7. Restoration Strategies and Best Management Practices

7.1. Watershed Restoration Strategies

7.1.1. Strategies for Controlling Pathogenic Contamination

Pathogenic contamination is the most significant water quality issue in the Neshanic River Watershed. Pathogens of concern include, among others, fecal coliform and *E. coli* from human and animal wastes. Pathogenic loading in the planning area was assessed using the SWAT watershed model. Based on the SWAT modeling results, the largest source of pathogens in the watershed is failing OSDSs. They contribute 46 percent of the pathogen load in the Neshanic River Watershed. The second largest source of pathogenic contamination is manure application to row crops, which contributes 31 percent of the annual pathogenic load to the Neshanic streams. Livestock in streams contributes 19 percent of the annual pathogenic load in the watershed. Livestock grazing on pasture contributes 2 percent of the pathogenic loads. Wildlife, including geese and deer, is a minor contributor to pathogenic loads. The TMDL for fecal coliform adopted for the Neshanic River in 2003 requires 87 percent reductions in fecal coliform in the upper part of the Neshanic River Watershed (NJDEP, 2003). As discussed in Chapter 6, this project updated the pathogenic reduction goals that satisfy the required water quality standards by incorporating additional water quality monitoring data and using SWAT modeling results. The updated assessment calls for 90 percent reduction of fecal coliform load and 91 percent reduction of *E. coli* load for the same upper portion of the Neshanic River Watershed. In terms of the whole study area, the load reduction required to meet the TMDL requirements is 89 percent for both fecal coliform and *E. coli*. The following strategies are recommended to control pathogenic contamination in the watershed.

7.1.1.1. OSDS Education and Management

Many residential homes and businesses in the Neshanic River Watershed rely on OSDSs for wastewater treatment. OSDSs require regular inspections and maintenance to function properly. Failing OSDSs are often very expensive to repair and may need to be rebuilt or replaced. Hunterdon County currently requires the inspection of an OSDS before a certificate of occupancy will be issued for new construction and prior to the sale or lease of an existing residence. Although such regulation helps reduce the number of failing OSDSs in the watershed, it affects only a very small portion of the OSDSs in the watershed. A comprehensive watershed-wide OSDS education and management program is needed to control pathogenic contamination and to improve water quality in the Neshanic River Watershed. The comprehensive education and management program should include the following elements:

- An education campaign (including regional educational workshops, flyers, newspaper articles and outreach at events like the Hunterdon County 4-H Fair) to make residents and businesses aware of their OSDSs and how to care for them;
- A regular (three-year) inspection and certification program;
- A technical assistance program on OSDS inspection, operation and maintenance; and
- A financial incentive program to motivate residents and businesses to properly maintain and care for their OSDSs. The program could include subsidies to install OSDSs that comply with current state and local regulations, replace or repair failing

systems, and inspect and maintain existing systems. These subsidies could be combined with fines for failing to maintain properly functioning OSDSs.

7.1.1.2. Animal Manure Management

Animal manure is both a health hazard and an environmental hazard. Proper management of animal manure in the Neshanic River Watershed is essential to control pathogenic contamination. The NJDA has developed and adopted the Criteria and Standards for Animal Waste Management (N.J.A.C. 2:91) to proactively address NPS that may originate from livestock operations in New Jersey. All farms with livestock must follow the general requirements of N.J.A.C. 2:91. Requirements for agricultural animal operations do not allow animals in confined areas to have uncontrolled access to waters. Manure storage areas must be located at least 100 linear feet from waters. Land application of animal waste must be performed in accordance with the principles of the NJDA BMPs Manual (NJACD, 2009). Farms with more than eight but less than 300 Animal Units (AU) [1 AU= 1,000 pounds of live animal weight] or those receiving or applying 142 tons or more of animal manure per year are required to develop and implement a self-certified Animal Waste Management Plan. Farms with 300 or more AU must adopt a comprehensive nutrient management plan certified by NJDA.

The NJDA Animal Waste Management Rules must be enforced in the Neshanic River Watershed. The NRCS has cost-share programs to help farms with livestock improve their manure management practices. A technical assistance program should be developed to assist farmers in designing and implementing manure management plans. Those programs should be expanded and implemented in the watershed to improve water quality. A comprehensive livestock manure management program that implements the NJDA Animal Waste Management Rules and NRCS cost-share programs should include the following elements:

- Each farm with livestock should develop an on-site manure management plan directing how manure will be collected, stored and dispersed.
- Regional manure composting facilities should be established that compost manure generated on farms for fertilizer to be used in home gardens and crop fields. Composting preserves the nutrient components of the manure, but significantly reduces the pathogenic components.
- Implement proper management on manure application in row crop, hay and pasture lands. Manure application timing, amounts and methods in agricultural fields are critical to improving downstream water quality. Extensive manure application in the beginning of the growing season (April) should be strongly discouraged. The amount of manure applied should be reduced to minimize negative water quality impacts. Better integration of manure with soil and use of appropriate cover crops should help to improve water quality.

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7.1.1.3. Livestock Access Control

Livestock with direct access to streams and their riparian areas not only damage streambank and cause soil erosion, but also deposit manure directly into streams and cause pathogenic contamination. One way to prevent such damages is to install exclusion fencing along streams that cross pasture. Such fencing prevents livestock from directly accessing the streams and their riparian areas and therefore helps improve water quality. The NRCS recommends that fencing be installed at least 35 feet from the streams to protect both streams and their riparian areas. The NRCS has been implementing exclusion fencing education, outreach and implementation projects in the watershed. Such programs should be expanded to completely eliminate livestock on pasture from having direct access to streams.

7.1.1.4. Sewer Infrastructure Maintenance in SSAs

The Raritan Township Municipal Utilities Authority (RTMUA) operates and maintains a 3.8 MGD conventional activated sludge wastewater treatment plant that treats wastewater discharges from sewered areas of Raritan Township, including a major portion of SSAs in Neshanic River Watershed. Maintaining the functional sewer system and preventing potential sewer leaking are critical to achieving the pathogenic reduction goals in the Neshanic River Watershed. As a part of its preventative maintenance program, RTMUA maintains internal cleaning and inspection equipment used to perform routine inspections of its collection system. The plant is staffed 24 hours a day. Plant staff performs daily inspections of its pump stations. The pump stations in this area include Hunterdon Estates, Walnut Brook, Flemington Fields, Pump Station No. 1, Pump Station No. 2 and Sun Ridge Station 2. These stations, collection system and developments were constructed in 2001-2003 with few exceptions. Pump Station No. 1 was rehabilitated in 1999 and 2000, and Sun Ridge Station 2 in 2010. Pump Station 2 is scheduled for rehabilitation in 2015. These collection systems (pipes and manholes) were low pressure air-tested prior to being placed in service to ensure watertight construction.

