.30 per acre, not including fencing, watering or seeding.

> ***Recommendation: Implement a prescribed grazing plan that will allow for pastures to regain healthy vegetation.***

7.2.5 Cover Crop

Cover crops are grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and other conservation purposes. Cover crops are widely accepted by agricultural professionals and farmers to have many benefits, with improving water quality being just one of them. Proper cover crop selection has led to operators reducing cost, reducing tillage, reducing herbicide uses and increasing soil health. Cover crops can easily be worked into any cropping system that has fields not in use for all or part of the year. With proper promotion, education and assistance, cover crops can be implemented watershed wide with excellent benefits.

Cover crops vary in cost depending on the cover crop selection. According to NRCS AWEP 2010 practice catalog, the least costly is winter cover crop at $71.50 per acre while a legume in the summer is estimated at $443.40 per acre. There is cost sharing available for these practices. There is often a return to the operation with reduced fertilizer needs and increased soil health. Cover crops reduce both wind and water erosion and promote infiltration. Nutrients left over from previous fertilizer and manure applications in the soil profile will be captured and recycled making them unavailable for runoff.

> ***Recommendation: An education and assistance program should be implemented to help farmers implement cover crops in their crop production to achieve the promising water quality and other environmental benefits.***

7.2.6 Contour Farming

Many row crops in the Assiscunk Creek Watershed are planted in straight rows without regards to the contours in the land or slope direction. This condition is conducive to increased erosion and fertilizer runoff. Contour farming is described in the NRCS Field Operations Technical Guide as using ridges and furrows formed by tillage, planting and other farming operations to change direction of runoff from directly downslope to around the hill slope. In essence this means farming with the natural shape of the land instead of against it. In addition the crop itself is used to slow water velocities with the ridges and furrows formed in row crops. The overall result is the reduction of the erosive capacity of the field which in turn reduces the potential for runoff. This practice has limits as it is most effective on slopes between 2 and 10 percent without excessive rolling topography.

This practice in its simplest form is just changing the direction in which an operation plants it rows from "up and down" the slope to across the slope. Field conditions do vary, and for this system of planting to work at its highest potential it will often require detailed planning from an agricultural professional. Contour farming might also need to be used in conjunction with other practices, such as terraces or filter strips, to realize its full potential. While there is not always cost sharing available for the practice of contour farming itself being that it is just a change in field orientation, there is often cost sharing for practices that need to be installed to help the system function properly. Consideration will have to be taken into account for operator learning curve.

The actual cost of contour farming does not have a figure attached because it is not a physical implementation but rather a change in how a farmer plants. Cost for support practices are on a field to field basis but are often cost shared. A conservation planner from NRCS can provide free technical assistance in making decisions about what supportive practice will be necessary and guide landowners to appropriate cost share programs.

Contouring farming can reduce erosion, reduce the transport of phosphorus to surface waters and increase water infiltration. The effectiveness of contour farming is amplified when incorporated with a strip cropping system. Strip cropping is the growing in systematic arrangement of row crops, small grains and forages of equal strips.

> ***Recommendation: Provide farmers with education and outreach materials on the process of contour farming.***

7.2.7 Residue Management- No-till

Residue management practices using no-tillage are described in the NRCS New Jersey Field Operation Technical Guide as managing the amount of plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residues, and plant crops. This management style often involves specialized equipment to drill seeds in below residue and inject fertilizers. This style of cropping has lent well to soybean farmers and is growing with types of crops successful under this management style, including vegetables.

No-till farming has been widely successful with some farming styles, such as soybean, while it is still in its infancy with other styles. The benefits of no-till farming in regards to soil health and runoff reduction are fully realized by many agricultural professionals. It requires some trial and error to incorporate into different crops. With proper promotion, education, experimentation and assistance no-till farming can be tried on different crop types.

The cost of no-till farming is often in the equipment required for this system. The upfront equipment costs are obstacles for farmers who are unsure if no-till will work right for their crops. If programs to help farmers convert to these styles become more prevalent, this might become a more easily realized management possibility.

No-till farming will result in increased soil health. No-till farming ensures that the soil is always protected from soil particles becoming dislodged by rain and becoming runoff. These two factors will lead to a reduction in agricultural pollutants. In addition crop residue will break down overtime releasing nutrients that can be used by plants, reducing the amount of fertilizer application required.

> ***Recommendation: Promote no-till, strip till, mulch till and ridge till systems to reduce erosion and sedimentation. Seek methods of funding this procedure.***

7.2.8 Nutrient Management

Currently in the Assiscunk Creek Watershed there are agricultural properties which apply fertilizers based solely on crop needs or a time schedule without current soil tests. This condition can lead to over application resulting in run off of excess nutrients into surface water. Nutrient management is managing the amount, source, form, and timing of the application of nutrients and soil amendments. It includes having current soil tests to understand what is already in the soil for the plants use so it can be taken into account when applying fertilizer. This avoids applying more than the crop needs. Nutrient management plans are often developed by a person certified in nutrient planning.

Any farmer can have a nutrient management plan written for him through several government agencies, including NRCS. There are often local agencies and non-profit groups offering this service for little or no cost. The use of a nutrient management plan can often lead to reduced input cost to the farmer. Plans can also discover nutrient deficiency and pH imbalances. Addressing these imbalances can increase yields and avoid potential pest issues. Soil fertility is linked to many agricultural issues. If proper promotion is conducted, it should be one of the easier practices to implement in the watershed.

The cost of implementing a nutrient management plan is estimated in NRCS AWEP 2010 practice catalog to be $25.36 per acre in a grain crop and $52.56 an acre in specialty crops. This cost is almost always cost shared and often funded 100%. This practice is supported by agricultural professional, agencies, and farmers.

An implementation of nutrient management plans watershed wide would reduce the nutrients available for runoff. There is the added benefit of understanding how the timing of these applications not only affects availability to the crops, but their potential for runoff. Since manure is a nutrient that can be applied, a nutrient management plan inherently addresses the issues of manure storage and application, creating a dialog with the producers to solve these issues.

> ***Recommendation: Provide farmers with education and outreach materials on the process of nutrient management.***

7.2.9 Cost Assistance Program for Farmers

Many of the conservation practices that have been recommended here are acceptable to farmers who care for the sustainability of their land and the essential water resources related to the land. These farmers are willing to incorporate these practices onto their land, but the financial implications may deter them. Funding opportunities using the Farm Bill may help to promote these practices, but often the farmer is not able to provide the cost share required. A program that would provide this cost share assistance to these farmers may create a larger body of farmers that are willing to participate in the conservation practices that are known to promote a healthier watershed.

> ***Recommendation: Create a program that will aid farmers in the cost share necessary to use the opportunities from the Farm Bill funding.***

7.3 Stormwater Best Management Priorities and Practices

Although the most intensive land use in Assiscunk Creek Watershed is agriculture, urban land use, consisting of residential, commercial and industrial uses make up approximately 25% of the land cover in this drainage area. For the urban land use, four primary stormwater best management practices (BMPs) are being recommended to address the sediment, nutrient and pathogen contamination and restore watershed hydrology in the watershed: rain gardens, detention basin retrofitting, roadside ditch retrofitting, and vegetative buffers. The impervious areas that are related to this type of development have been increasing over the past two decades and should be managed for optimal stormwater recharge.

7.3.1 Rain Gardens

A rain garden is a landscaped, shallow depression designed to capture, treat, and infiltrate stormwater at the source before it reaches to a stormwater infrastructure system or a stream. Plants used in the rain garden help retain pollutants that could otherwise degrade nearby waterways. Rain gardens are becoming popular in suburban and urban areas. These systems not only improve water quality, but also help homeowners minimize the need for watering and fertilizing large turf grass areas and promote groundwater recharge. If designed properly, these systems improve the aesthetics of the urban/suburban neighborhoods through the use of flowering native plants and attractive trees and shrubs.