The RTMUA conducted sewer and manhole repair projects in Flemington South in 2006. The RTMUA has no history of sewer overflows. The RTMUA experiences an increase in sewage flow to its treatment plant in wet weather primarily due to connection of residential sump pumps and roof leaders to the collection system. In 2007, the RTMUA worked with Raritan Township to pass an ordinance banning illicit connections to the RTMUA sewer system. In addition, during periods of elevated groundwater levels, RTMUA can experience some infiltration of groundwater into its collection system. There is no evidence that sewage exfiltrates out of the sewers.

There are still homes and businesses in SSAs that depend on OSDSs for wastewater treatment. The previously mentioned comprehensive OSDS education and management program in Section 7.1.1.1 should also be applied to these OSDSs to ensure their properly functioning. A plan should also made to connect some homes and businesses that rely currently on OSDSs to the RTMUA sewer system. It should be noted that the RTMUA currently does not have any sewer capacity that can be allocated for this purpose. Hooking potential failing septics to the RTMUA is not an option unless the plant were expanded, and there are no plans for expansion. The RTMUA should periodically assess the conditions and capacity of all sewer infrastructures in its service area and make planned updates and/or improvements in the sewer infrastructure. Such updates and improvements should help reduce pathogenic loads to Neshanic streams and therefore improve water quality.

7.1.1.5. Wildlife Management

Like many other suburban watersheds in New Jersey, the Neshanic River Watershed faces wildlife overpopulation problems, particularly for deer and geese. Wildlife waste is a source of pathogenic contamination in the watershed. Wildlife waste dropped in and along streams could generally have much greater impacts on water quality than in areas away from the streams. Although the SWAT modeling results indicate that the contribution of wildlife to pathogenic contamination in the watershed is generally minor compared to other sources, active wildlife management measures should be taken to reduce wildlife impacts on water quality for several reasons. First, wildlife's pathogenic contribution to water contamination is usually heavier during the winter season, due to low vegetative cover, than in other seasons. Second, as management measures are gradually implemented to control other sources of pathogenic contamination as discussed above, the wildlife contribution to the pathogenic contamination becomes much more significant. Third, reduction of pathogens from any source would help to achieve the required 89 percent reduction in pathogenic load in the watershed.

The state and county have been implementing various programs to control wildlife populations. The NJDEP Division of Fish and Wildlife published the Community Based Deer Management Manual for Municipalities (http://www.nj.gov/dep/fgw/cbdmp.htm) to guide the communities' effort to control deer population. The recommended measures to control deer population include controlled hunting, trap and euthanize, and chemical fertility control. The NJDEP Division of Watershed Management (2001) published a guide regarding the management of Canadian geese in suburban areas. The guide recommended the following measures to reduce the geese population and its negative impacts on streams and water quality: indirect measures such as stopping all feeding, hazing, altering habitat, and direct measures such as geese removal and harvest. The most practical measures the municipalities in the watershed can take are to alter the geese habitat. The habitat most desirable to geese is a large, flat to gently rolling managed turf area close to a lake, pond, or slow moving watercourse. Habitat alteration consists of eliminating, modifying, or reducing access to areas that provide attractive spots for geese. Such measures include reducing turf adjacent to streams, building barrier fence and rock barriers, establishing vegetative buffers along the streams and placing overhead lines on the waterbodies. The simplest one among habitat alteration measures is to maintain non-mowed areas along the streams. The vegetation in those undisturbed areas will naturally grow into vegetative buffers in a couple of years.

7.1.1.6. Detention Basin Retrofitting

There are 153 mapped detention basins in the study area of which one-third have outlet structures with a three-inch water quality orifice. A three-inch orifice outlet structure extends the water detention time in the basin, allowing TSS and attached nutrients to settle out, and thereby improving water quality. The remaining two-thirds of detention basins in the watershed were not constructed to achieve water quality benefits through extended water detention.

Virtually all detention basins in the watershed present an opportunity for upgrading or retrofitting to reduce pathogenic loads and improve water quality in the watershed. There is no existing empirical study indicating how much retrofitting detention basins would reduce pathogenic loads. Depending on the final design of the detention basin, a retrofitted detention basin can function like a bio-retention basin or a constructed wetland. Removal rates of bioretention basins and wetlands are 90 percent or greater for fecal coliform (Rusciano and Obropta, 2007; Karathanasis et al., 2003). Since the drainage areas for each basin were not readily available, it was difficult to estimate the reductions in total pathogenic loads from retrofitting detention basins in the watershed.

7.1.2. Strategies for Controlling Nutrient Contamination

Nutrients refer to TN and TP in streamflow. Multiple water quality monitoring efforts by USGS, NJDEP and the project team indicate that TP is and TN is not a serious water quality issue in the watershed. The attainment of the water quality standard for the FW2- NT streams requires a 49 percent reduction in the concentration of TP in the Neshanic River Watershed. Watershed assessment using the SWAT model indicates that the primary source of nutrients in the watershed is agriculture, including row crop and other agriculture. Row crops, such as corn, soybeans, and wheat and rye account for 67 percent of the TN load and 47 percent of the TP load. Other types of agricultural production, including hay and pasture, account for 12 percent of the TN load and 17 percent of the TP load. Lawn care fertilizers applied to urban lands contribute 11 percent of the TN load and 29 percent of the TP load; they are the second largest source of TN and TP loads in the watershed. Other minor land-based sources include forests and wetlands, where wildlife and natural processes contribute nitrogen and phosphorus into the environment. Since TP is the primary nutrient contaminant in the watershed, strategies were developed to reduce TP as discussed in the remainder of section 7.1.2. All of these strategies should also reduce TN loads since TN and TP are closely related.

7.1.2.1. Integrated Crop Nutrient Management (ICM)

Fertilizer application to crops and plants is essential because it achieves economic yields and acceptable levels of profit. However, excess fertilizer use, poor application methods and the timing of application can cause fertilizer to move into and contaminate ground and surface waters. One way to eliminate the negative impacts of agricultural fertilizer application is to implement an ICM program for fertilizer application that optimizes fertilizer application rates, timing and methods and maximizes profit subject to minimizing adverse effects on water quality.

The SWAT model was used to evaluate the water quality impacts of three nutrient management scenarios for both agricultural lands and urban lawns. The first scenario is to reduce N commercial fertilizer application rates on all agricultural lands and urban lawns by 25 percent (N Reduction). The second scenario is to reduce P commercial fertilizer application rates on all agricultural lands and residential lawns by 25 percent (P Reduction I). The third scenario is to reduce P commercial fertilizer application rates on all agricultural lands rates by 25 percent and eliminate application of P commercial fertilizer on urban lawns (P Reduction II). These nutrient management scenarios have little effect on TSS, fecal coliform and *E. coli* loads in the watershed. As expected, the N Reduction scenario reduces TN load by 11 percent, but increases TP load by 4 percent. The scenario P Reduction I reduces TP load by 15 percent and has limited impacts on TN loads. The scenario P Reduction II reduces TP load by 26 percent, but increases TN load by almost 45 percent. The SWAT analysis indicates that nutrient management for both crops and lawns is a complicated balancing act. Simply limiting one nutrient or another will affect plant growth and result in additional water quality problems. Crop nutrient management should be plant specific and site specific. Fertilizer application rates should be based on reasonable crop yield goals and available nutrients in soils as determined by soil testing. The soil test-based ICM can be offered as part of a technical assistance program for farmers in the watershed designed to improve water quality. A similar program is currently under way in the Mulhockaway Creek watershed in the Raritan River Basin (NJWSA, 2007).

7.1.2.2. Conservation Buffers

Conservation buffers are structuralized vegetative mixtures of trees, shrubs and grasses placed in the 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). In this project, the term conservation buffer is used to refer to all types of buffer practices being used in the watershed. Different conservation buffer practices can be applied in different settings in the watershed to improve water quality, control soil erosion and enhance wildlife habitat. Water quality benefits of conservation buffers are well documented. As runoff flows through conservation buffers, the buffers filter out sediments and pollutants attached to sediments. Buffers also dissolve some pollutants through chemical and biological processes, promote ground water recharge and evapotranspiration and reduce runoff. Well designed and positioned conservation buffers can achieve at least 50 percent reduction of N, P, and sediment loads (Lowrance et al., 1986). In New Jersey, vegetative buffers are expected to reduce TSS by 80 percent and N and P by 30 percent in stormwater runoff (Semple et al., 2004). Research is more limited on the effectiveness of buffers in reducing pathogenic loads than in reducing TSS, TN, TP and pesticides. Some research suggests that conservation buffers can remove up to 60 percent of pathogens in runoff (SWCS, 2001). A suit of conservation buffer practices should be applied in critical source areas to maximize the effectiveness of conservation buffers in reducing nutrient loads and improving water quality (Qiu, 2009).

7.1.2.3. Cover Crop

Cover crops are grasses, legumes, forbs or other herbaceous plants established for seasonal cover and other conservation purposes. Cover crops reduce soil erosion, help maintain soil moisture and improve soil nutrients and organic content. Proper use of cover crops has other benefits, including reducing farm operational costs, less herbicide use and better overall soil health. Technical assistance and financial incentives should be provided to incorporate cover crops into cropping system for fields that are not in use for all or part of a year.

The SWAT model was used to evaluate the impacts of planting winter rye as a cover crop after harvesting corn or soybeans in continuously operated row crop fields in the watershed. A well implemented cover crop program can potentially achieve a 15 percent reduction in TSS, a 23 percent reduction in TN and a 16 percent reduction in TP loads to Neshanic streams. Cover crops have limited capacity to reduce pathogenic loads. The expected reduction in pathogenic loads to Neshanic streams is only about 1 percent. Besides the measured water quality benefits, cover crops have soil health benefits including breaking up fragipan or manmade compaction, improving nutrient cycling and increasing corn and soybean yields.

The NRCS provides cost share to farmers who establish cover crop in their fields. An education and assistance program should be implemented to help farmers implement cover crops in their fields to achieve the water quality and other environmental benefits.

7.1.2.4. Manure management

The animal manure management program for pathogenic load reduction as discussed in Section 7.1.1.2 should also reduce TP and TN loads to the streams in the watershed. While nitrogen in field-applied manure is easily dissolved, phosphorus in field-applied manure usually builds up in soils. Phosphorus that accumulates in soil can be transported to streams via runoff. Cropland should not be simply used as a dumping ground for animal manure. Rotating manure application among different fields can reduce manure concentration in a limited area. Manure should not be applied to HSAs in the watershed where soils can be easily saturated. Just like any other nutrients, manure should be applied based on an ICM or nutrient management plan. Manure should be tested for nutrient content and then applied according to crop needs to protect water resources and promote crop growth and soil health.

7.1.2.5. Prescribed Grazing

Prescribed grazing is a system that helps agricultural producers to manage grazing and browsing of animals to ensure there is always adequate ground cover and proper nutrition for livestock. A prescribed grazing plan may include reducing the number of livestock grazing an area and rotating livestock among paddocks more frequently. The latter requires using temporary fencing to exclude livestock from pasture recovering from grazing pressure. Prescribed grazing helps maintain healthy and productive pastures by reducing soil erosion and the resulting transport of phosphorus and pathogens in runoff. In addition, an actively growing pasture takes up nutrients and improves water infiltration.

7.1.2.6. Nutrient Management for Lawn Care

As urban development continues in the watershed, fertilizer use in lawns, and its contribution to water contamination, will increase. Nutrient management for lawns is essential to achieve the nutrient reduction goals in the Neshanic River Watershed. The newly-enacted New Jersey Fertilizer Control Law establishes standards for certain fertilizer applications, requires certification of professional fertilizer applicators and regulates labeling and sale of certain fertilizers. Key provisions of the law are:

- Eliminate phosphorus in lawn fertilizer used and sold in New Jersey, helping to curb excess phosphorus from running off soils already laden with the nutrient. Require at least 20 percent slow release nitrogen in all lawn fertilizers to help keep nitrogen out of waterways.
- Require lawn care professionals to attend training about appropriate fertilizer application and content.
- Prohibit application of lawn fertilizer when it is raining or when rain is predicted, between November 15 and March 15 for individuals caring for their own laws and

December 1 and March 15 for professional lawn care providers when the ground is typically frozen and lawns cannot absorb nutrients.
- Prohibit licensed professionals from applying fertilizers within 10 feet and homeowners within 25 feet of a waterway.