A typical rain garden is designed to capture, treat and infiltrate the water quality storm of 1.25 inches of rain from a 1,000 square foot impervious area from an individual lot (i.e., a 25 foot by 40 foot roof for a house or a 20 foot wide by 50 foot long driveway). By collecting runoff generated by the first 1.25 inches of rainfall, the rain garden prevents the "first flush" of runoff from entering the stream, which characteristically has the highest concentration of contaminants. For the water quality storm of 1.25 inches of rainfall, the rain garden needs to be 10 foot by 20 foot and six inches deep. Since 90% of all rainfall events are less than one inch, rain gardens are able to treat and recharge a majority of runoff from these storms. It is fair to assume, if designed correctly, rain gardens will reduce the pollutant loading from a drainage area by 90 percent wherever they are installed. Furthermore, they will reduce stormwater runoff volumes and reduce the flashy hydrology of local streams. This reduction of flashy hydrology will minimize stream bank erosion and stream bed scour, thereby reducing TSS and phosphorus loads in the waterway. According to Rusciano and Obropta (2007), rain gardens are found to remove 90 percent of fecal coliform from stormwater runoff.

Rain gardens can be installed almost anywhere. Ideally the best installation sites are those where the soils are well-drained so that an underdrain system is not required. However, any diversion runoff and filtration through native vegetation anywhere in the watershed would help reduce pollutant loading to the streams. Since many areas of the Assiscunk Creek Watershed have high groundwater tables, it will be necessary to quantify depth and install an underdrain if the system requires.

> ***Recommendation: Education and outreach programs and demonstration projects should be conducted to educate the general public and the municipal officials and to train landscape professionals in installing rain gardens.***

7.3.2 Roadside Ditch Retrofitting

In many of the agricultural areas of the watershed, piped drainage is less prevalent. Stormwater in those areas is usually routed by the use of drainage ditches along the roadways. Most roadside ditches do not have design standards unlike more conventional stormwater infrastructure systems. Roadside ditches alter the natural hydrology and appear to be designed not for stormwater management but convenience to the landowners. This approach to ditch design exacerbates water quality issues. In addition, typical ditches are not well maintained and usually consist of bare soil.

The recommended management strategy is meant to protect the existing drainage ditches from erosion and improve the water quality of runoff traveling through them. The New Jersey Department of Transportation (NJDOT) Roadway Design Manual requires outlet protection of conduits for runoff velocity generated during the 25-year storm (at a minimum) to prevent erosion. Therefore it is recommended that any alteration of designs for a drainage ditch should provide for the capacity of a 25-year storm to prevent erosion in the ditch. The other goal of the strategy is to improve the water quality of the runoff entering the ditch. A common method of improving water quality is to reduce the velocity of runoff to allow the contaminants it carries to settle out. Designs should work to mimic the flow reductions seen in grassed filter strips for water quality improvement. An additional benefit of reducing velocities is encouraging infiltration of stormwater by retaining runoff in the ditch for more time.

When recommendations are made to improve road side ditches, it is typically planned to widen and plant with a diverse mix of vegetation. Vegetation creates friction to reduce flow and encourage infiltration. If there is very little space available to widen the ditches to the limiting size of the right of ways, using rip-rap (large stones), gabion baskets and weirs in different ways is recommended to control the flow as the vegetation would.

The first retrofitting strategy is to use stone-filled gabion baskets. The gabion basket is an empty cube made of wire mesh. The mesh is filled with large stone; the stone can provide structural support while the mesh holds the stone in place. While the baskets are porous, they restrict flow through them. Gabion baskets can be installed periodically in drainage ditches to serve as an obstruction reducing the velocities in the channel and improving water quality. The reduction in velocity will require the ditches to have a larger storage capacity. If there is little room to widen the ditch, it can be deepened to meet the additional storage capacity requirements. The retrofitting cost is depending on how many gabion baskets are installed in each ditch, which in turn is affected by many factors. The cost to buy the materials and install one gabion basket would be approximately $200.

The second retrofitting strategy is to use French drain exposed to the surface. A French drain is an underground trench filled with stone. The trench is a drainage device that creates a path of least resistance for water to flow. The basic design for this strategy proposes stone filled channels. The size of the channels filled with stone and portions of the ditch upstream of the exposed French drain need to be designed to account for the additional storage capacity required in the ditch due to the reduction in velocity of the runoff. The front and the end of the French drain needs to have structural support to prevent stone from dispersing up and downstream over time. A gabion basket check dam placed at the front and back of each exposed French drain would provide sufficient support. Essentially, this is a longer check dam. It is useful for locations that require vehicles to cross the ditch on a routine basis (farmers often require this, and it could also be used for driveways). The strategy includes installing gabion baskets, as well as laying stone in narrow ditches. The cost for the material and installation per length of stone would be $400 for the gabion basket on each end of length and $100 per linear foot of stone in between the two gabion baskets.

The third retrofitting strategy is to use a weir. Gabion baskets provide a basic form of velocity control, but they do not have the flexibility of flow control that other devices have such as weirs. A weir is simply a wall with a notch cut out of it. The size and placement of the notch has a strong effect on the amount of flow that the weir will allow through it. The flow is controlled by the shape, elevation and size of the notch and the height of the water behind the notch. The flow rate will be higher with higher water levels behind the weir. Weirs are interchangeable with gabion baskets. The weirs get greater control over the flow than the gabion baskets, but would cost more to design and implement. Installation of a weir with a scour hole in place of a gabion basket would cost $400 per weir installation.

> ***Recommendation: All ditches, roadside (current section) and agricultural (Section 7.1.3.1) should be retrofitted with native vegetation to reduce flow, filter and stabilize banks. Funding agencies (e.g. NJDEP 319(h) can coordinate efforts with Highway Department or County Engineering Department. (For an example of such a project, refer to Appendix D, Sheets 3 and 5 and Appendix E, Naturalized Agricultural Swale and Roadside Ditch Retrofits BMP Information Sheets)***

7.3.3 Detention Basin Retrofitting

Stormwater from the more recently developed areas of the watershed is usually managed with detention basins. Detention basins are constructed impoundments for reducing flooding, lowering the volume and velocity of stormwater that flows into streams immediately after a storm. There are a few detention basins in the Assiscunk Creek Watershed. Some of the detention basins in the watershed present an opportunity for upgrades or retrofits to improve water quality.

Detention basins in the watershed are usually covered with turf grass that provides for minimal infiltration. Turf grass has a shallow root structure that does not open up the soil below the surface allowing water to infiltrate. One important measure in retrofitting detention basins is to replace turf grass with native grasses and vegetations that require low maintenance. By introducing native grasses and reducing the frequency of mowing from once a week to once or twice a year (usually in the winter), native grasses develop a deep root structure. Using native grasses reduces maintenance costs due to less mowing and improves water quality through increases in infiltration and subsequent decreases in stormwater discharges to nearby waterways.

The cost of retrofitting a detention basin will vary depending on the amount of work that needs to be done to improve the detention basin. If the detention basin needs to be excavated and replanted, the cost would be approximately $2 to $4 per square foot of the detention basin. When a detention basin needs to be re-vegetated the cost to improve the detention basin is $0.25 to $2 per square foot. The cost estimates vary because the designs to improve the detention basins have so much flexibility to them. The cost to remove a low flow concrete channel is approximately $100 per linear foot.

Targeted reductions in TSS, total nitrogen and total phosphorus are expected to be 90, 60 and 30 percent, respectively. Depending on the final design of the detention basin, it will function like a bioretention basin or a wetland. The removal rates for bioretention basins and wetlands are at or above 90% for fecal coliform (Rusciano and Obropta, 2007; Karathanasis *et al.*, 2003).