Nutrient management for lawns should be implemented by strictly carrying out the new Fertilizer Control Law in the watershed. Since phosphorus contamination is a common water quality issue in New Jersey, the NJDEP encourages municipalities to adopt non-phosphorus fertilizer ordinances to minimize the water quality impacts of fertilizer applications in residential and commercial lawns. Some municipalities, such as Jefferson and Morris Townships, have adopted such ordinances. Although the implementation of the new Fertilizer Control Act and the establishment and enforcement of the municipal phosphorus ordinance help reduce nutrient loads to streams in the watershed, attention should be paid to the long-term effects of non-phosphorus fertilizer application. Long-term application of non-phosphorus fertilizer could potentially result in a phosphorus deficiency, which could limit lawn growth and reduce the intake of nitrogen. If the same amount of nitrogen is still being applied, the extra nitrogen could end up in streams, which can result in nitrogen pollution of water. As with agricultural fertilizer application, lawn fertilizer application rates should based on soil tests in order to promote healthy lawns and reduce nutrient loads to streams.

7.1.3. Strategies for Controlling Sediment Contamination

The SWAT modeling results indicate that the Neshanic River Watershed carries 1,823 tons of sediment away from the watershed each year and that streams are the primary sediment source and contribute 1,094 tons of sediment each year, which is equivalent to 60 percent of the total annual sediment load. The remaining 40 percent of sediments, roughly 729 tons, comes from land. Among the various land uses, row-crop agriculture, such as corn, soybean, wheat and rye, is the largest land contributor of sediment. Row-crop agriculture accounts for about 60 percent of land contribution of sediment, followed by urban land (16 percent) and other agricultural lands, such as pasture and hay (14 percent). A 9 percent reduction in the TSS concentration is required to achieve the designated water quality standard for the Neshanic River Watershed. The following strategies are proposed to control sediment. It should be noted many strategies for reducing nutrient loads also reduce sediment.

7.1.3.1. Contour Farming

Contour farming uses ridges and furrows formed by tillage, planting and other farming operations to change the direction of runoff from directly downslope to around the hill slope. Contour farming reduces sediment from gully erosion and slows down surface water runoff, which reduces the transport of sediment, phosphorus and other contaminants to surface waters.

7.1.3.2. Conservation Buffers

As discussed previously, conservation buffers have multiple water quality benefits. The best documented water quality benefit is to reduce sediment loads to streams. As runoff flows through a conservation buffer, dense vegetation in the buffer acts as a filter, preventing sediments and sediment-absorbed nutrients, pesticides and pathogens from entering streams. Conservation buffers should be installed in proper locations to achieve their optimal effectiveness in improving water quality.

7.1.3.3. Livestock Exclusion Fence

As discussed previously, livestock exclusion fencing should be installed in pasture areas located along streams to eliminate livestock's direct access to streams and thereby reduce the pathogenic loads into the streams in the watershed. The same exclusion fencing also eliminates livestock disturbances to streambanks and maintains streambank stability. A stable streambank generates less soil erosion, which reduces TSS loads to streams in the watershed.

7.1.3.4. Cover Crops

As discussed previously, cover crops have multiple environmental benefits. Cover crops can be incorporated into any cropping system that has fields that are not in use for all or part of a year to reduce the exposure of bare soil to wind and rain and therefore reduce soil erosion. The growing vegetation and healthy soil reduce runoff, which brings less sediment to the nearby streams.

7.1.3.5. Prescribed Grazing

Prescribed grazing helps to maintain healthy and productive pastures. Healthy pastures protect soil from erosion, which reduces phosphorus and pathogens in runoff. In addition, an actively growing pasture uptakes nutrients and improves water infiltration.

7.1.3.6. Roadside Ditch Retrofitting

There are 853 mapped roadside swale and ditch segments in the watershed having a total length of 40 miles. Of the mapped segments, 185 (about 9 miles) are actively eroding, thus contributing sediment to stormwater that flows through them that need to be repaired. 515 out of 853 segments (about 26 miles) have exposed earth in at least some portions of the conveyance and need repair. Roadside ditch retrofitting convert ditches into bio-retention systems that are very similar to constructed wetlands to remove sediments and nutrients.

7.1.3.7. 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 problem in the Neshanic River Watershed. The SWAT modeling results indicate that streambank erosion contributes significantly to TSS in streams in the watershed. Streambank stabilization is an important way to reduce streambank erosion, improve water quality and enhance stream ecology. The SVAP assessment and the stormwater infrastructure inventory were used to identify potential sites for streambank stabilization. A wide range of streambank stabilization methods and techniques can be used. The selection of appropriate streambank stabilization methods should be based on the channel evolution stage of the stream, which can be identified using channel evolution models. Although the streambank can be temporarily stabilized through various streambank stabilization measures, permanent stabilization requires controlling the amount and velocity of stormwater runoff in the watershed. In order to stabilize streambanks, any land use activities that disturb the streambank should be prohibited.

7.1.4. Strategies for Restoring Watershed Hydrology and Streamflow

Land use changes and the associated stormwater infrastructure have significantly altered watershed hydrology. Watershed restoration is one way to mitigate the negative impacts of land use changes on watershed hydrology. The following BMPs are proposed to restore watershed hydrology and streamflow in the Neshanic River Watershed. These BMPs also improve water quality.

7.1.4.1. Bio-retention Systems

Traditional stormwater infrastructure is designed to quickly deliver stormwater from sources to streams. Bio-retention systems are BMPs that are designed to retain stormwater and then discharge it to stormwater systems and/or streams if necessary. These systems are designed to treat the retained stormwater to achieve substantial water quality benefits through various biological processes embedded in the system. The stormwater retained in those systems could infiltrate through the soils to recharge groundwater, thus reducing the amount of stormwater entering streams. Bio-retention systems in the watershed should include a series of bio-retention facilities. They include:

- Rain gardens to capture, treat, and infiltrate stormwater at homes;
- Bio-retention facilities at business and corporate campuses; and
- Constructed wetlands along roads.

7.1.4.2. Conservation Buffers

Conservation buffers provide both water quality and quantity benefits. Conservation buffers could achieve runoff reduction through evapotranspiration processes by plants and could promote groundwater recharge through multiple biological and hydrological processes.

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 watershed. In response to those water quality and quantity problems, municipalities in the watershed have developed various conservation plans and ordinances to control land use activities and protect water resources. For example, steep slope ordinances were developed to regulate the intensity of use in areas having steeply sloped terrain in order to limit soil loss, erosion, excessive stormwater runoff and degradation of surface water, and maintain the natural topography and drainage patterns of the land. Stream corridor protection ordinances were enforced to restrict land use activities in riparian areas of streams in order to improve water quality, mitigate the impacts of floods and protect streams and their surrounding ecosystems. As suburban development continues in the watershed, conservation plans and ordinances should be reviewed, developed, implemented and enforced to help prevent harmful land use activities and protect water resources in the watershed.

An ordinance review was conducted for municipalities in the Lockatong and Wickecheoke Creek Watershed Restoration and Protection Plan developed by NJWSA (May 2009) and recommendations were made to improve the conservation planning and ordinances in those communities for water resource protection and water quality improvement (NJWSA, 2009). That review covered Raritan and Delaware townships, portions of which are also located in the Neshanic River Watershed. The NJWSA (2008) concluded that Delaware Township has an excellent Master Plan, Environmental Resource Inventory, Riparian Protection and Well Testing Ordinance; and Raritan Township had the most up-to-date and comprehensive collection of Plans, Policies and Ordinances. As a Stormwater Tier A community, Raritan Township had passed Ordinances on Pet Waste, Litter Control, Improper Disposal of Waste, Wildlife Feeding, Yard Waste Collection, and Illicit Connections. The NJWSA made the following recommendations for Delaware Township:

- Prepare a build-out analysis in conformance with the Water Quality Management Planning Rules at N.J.A.C. 7:15.
- Prepare a Wastewater Management Plan in conformance with the Water Quality Management Planning Rules at N.J.A.C. 7:15.
- Revise the existing Steep Slope Provisions of the Land Use Code in conformance with the Water Quality Management Planning Rules at N.J.A.C. 7:15.
- Prepare a Woodlands Protection Ordinance.
- Prepare a Wellhead Protection Ordinance.
- Prepare a Septic Management Plan and implementing ordinance in conformance with the Water Quality Management Planning Rules at N.J.A.C. 7:15.
- Prepare a Soil Erosion and Sediment Control Ordinance to regulate activities not under the jurisdiction of the County Soil Conservation District.
- Revise the existing Floodplain Provisions of the Land Use Code in conformance with the Water Quality Management Planning Rules at N.J.A.C. 7:15 and Flood Hazard Control Act Rules at N.J.A.C. 7:13.
- Prepare a Wetlands Protection Ordinance.
- Prepare a Nutrient Management Plan and adopt a Fertilizer Management Ordinance.
- Prepare a Pet Waste Ordinance.
- Prepare a Litter Control Ordinance.
- Prepare an Improper Disposal of Waste Ordinance.
- Prepare a Wildlife Feeding Ordinance.
- Prepare a Containerized Yard Waste Ordinance.
- Prepare a Yard Waste Collection Ordinance.
- Prepare and Illicit Connection Ordinance.
- Prepare a Water Conservation Ordinance.
- Reduce permitted impervious surface areas to 5% in areas zoned agricultural, rural or low density residential.

- Conduct on-going Outreach and Education programs through the Environmental Commission to inform local residents of the value of water resource protection. Engage local schools to participate in activities that are protective of water resources.

The following recommendations were made to Raritan Township:

- Prepare a build-out analysis in conformance with the Water Quality Management Planning Rules at N.J.A.C. 7:15.
- Prepare a Nutrient Management Plan and adopt a Fertilizer Management Ordinance.
- Prepare a Containerized Yard Waste Ordinance.
- Prepare a Water Conservation Ordinance.
- Reduce permitted impervious surface areas to 5% in areas zoned agricultural, rural or low density residential.
- Conduct on-going Outreach and Education programs through the Environmental Commission to inform local residents of the value of water resource protection. Engage local schools to participate in activities that are protective of water resources.

Similar reviews should be conducted and recommendations made in other municipalities in the watershed.

7.1.4.4. Farmland and Open Space Preservation

All the municipalities in the Neshanic River 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 and suburban development, retain the amenities of traditional rural communities and improve environmental quality including water quality. Municipal farmland and open space preservation programs in the watershed should be continued and expanded to protect Hydrologically Sensitive Areas (HSAs) from intensive land use disturbances and prevent water resources from being degraded at their sources.

The NJWSA (2002) identified 20 criteria to rank parcels for open space acquisition and easements for water resource protection in the Raritan River Basin. Those criteria are listed in Table 7.1.

Table 7.1: NJWSA open space criteria for acquisition and easements (NJWSA, 2002)

Recharge Areas	Floodplains and Riparian Corridors	Trout Production Streams
Wellhead Protection Areas	Wetlands	Vegetative Cover
Drinking Water Source Areas	Mature Forest	Soil Type
Headwaters	Threatened or Endangered Species	Proximity to Water Body
Water Pollution Hazard Areas	Contamination and Previous Use	Land Use/Land Cover
Areas with Steep Slopes	Size of Parcel	% Impervious Surface
Lakes and Ponds	Length of Stream	

Several project partners, including NJIT, RC&D, and NJWSA, are including new information in the criteria to define the areas for future protection and preservation. The new information is called HSAs and is derived from a modified topographic index that simulates the likelihood that runoff is generated during a storm event. HSAs are the parts of the watershed that are likely to be saturated during a storm event. These areas should be protected from development and disturbance through farmland and open space preservation programs. As discussed in Section 4.2.3, the total area in HSAs is about 2,642 acres (i.e., about 14 percent of the watershed). Figure 4.9 illustrates the location of HSAs that should be prioritized for protection and preservation in the Neshanic River Watershed.

7.2. **Stormwater BMPs and Prioritization**

Two intensive land uses in the Neshanic River Watershed are agriculture and urban with urban consisting of residential, commercial and industrial uses. For urban land uses, four primary stormwater BMPs were recommended to address the sediment, nutrient and pathogen contamination and to restore watershed hydrology in the watershed: building rain gardens, retrofitting detention basins, retrofitting roadside ditches and establishing vegetative buffers.