> ***Recommendation: Retrofit older detention basins with native vegetation for lower maintenance and higher pollutant removal efficiency.***

7.5 Site Specific Restoration Projects

7.5.1 Mansfield Township Overview

Mansfield Township has a total of 22 square miles within its borders, but only a 3.5 square mile section along the southern border with Springfield is part of the Assiscunk Creek Watershed (Figure 18).

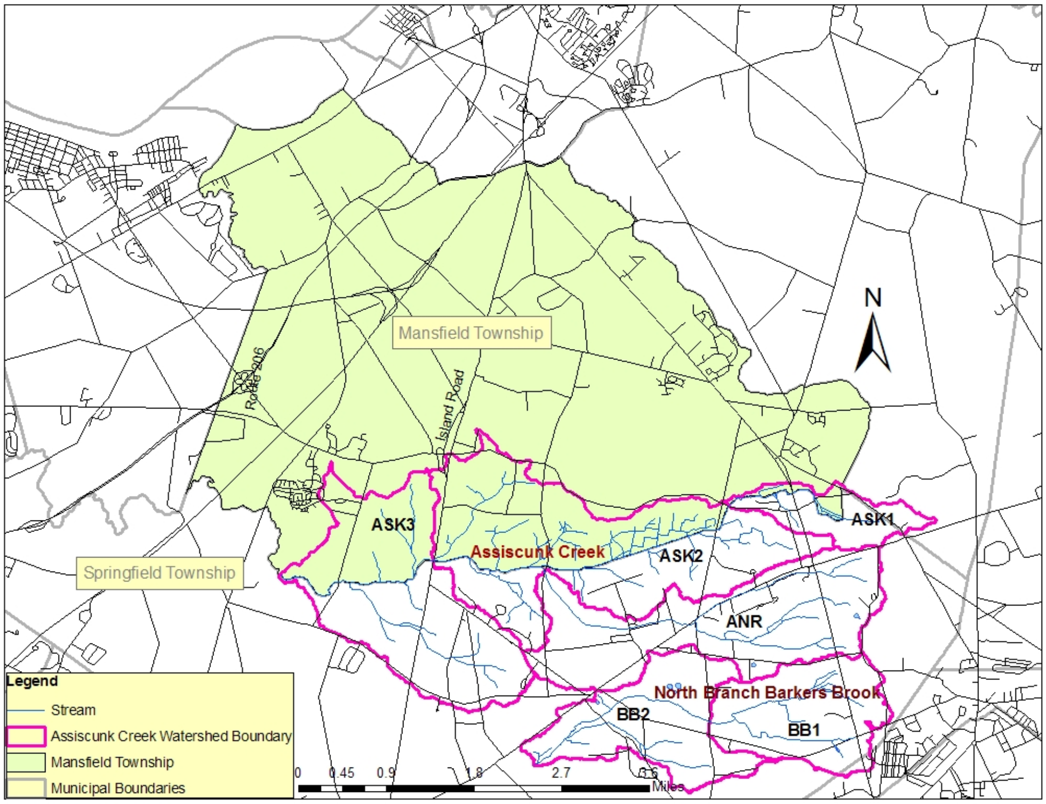

Figure 18: Mansfield Township and Boundary of Assiscunk Creek Watershed

The land use in Mansfield is fairly consistent across the Assiscunk subwatersheds that fall within its boundaries. In ASK3, the outlet subwatershed, the land east of Petticoat Bridge Road remains primarily agriculture with some forested areas. The area west of Petticoat Bridge Road has portions of densely developed residential areas with high impervious areas. The area of ASK2 in Mansfield between Route 206 and Island Road is primarily agriculture with some forested areas and nursery operations. West of Island Road in ASK2 is more agricultural lands and many areas of rerouted drainage from these lands. In the headwaters of the ASK3 subwatershed, the land area of Mansfield is forested, with small sections of streams with no vegetative buffer and eroding streambanks.

Table 30: Subwatershed Area in Mansfield Township

Mansfield		Acres	Sq Mi
	ASK3	760.66	1.19
	ASK2	1386.53	2.17
	ASK1	86046	0.14
Total			3.5

7.5.2 Mansfield Priority Solutions

The runoff from the 3.5 square miles of land area in Mansfield that contributes areal loading of nonpoint source pollutants to the Assiscunk Creek Watershed have easy overland access due to the multiple areas of un-buffered streams. Site specific solutions have been identified through field visits, SVAP evaluations and aerial analysis (Table 31) and have been spatially located on a GIS project (Figures 19, 20 and 21) available to stakeholders. The locations of roadside ditches that have been identified as potentially benefitting from a retrofit have been spatially located on a plan sheet that accompanies this report (Appendix D, Sheet 5). A site specific example of all major best management practices recommended by this plan has been provided in accompanying sheets (Appendix D). Each of these site specific recommendations have an associated “BMP Information Document” found in Appendix E). Identified projects should be implemented in accordance with the USDA NRCS Field Operations Technical Guide (USDA, 2004), the New Jersey Best Management Practices Manual (NJDEP, 2009) and Chapter 7 of this plan.

Table 31: Site Specific Projects in Mansfield Township

Mansfield	Project ID	Issue	Solution	Notes
ASK3	A3_SM01	Inadequate Buffer	Enhance Buffer	C1 waters
	A3_MN01	Inadequate Buffer	Enhance Buffer	C1 waters
	A3_MN02	Inadequate Buffer	Enhance Buffer	C1 waters
	A3_MN03	Inadequate Buffer	Enhance Buffer	C1 waters
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
ASK2	A2_MN06	Inadequate Buffer	Enhance Buffer	C1/Preserved Farmland
	A2_MN07	Inadequate Buffer	Enhance Buffer	C1/Preserved Farmland
	A2_MN08	Inadequate Buffer	Enhance Buffer	C1/Preserved Farmland
	A2_MN09	Inadequate Buffer	Enhance Buffer	C1/Preserved Farmland
	A2_MN10	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_MN11	Rerouted Drainage	Swale Retrofit	C1 waters
	A2_MN12	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_MN13	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_MN14	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_MN15	Rerouted Drainage	Swale Retrofit	C1 waters
	A2_MN16	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_MN17	Rerouted Drainage	Swale Retrofit	C1 waters
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
ASK1	A1_MN01	Inadequate Buffer	Enhance Buffer	C1 waters
	A1_MN02	Unstable Streambank	Stabilize Streambank	See SVAP
	A1_MN03	Low Habitat Quality	Habitat Enhancement	See SVAP
	A1_MN04	Unstable Streambank	Stabilize Streambank	See SVAP
	A1_MN05	Inadequate Buffer	Enhance Buffer	C1 waters