7.2.1. Rain Gardens

A rain garden is a landscaped, shallow depression designed to capture, treat and infiltrate stormwater at the source before it reaches the 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 rain water from a storm of 1.25 inches from a 1,000 square foot impervious area from an individual lot (i.e., a 25' by 40' roof for a house or a 20' wide by 50' 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. To handle a rain storm of 1.25 inches, the rain garden needs to be 10' by 20' and six inches deep. Since 90 percent of all rainfall events are less than one inch, rain gardens are able to treat and recharge a majority of runoff from these storms. If designed and installed correctly, rain gardens will reduce the pollutant loading from a drainage area by 90 percent. Furthermore, they will reduce stormwater runoff volumes and the flashy hydrology of local streams. The latter will lessen streambank erosion and stream bed scour, thereby reducing TSS and phosphorus loads in the waterway. According to Rusciano and Obropta (2007), rain gardens remove 90 percent of fecal coliform from stormwater runoff.

There are 3,545 low density residential homes in the Neshanic River Watershed that are suitable for rain garden installation. Figure 7.1 shows the potential neighborhoods in the watershed where rain gardens can be installed. Appendix 1 lists the potential numbers of rain gardens in each of those neighborhoods by subwatersheds in the watershed. If each suitable home installs a rain garden to capture, treat and infiltrate runoff from 1,000 square feet of impervious surface, then about 89 million gallons of stormwater runoff would be captured, treated and infiltrated. Assuming aerial loading coefficients of 0.6 pounds per acre per year of TP, 5.0 pounds per acre per year of TN and 100 pounds per acre per year of TSS, the total pollutant loads removed by the 3,545 rain gardens are conservatively estimated to be 44 pounds per year of TP, 366 pounds per year of TN and 7,324 pounds per year of TSS.

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. Reduction in runoff and increase in groundwater recharge from rain gardens would help reduce the stream peak flow and increase the baseflow, thereby improving watershed hydrological conditions. The willingness of home and business owners to adopt rain gardens is essential to their installation. Home and business owners in the identified target neighborhoods who are willing to install and maintain rain gardens on their properties should be encouraged to do so. Education and outreach programs should be conducted and demonstration projects should be initiated to educate the general public and municipal officials about the benefits of installing rain gardens and to train landscape professionals in such installation.

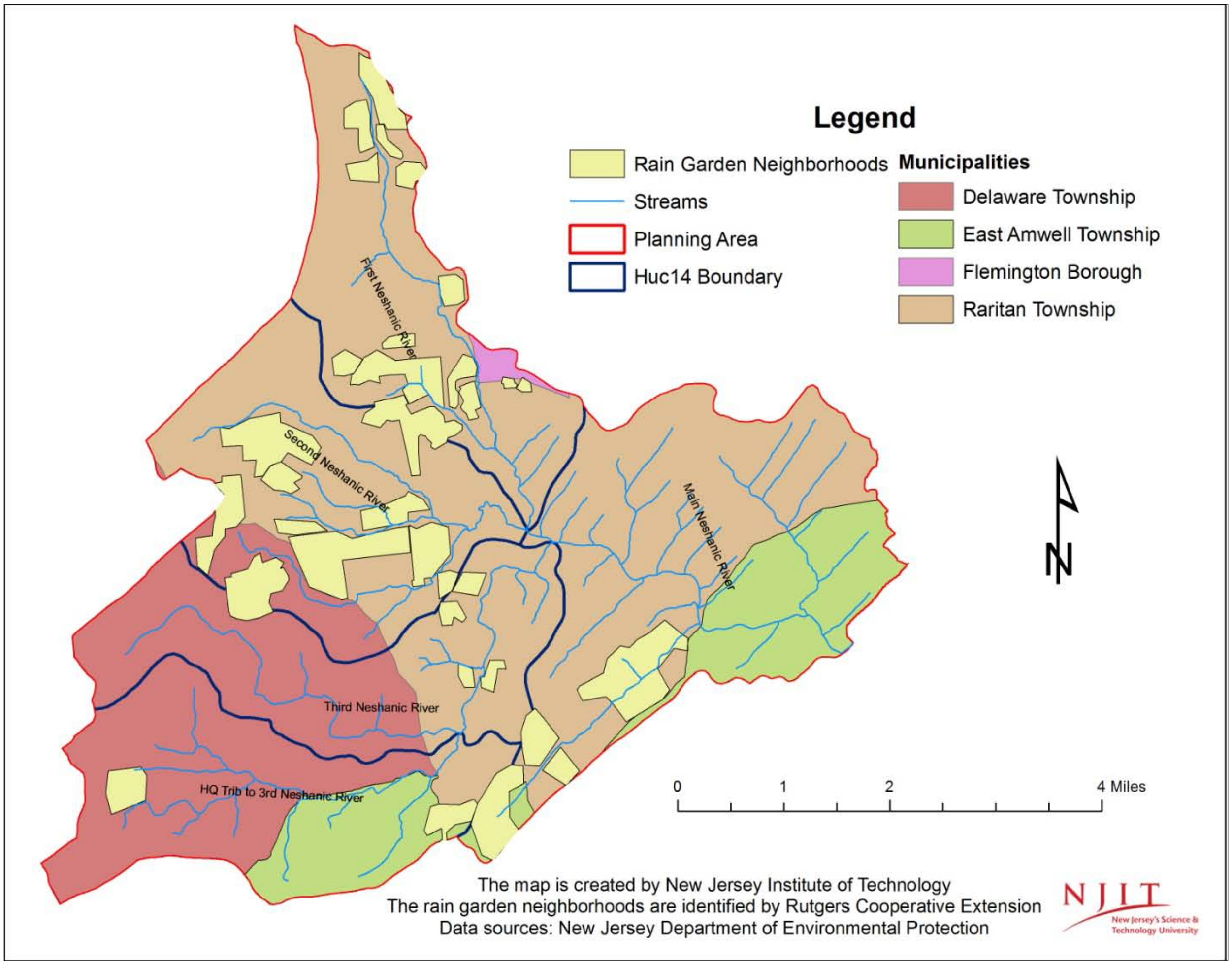


Figure 7.1: Location of potential neighborhoods for rain garden installation in the Neshanic River Watershed

Table 7.2 lists annual pollutant load reduction and volume of water intercepted for different homeowner adoption rates for residential rain gardens in the Neshanic River Watershed. There may be additional locations throughout the watershed where commercial and industrial properties can install rain gardens and achieve similar load reductions.

Table 7.2: Annual pollutant load reduction and volume of water intercepted for different homeowner adoption rates for residential rain gardens in the Neshanic River Watershed

Adoption Rate for Rain Gardens	Pollutants Removed (lbs/yr)			Stormwater Intercepted (million gallons/yr)
	TP	TN	TSS	
25%	11	92	1,831	22
50%	22	183	3,662	44
75%	33	275	5,493	66
100%	44	366	7,324	89

7.2.2. Roadside Ditch Retrofitting

In the rural 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 lack the design standards of conventional stormwater infrastructure systems. Roadside ditches are ad hoc creations and appear to be designed not for stormwater management, but for the convenience of landowners. This approach to ditch design exacerbates water quality problems.

Typically, ditches are not well maintained and consist of bare soil. This project mapped 853 swale and ditch segments (40 miles) in the watershed. Of the mapped segments, 185 (about 9 miles) are actively eroding. These segments contribute sediment to stormwater and are in urgent need of repair. 515 out of 853 segments (about 26 miles) have exposed earth in at least portions of the ditch and need some repair. Only 153 swale and ditch segments (about 6 miles) were found to be in good condition and conform to soil erosion standards for a grassed waterway or rip-rap channel.

The eroded roadside ditches should be retrofitted to protect them from erosion and improve the water quality of runoff traveling through them. To prevent erosion, the New Jersey Department of Transportation Roadway Design Manual requires outlet protection of conduits for runoff velocity generated during the 25-year storm (at a minimum). 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.

Roadside ditch retrofitting should also improve water quality of the runoff entering the ditch. A common method of improving water quality is to reduce the velocity of runoff to allow contaminants to settle out. Designs should work to mimic the flow reductions seen in grassed filter strips for water quality improvement. Reducing velocities also increases infiltration of stormwater by increasing the length of time that runoff is retained in ditches.

The first retrofitting strategy to improve roadside ditches is to widen the ditches and plant them with a diverse mix of native vegetation. Vegetation creates friction, which reduces flow and encourages infiltration. The Neshanic River Watershed, especially Delaware Township where the majority of roadside ditches are located, has a very narrow right of way (ROW) along the side of the road. Ditches should be widened when vegetation is planted to make maintenance of ditches easier and more affordable.

Due to the limiting size of ROWs, there is very little space available for widening ditches in the Neshanic River Watershed. For that reason, use of rip-rap (large stones), stone-filled gabion baskets and weirs is recommended to control the flow in ditches. A gabion basket is a cube made of wire mesh that is filled with large stones. The stones provide structural support and the mesh holds the stones in place. Because gabion baskets are porous, they reduce the velocity of water flow in drainage ditches, which improves water quality. The reduction in flow velocity requires the ditches to have a larger storage capacity. Because there is little room to widen ditches, the need for larger storage capacity can only be achieved by deepening the ditches. The cost of this strategy depends on how many gabion baskets are installed in each ditch. Material and installation cost for the one gabion basket is approximately $200.

A second retrofitting strategy is to use French drains that are exposed to the surface. A French drain is an underground drainage trench or channel filled with stone that creates a path for water to flow. Because the French drain reduces the velocity of the runoff flowing through the drain, the ditch upstream of the drain and the channels of the drain need to have additional storage capacity. In addition, the inlet and outlet of the French drain need to have structural support to prevent stone from being washed out of the drain over time. A gabion basket check dam placed at the front and back of each exposed French drain would provide sufficient storage capacity for the drain. A larger gabion basket should be used where vehicles cross the ditch on a routine basis; farmers often make such crossings. The strategy involves installing gabion baskets as well as laying stone in narrow ditches. Material and installation cost is about $400 per gabion basket and $100 per linear foot of stone in between the two gabion baskets.

A third retrofitting strategy is to install weirs. Gabion baskets provide a basic form of water flow velocity control, but they lack the flexibility of other flow control devices, such as weirs. A weir is simply a small dam with a notch cut out of it. The size and placement of the notch affects water flow past the weir. The flow is controlled by the shape, elevation, location and size of the notch and the height of the water behind the notch. The higher the water behind the weir and the larger the shape and size of the weir, the higher the flow rate. Although weirs are interchangeable with gabion baskets, the former allow greater control over flow and cost more to design and implement than the latter. Installation of a weir with a scour hole in place of a gabion basket costs $400.

Further details regarding how roadside ditches can be retrofitted using the strategies described above are provided by the examples in Section 7.4. If all existing ditches in the Neshanic River Watershed were retrofitted with the recommended strategies, then 48.5 acres of roadway and many more acres of surrounding drainage areas would be affected.

Using the retrofitting strategies described above would turn roadside ditches into something very similar to constructed stormwater wetlands. Care needs to be taken with constructed wetlands due to the need for maintenance of roadways and potential permitting issues. The removal rate for constructed stormwater wetlands is 90 percent for TSS, 50 percent for TP and 30 percent for nitrogen. The fecal coliform removal rate of wetlands is 93 percent (Karathanasis et al., 2003). Assuming ditches treat 90 percent of the stormwater runoff, aerial loading coefficients for the 48.5 acres of roadways being treated by these ditches of 2.1 pounds of TP per acre per year, 22 pounds of TN per acre per year and 200 pounds of TSS per acre per year, 46 pounds of TP per year, 288 pounds of TN per year and 7,857 pounds of TSS per year would be removed. In reality, the ditches would treat a much larger area than the 48.5 acres of roadway. They should be able to treat the land adjacent to the roadways, yielding much larger reductions in pollutant loads.

Every roadside ditch and culvert in the Neshanic River Watershed is listed in the project Stormwater Infrastructure Inventory, along with their type and condition. Roadside ditches are categorized using three criteria: ditch type; ditch condition; and whether the ditch conforms to any design standards. Table 7.3 summarizes the roadside ditch prioritization criteria and criteria scores. Those roadside ditches with the highest total score have the highest priority for retrofitting.