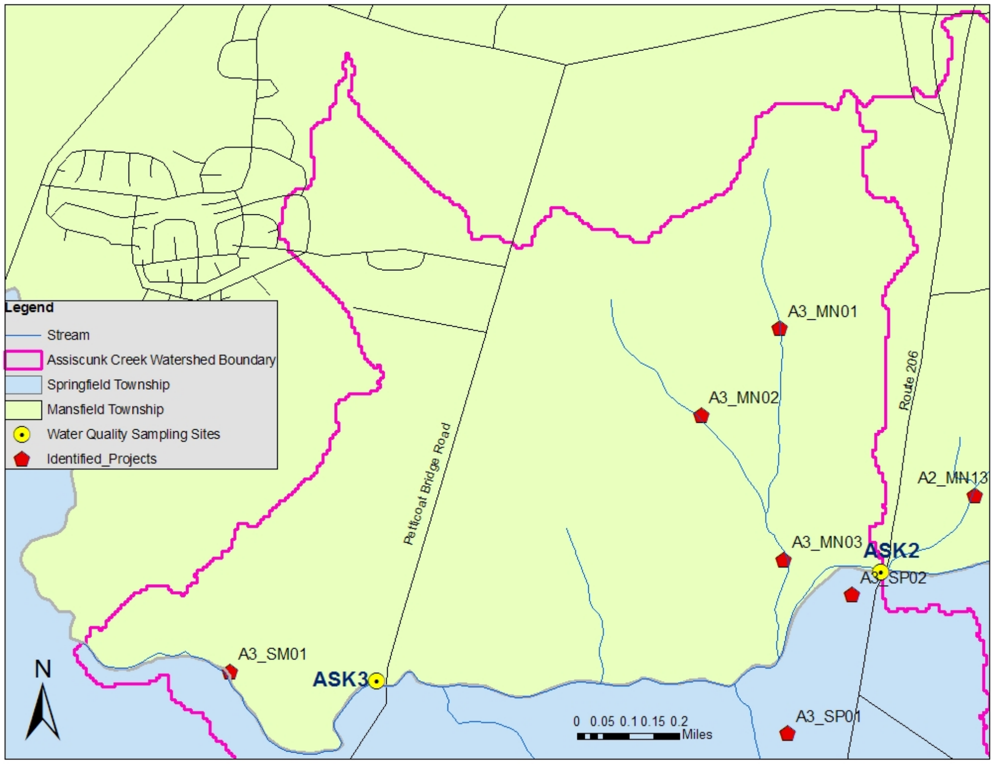

Figure 19: Spatially Located Site Specific Projects for ASK3 in Mansfield

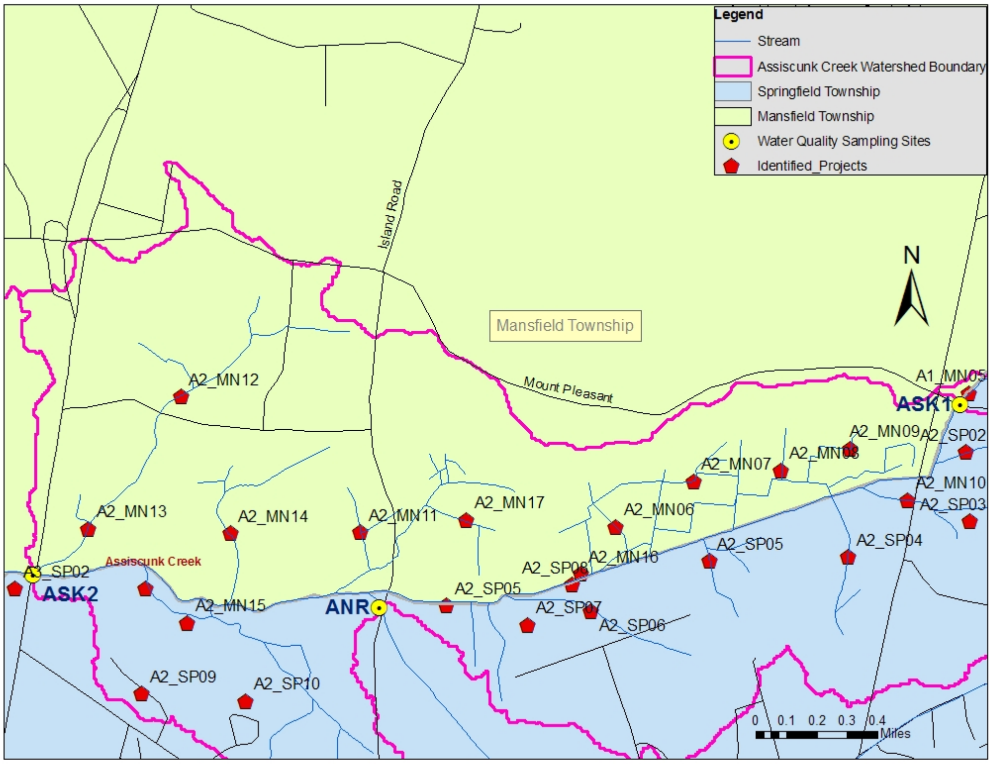

Figure 20: Spatially Located Site Specific Projects for ASK2 in Mansfield

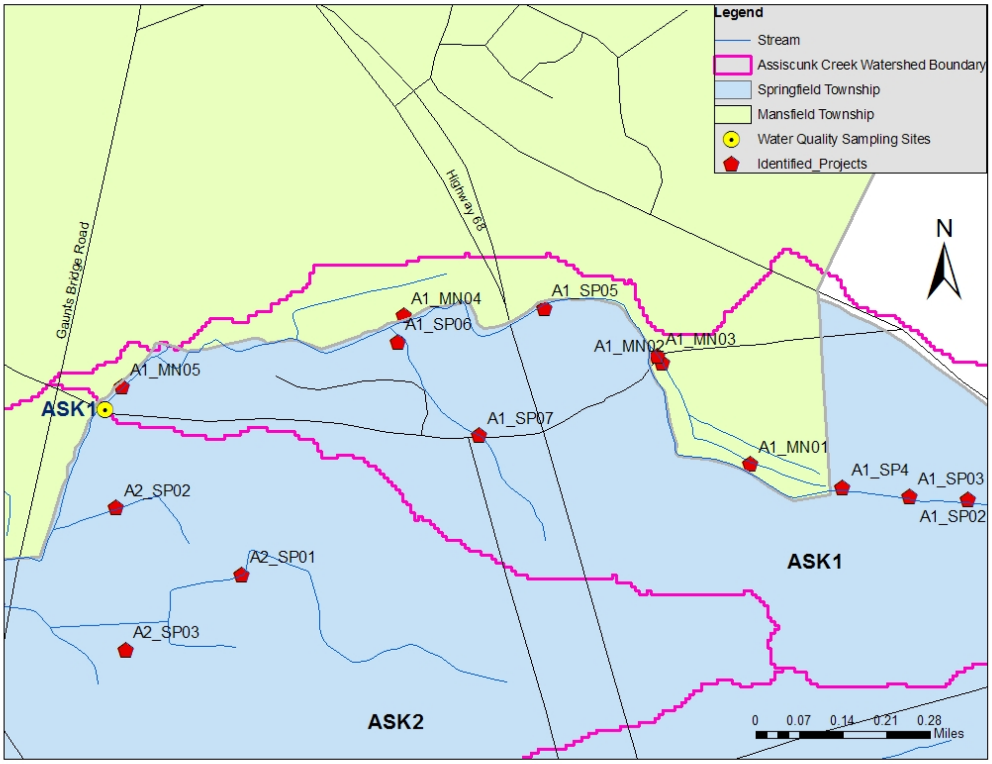

Figure 21: Spatially Located Site Specific Projects for ASK1 in Mansfield

Estimated project costs and loading reductions have been used for the evaluation of different choices. Although costs and loading reduction are critical to consider when allocating scarce resources, often projects are best sited when landowners are cooperative and will benefit from the resultant outcome. (For an example of such a project, refer to Appendix D, Sheet 2 and Appendix E, Riparian Buffer and Filter Strip BMP Information Sheet).

Costs for the conservation buffers have been estimated to range from $300 to $1,850 per acre (NRCS AWEP, 2010). Pollutant loading reductions are based on a 30% removal of nutrients (NJDEP, 2009) from a drainage area of 150 feet of overland flow to the buffer. Estimates for both cost and phosphorus reductions can be found in Table 32. Numerous assumptions were made when compiling these estimates and should be used for general comparisons only.

Table 32: Mansfield Recommended Buffers: Estimated Cost and Phosphorus Removal

Mansfield Subwatershed	Project ID	Estimated Acreage of Buffer	Estimated Total Cost	Estimated P removal (lbs/acre/yr)
ASK3	A3_SM01	0.3	$100-600	3.0
	A3_MN01	4	$1200-7400	2.4
	A3_MN02	2.1	$600-4000	1.2
	A3_MN03	1.4	$400-2600	0.8
ASK2	A2_MN06	0.5	$150-1000	2.8
	A2_MN07	0.4	$100-800	2.1
	A2_MN08	0.3	$100-600	1.4
	A2_MN09	0.4	$120-740	2.1
	A2_MN10	0.6	$200-1000	1.2
	A2_MN11	0.2	$60-400	1.0
	A2_MN12	0.2	$60-400	1.2
	A2_MN13	0.2	$60-400	0.7
	A2_MN14	0.3	$100-600	1.3
	A2_MN15	0.2	$60-400	0.3
	A2_MN16	1	$300-1850	2.1
	A2_MN17	0.2	$60-400	0.9
ASK1	A1_MN01	0.5	$150-1000	0.2
	A1_MN04	0.2	$60-400	0.0
	A1_MN05	0.2	$60-400	0.1

7.5.3 Springfield Township Overview

Springfield Township has a total of 29 square miles within its borders, but only an 11 square mile section along the northern border with Mansfield is part of the Assiscunk Creek Watershed (Figure 22, Table 33).

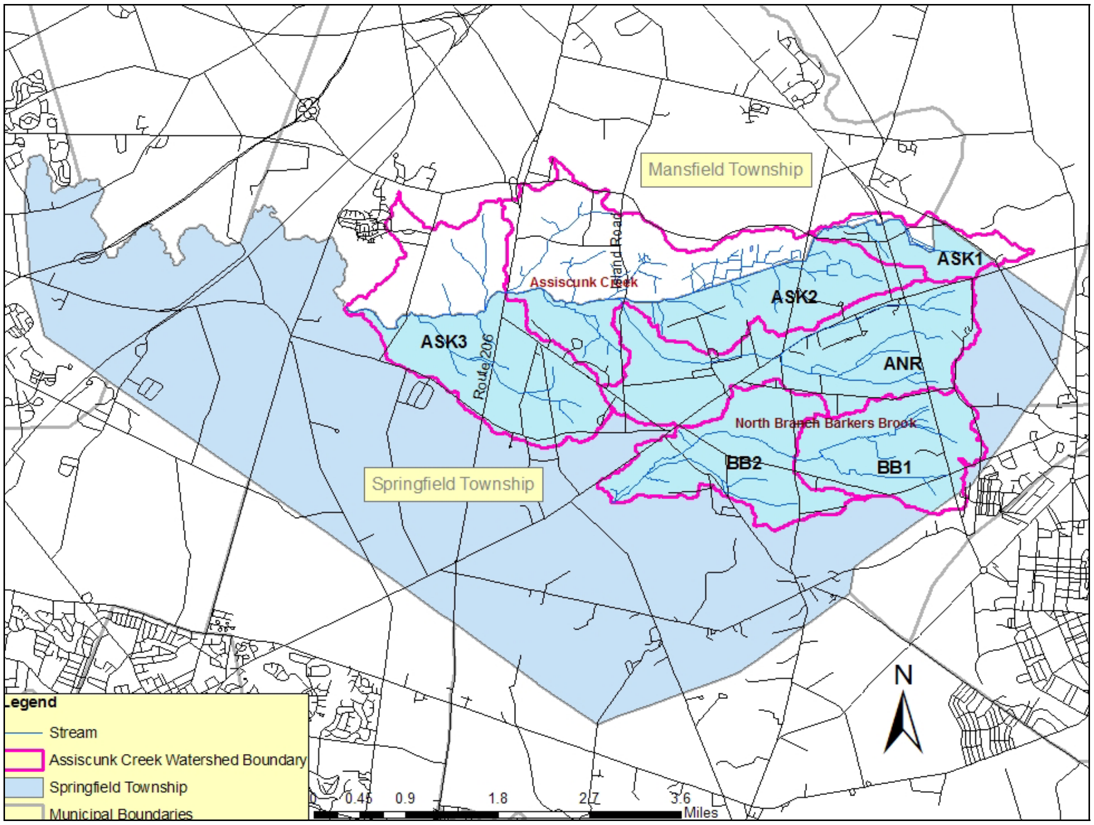

Figure 22: Springfield Township and the Boundary of the Assiscunk Creek Watershed

Springfield contains the entire subwatershed drainage areas of the Annaricken (ANR) and Upper Barkers Brook (BB1 and BB2), which are the drainage areas named in the TMDLs for phosphorus and bacteria. The section of Springfield that contains the subwatershed ASK3 includes some agricultural land, an asphalt plant that backs up to an unaccessible tributary to the main stem Assiscunk and a farmers market and flower farm on Route 206. Long lengths of stream meander through fields with no buffers, and several SVAP evaluations in accessible areas rated the stream quality as poor.

Northeast of Columbus-Jobstown Road, ASK2 contains small areas of medium density residential areas and forested areas where the streams pass. The eastern section of ASK2 contains largely agricultural lands with minimal buffers protecting stream quality. The Annaricken subwatershed (ANR) is primarily agricultural lands with some small areas of forest and residential development. This drainage basin contains animal facilities, some large, and one horse facility that is noted in the bacteria TMDL (AN_SP02). The lack of substantial stream buffer is evident for 1.5 stream miles northwest of Monmouth Road and then upstream for a total of almost 2 stream miles south of Monmouth Road.

In ASK1, the land use is divided into low density residential, agriculture and forested lands. Some sections of the stream remain unbuffered, while other sections have been noted as having poor habitat potential. An online retention basin is evident, and it may be beneficial to provide monitoring of the upstream and discharging water quality to evaluate site specific sink or source characteristics.

The outlet of the Barkers Brook Watershed is located south of Monmouth Road. The upstream segments of BB2 course through agricultural fields with little to no buffers. The subwatershed drainage of BB1 contains a larger percentage of forested lands, including Fort Dix, and also contains a large disturbed section of land that was previously a composting site.

Table 33: Subwatershed Area in Springfield Township

Springfield		Acres	Square MIles
	ASK3	1247.16	1.99
	ASK2	1306.31	2.24
	ANR	1933.22	3.14
	BB2	1139.35	1.81
	BB1	1035.41	1.92
Total			11.1

7.5.4 Springfield Priority Solutions

The runoff from the 11 square miles of land area in Springfield that contributes areal loading of nonpoint source pollutants to the Assiscunk Creek Watershed has easy overland access due to the multiple areas of streams with little or no buffers. Site specific solutions have been identified through field visits, SVAP evaluations and flyover analysis (Table 34) and have been spatially located on a GIS project (Figures 23 through 27) available to stakeholders. The locations of roadside ditches that have been identified as potentially benefitting from a retrofit have been spatially located on a plan sheet that accompanies this report (Appendix D, Sheet 5). A site specific example of all major best management practices recommended by this plan have been provided in accompanying sheets (Appendix D). Each of these site specific recommendations have an associated "BMP Information Document" found in Appendix E. Identified projects should be implemented in accordance with the USDA NRCS Field Operations Technical Guide (USDA, 2004), the New Jersey Best Management Practices Manual (NJDEP, 2009) and Chapter 7 of this plan.

Table 34: Site Specific Projects in Springfield Township

Springfield	Project ID	Issue	Solution	Notes
ASK3	A3_SM01	Inadequate Buffer	Enhance Buffer	C1 waters
	A3_SM02	Inadequate Buffer	Enhance Buffer	C1 waters
	A3_SP01 and Plan Sheet 4 (Appendix D)	Impervious/Inadequate Buffer	Implement BMPs	C1/Farmers Market
	A3_SP02	Debris/Inadequate Buffer	Implement BMPs	C1/Flower Farm
	A3_SP03	Rerouted Drainage	Swale Retrofit	C1 waters
	A3_SP04	Rerouted Drainage	Swale Retrofit	C1 waters
	A3_SP05	Rerouted Drainage	Swale Retrofit	C1 waters
	A3_SP06	Rerouted Drainage	Swale Retrofit	C1 waters
	A3_SP07	Rerouted Drainage	Swale Retrofit	C1 waters
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
ASK2	A2_SP01	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_SP02	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_SP03	Eutrophic Pond	Retrofit outlet	Online
	A2_SP04	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_SP05	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_SP06	Rerouted Drainage	Swale Retrofit	C1 waters
	A2_SP07	Rerouted Drainage	Swale Retrofit	C1 waters
	A2_SP08	Inadequate Buffer	Enhance Buffer	C1 waters
	A2_SP09	Impervious/Inadequate Buffer	Implement BMPs	
	A2_SP10	Impervious/Inadequate Buffer	Implement BMPs	
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
ASK1	A1_SP01	Inadequate Buffer	Enhance Buffer	C1 waters
	A1_SP02	Inadequate Buffer	Enhance Buffer	C1 waters
	A1_SP03	Inadequate Buffer	Enhance Buffer	C1 waters
	A1_SP04	Inadequate Buffer	Enhance Buffer	C1 waters
	A1_SP05	Inadequate Buffer	Enhance Buffer	C1 waters
	A1_SP06	Online Retention	Outlet Retrofit	
	A1_SP07	Low Habitat Quality	Habitat Enhancement	See SVAP

	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
ANR	AN_SP01	Animal access	fencing and buffer	C1 waters
	AN_SP02	Animal facility	Waste management	C1 waters
	AN_SP03	Animal facility	Waster management	C1 and Flood Zone
	AN_SP04	Inadequate Buffer/Debris	Enhance Buffer	C1
	AN_SP05	Rerouted Drainage	Swale Retrofit	C1 waters
	AN_SP06	Eutrophic Pond	Retrofit outlet	C1 and Online
	AN_SP07	Unstable Streambank	Stabilize Streambank	C1/See SVAP
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
BB2	BB2_SP01	Rerouted Drainage	Swale Retrofit	See SVAP/Severe
	BB2_SP02	Inadequate Buffer	Enhance Buffer	
	BB2_SP03	Inadequate Buffer	Enhance Buffer	
	BB2_SP04	Inadequate Buffer	Enhance Buffer	
	BB2_SP05	Inadequate Buffer	Enhance Buffer	
	BB2_SP06	Rerouted Drainage	Swale Retrofit	
	BB2_SP07	Inadequate Buffer	Enhance Buffer	Preserved Farmland
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	
BB1	BB1_SP01	Composting Runoff	Evaluate for BMPs	
	BB1_SP02	Inadequate Buffer	Enhance Buffer	
	BB1_SP03	Inadequate Buffer	Enhance Buffer	
	BB1_SP04	Inadequate Buffer	Enhance Buffer	
	BB1_SP05	Animal Access	Fencing	
	BB1_SP06	Composting Runoff	Evaluate for BMPs	
	BB1_SP07	Rerouted Drainage	Swale Retrofit	
	BB1_SP08	Composting Runoff	Evaluate for BMPs	
	BB1_SP09	Composting Runoff	Evaluate for BMPs	
	Plan Sheet 5	Roadside Drainage Ditch	Enhance pollutant removal and infiltration capacity	

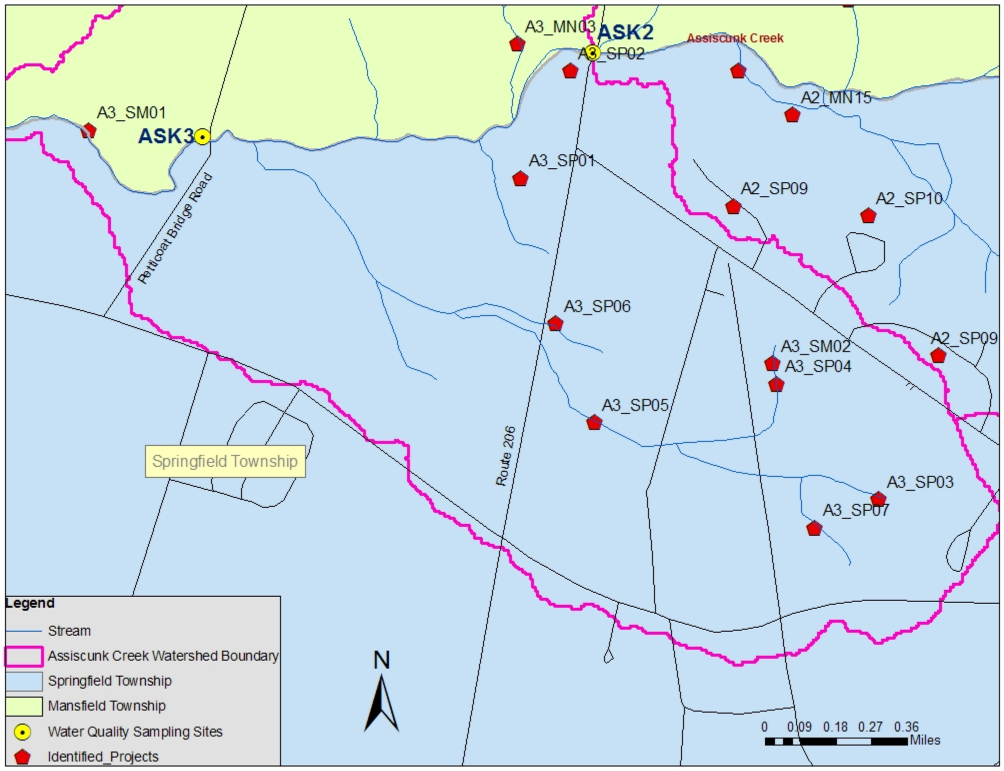

Figure 23: Spatially Located Site Specific Projects for ASK3 in Springfield

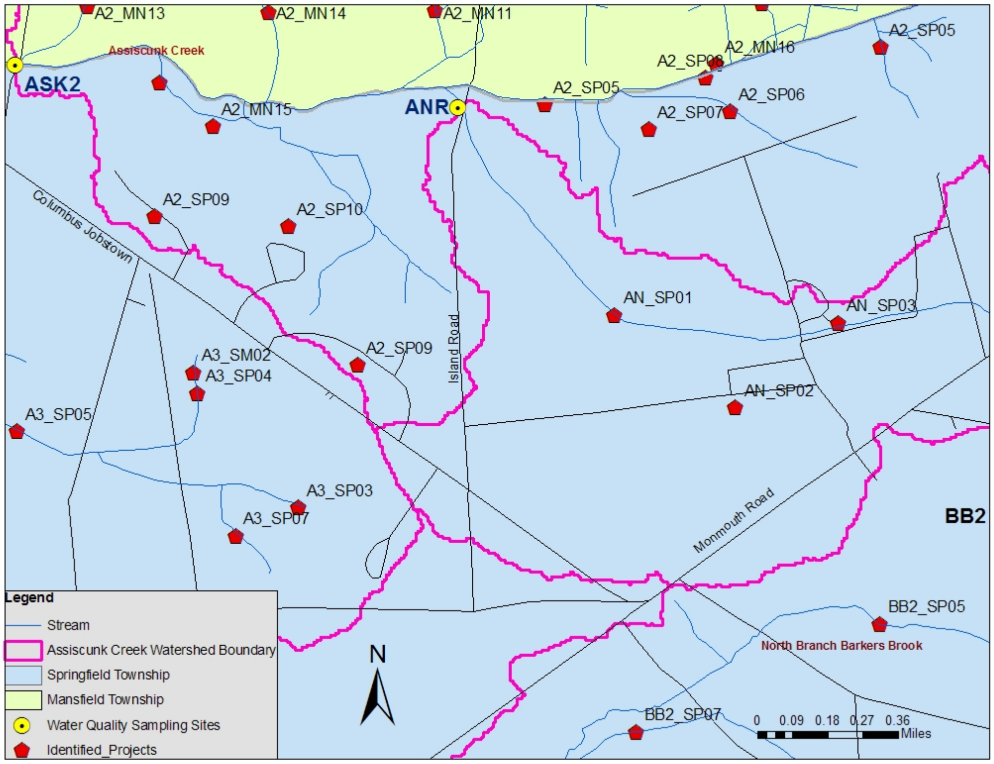

Figure 24: Spatially Located Site Specific Projects for Western ASK2 and ANR in Springfield

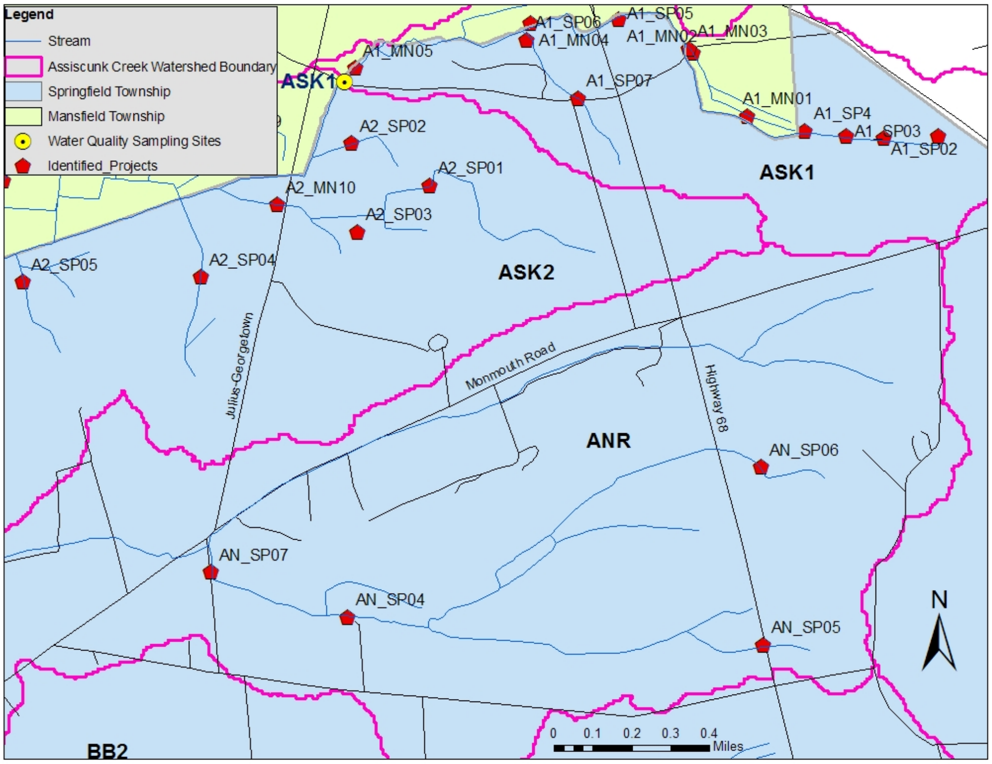

Figure 25: Spatially Located Site Specific Projects for Eastern ASK2, ASK1 and ANR in Springfield

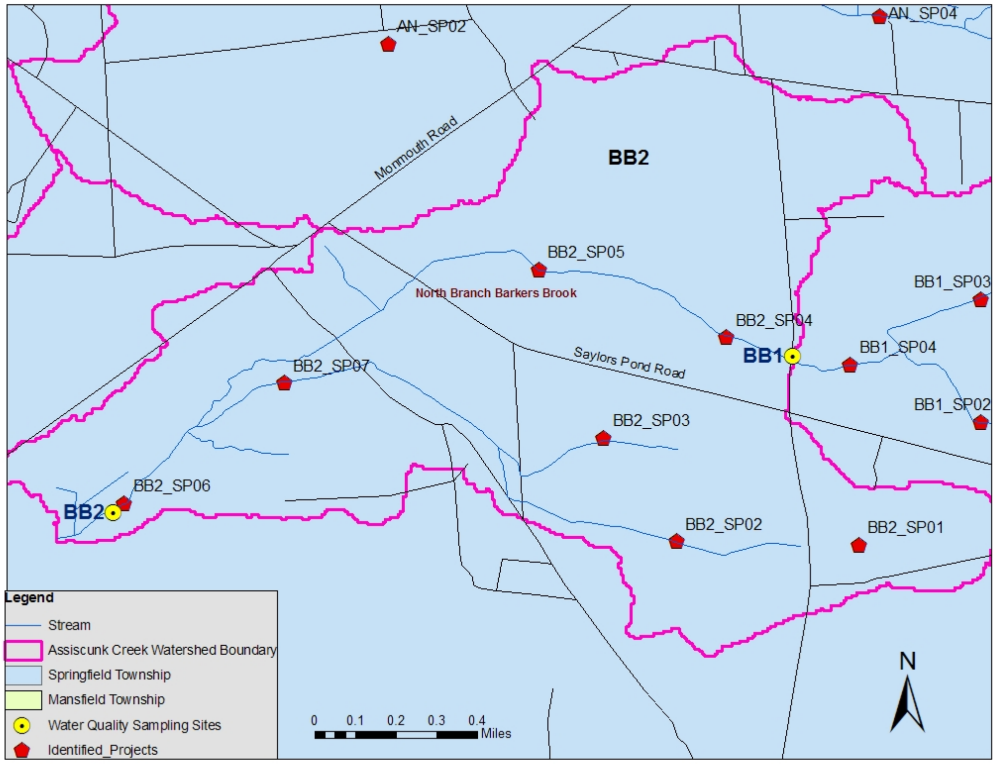

Figure 26: Spatially Located Site Specific Projects for BB2 in Springfield

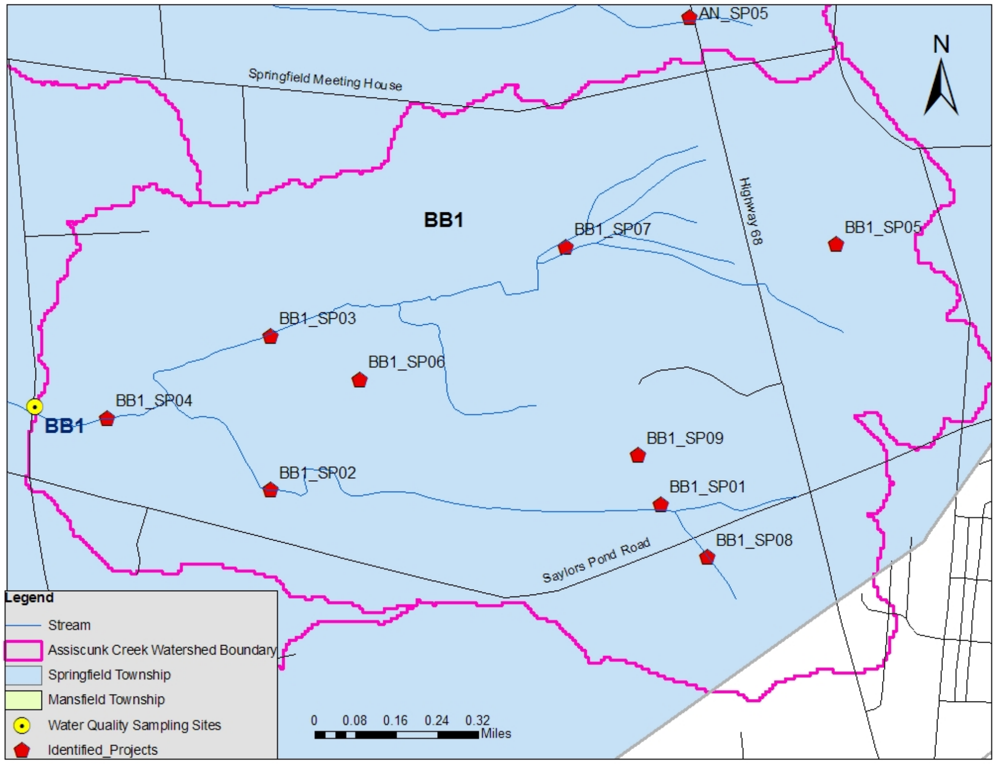

Figure 27: Spatially Located Site Specific Projects for BB1 in Springfield

Costs for the conservation buffers have been estimated to range from $300 to $1,850 per acre (NRCS AWEP, 2010). Pollutant loading reductions are based on a 30% removal of nutrients (Semple, 2004) from a drainage area of 150 feet of overland flow to the buffer. Estimates for both cost and phosphorus reductions for the recommended Springfield projects can be found in Table 35. Numerous assumptions were made when compiling these estimates and should be used for general comparisons only.

Table 35: Springfield Recommended Buffers: Estimated Cost and Phosphorus Removal

Springfield	Estimated Buffer Acreage	Estimated Cost	Estimated Phosphorus Removal (lbs/acre/yr)
A3_SM01	15.2	$4,500-28,000	3.0
A3_SM02	1.0	$300-1,800	0.2
A2_SP01	0.55	$160-1000	1.1
A2_SP02	0.29	$90-500	0.6
A2_SP04	0.86	$250-1,600	1.7
A2_SP05	0.31	$90-600	1.2
A2_SP08	1.03	$300-2,000	0.6
A1_SP01	0.43	$125-800	0.2
A1_SP02	1.03	$300-2,000	0.2
A1_SP03	0.2	$60-400	0.1
A1_SP04	0.86	$250-1,600	0.2
A1_SP05	0.31	$90-600	0.3
AN_SP04	1.38	$400-2,500	0.8
BB2_SP02	4.36	$1,300-8,000	2.6
BB2_SP03	0.46	$135-900	0.3
BB2_SP04	2.3	$700-4,300	1.4
BB2_SP05	3.21	$1,000-6,000	1.9
BB2_SP07	2.3	$700-4,300	1.4
BB1_SP02	1.15	$350-2,200	0.7
BB1_SP03	1.01	$300-6,500	0.6
BB1_SP04	3.44	$1,000-6,5000	1.0

7.6 Project Prioritization

Both the 2003 bacteria TMDL and the 2007 phosphorus TMDL dictate that priority should be given to the Annaricken subwatershed (ANR) and the North Branch Barkers Brook subwatersheds (BB2 and BB1). Given the percent reduction required for the bacteria TMDL is 95% in the Annaricken and 96% in Barkers Brook, the implementation measures taken to address the bacteria issue at that level will also address the phosphorus impairments at the lower percent reduction levels. These three subwatersheds within the Assiscunk Creek Watershed should be given priority for stream buffer implementation projects when land owners are cooperative.

However, the priority ranking analysis conducted as a part of this plan revealed that subwatershed ASK2 was the highest ranked annual load and loading rate for both fecal coliform and *E. coli*, with BB2 being ranked second. ASK3 was ranked as the highest priority for phosphorus, with BB2 being ranked second, again.

Project prioritization should also seek to preserve existing wetlands, as this was found to be a significant factor in attaining water quality status.

8. Information and Education

Although site specific projects will address the physical nature of the nonpoint source entry into the waterway, true source reduction is exceedingly enhanced by watershed wide information and educational programs that will bring about a true change of behavior. These programs can include information on intregrated crop management, no till and residue management and rain garden training for landscape professionals or other recommendations from Section 7.1, 7.2 and 7.3 of this plan. Many of these programs exist through the Burlington County Soil Conservation District, the Burlington County Farm Bureau and the Rutgers Cooperative Extension.

These educational programs addressing the use of the land and how it impacts the waterways can be distributed by the Soil Conservation District, Rutgers Cooperative Extension or many other entities. The focus of many of these programs should be on the management of agricultural lands to ensure that field applications remain on the field and that the soil is conserved for its growing potential. These two goals will protect the waterways and will also conserve scarce resources to benefit the valuable institution of farming present in this watershed.

Due to the extent of small farms within the Assiscunk Creek Watershed, it would be greatly beneficial to establish a watershed-wide outreach and education program that will address multiple agricultural land use practices. This program will be able to address both bacteria and nutrient inputs to the waterways, as well as provide information on economically feasible solutions to manure management and stormwater runoff.

9. Implementation Plan and Milestones

The implementation of the management measures outlined in Section 7 and 8 will result in water quality improvements while minimizing flooding and promoting groundwater recharge. Both modeling and monitoring can be conducted to quantify these improvements. Several models were developed for this plan including a SWAT model of the watershed and an aerial loading model of nonpoint source loads for the watershed. As improvements are made, these models can be used to predict improvements in water quality, flooding, and groundwater recharge.

Five years after the acceptance of the plan, a detailed evaluation should be conducted to quantify the improvements attained in the watershed with respect to water quality. Based upon this evaluation, the priorities in the plan can be modified to further refine the recommendations for management measures, which are needed to ultimately attain the goal of the plan. The project partners should work together to secure funding for this effort.

10. Monitoring and Evaluation

Additionally, monitoring can be conducted to also quantify the improvements to the Assiscunk Creek and its watershed that result from the implementation of the plan. Water quality samples can be collected at intervals throughout the system at the designated subwatershed outlet sampling stations and analyzed for various pollutants that are a concern within the watershed such as nutrients and bacteria. The municipalities, Burlington County, Rutgers University, and other project partners will work together to solicit funding to collect water quality data. These actions should begin within one year of acceptance of this plan by the NJDEP.

One possible approach would be to begin implementing management measures in one or two subwatersheds within the basin. Then monitoring of the water quality within these basins will document improvements that have resulted from the implementation of management measures. It is crucial to show how the implementation of a watershed based plan can result in water quality improvements, not just for the stakeholders in the Assiscunk Creek Watershed, but for all the residents of New Jersey. Only through the proper documentation of results will other stakeholder groups embrace these plans and begin moving forward with their development and ultimately their implementation.

11. Estimated Budget, Source of Funding and Technical Assistance

The implementation of the conservation buffers can be funded through various federal, state and local programs that provide cost-share for implementation. In New Jersey, the New Jersey Conservation Reserve Enhancement Program (NJCREP) has been the primary funding mechanism for installing conservation buffers on agricultural lands. The $100 million NJCREP offers a one-time sign-up incentive and covers 100 percent of the implementation costs of installing buffers and offers land rental payments up to 15 years. NJCREP supports four types of buffer practices in agricultural lands: grass waterways, contour grass strips, filter strips, and riparian buffers. The land rental payments offset the opportunity cost of the land being taken out of agricultural production and are determined by soil types and the annual soil rental rate set by the USDA Farm Service Agency. Some other governmental agencies and non-profit conservation groups are often interested in implementing conservation buffers and can also become involved in offering mini grants and assisting in the implementation and maintenance of conservation buffers. The Conservation Innnovation Grant program with the NRCS is also a funding option for no-till and cover crop projects. The NJDEP 319(h) program may also be a source of funding these efforts.

12. Summary and Conclusions

The Assiscunk Creek Watershed is a valuable resource for New Jersey, having rich farmlands and floodplains and only light development. The land use in the watershed has not undergone the rapid changes in development that other areas of New Jersey have experienced, and efforts of local stakeholders are working towards preserving this. However, the water resources within this watershed have been used in an unsustainable manner, receiving direct drainage from lands, including stormwater and irrigation runoff. Methods to reduce the impact of this type of water use have not been used, and therefore many pollutants found on the land have contaminated the waterway and served to impair other water uses, such as recreational uses and macroinvertebrate habitat.

This plan provides cost effective solutions to improve water quality while maintaining the character of the watershed. It is in the best interest of future generations to create a system of sustainable water resources that will provide for all the needs of the watershed.

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