Table 7.3: Roadside ditch prioritization criteria and criteria scores

Prioritization Criteria for Ditch	Criteria Score					
	1	2	3	4	5	6
Type	Wetland	Vegetation	Stone	Mixed	Soil	Other
Condition	Good				Need Repair	Urgent
Design	Yes					No or unsure

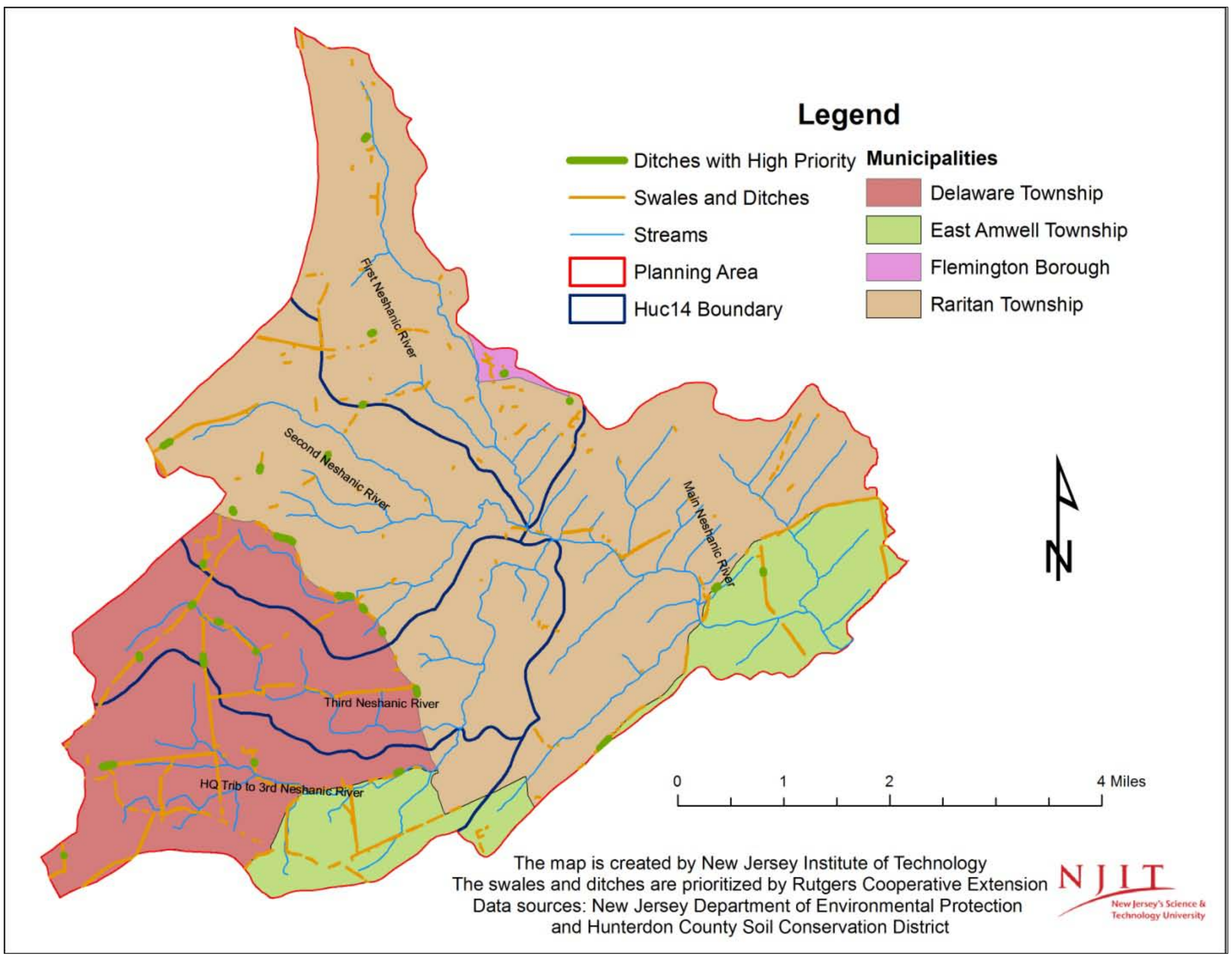


Figure 7.2: Location of swales and ditches in the Neshanic River Watershed

Prioritization criteria and criteria scores are based upon the inputs provided by the project partners. The highest score a ditch can have is 18 and the lowest score is 3. Any ditch with a score equal to or less than 5 is a good quality ditch and does not need retrofitting. The score of 5 was arrived at by assuming that a good quality ditch should be in good condition (1 point), have a stone-type ditch (3 points), and have a formal design (1 point). Only 33 swales and ditches have scores of 5 or lower. The 138 ditches and swales with prioritization scores of 16 or higher were considered high priority for retrofitting. Figure 7.2 shows the location of all 853 swales and ditches in the watershed; ones with high priority for retrofitting are highlighted in green. Appendix 2 list all ditches with their prioritization scores and the prioritization categories by subwatersheds in the Neshanic River Watershed.

7.2.3. Detention Basin Retrofitting

Stormwater from the more developed areas of the watershed is usually managed with detention basins. Detention basins are constructed impoundments for reducing flooding and lowering the volume and velocity of stormwater that flows into streams immediately after a storm. Figure 7.3 shows a detention basin in Subwatershed TN3a. There are 153 mapped detention basins in the Neshanic River Watershed with a variety of different detention basin designs including wet ponds, infiltration basins, bio-retention basins, extended dry detention basins and even bermed-off stream corridors with flow control weirs. The quality of maintenance of the existing basins ranges from heavily landscaped and manicured, to benign neglect, to outright abandonment. Virtually every detention basin in the watershed presents an opportunity for upgrades or retrofits to improve water quality.

Figure 7.3: Detention basin in TN3a

The condition of the bottoms of many detention basins are suitable for retrofits: 106 of 153 basins were found to have mowed turf bottoms; eight basins had weeds or successional vegetation due to a lack of mowing; three basins were fully overgrown with trees and shrubs; and one basin lacked any vegetation and was covered with deposited material.

Low flow channels were very common in the detention basins in the watershed. Out of 196 mapped low flow channel segments, 156 were found to be concrete. Only one-third of the detention basins have outlet structures with a three-inch water quality orifice. The three-inch orifice outlet structure extends the water detention time in the basin to allow TSS and the attached nutrients to settle, which achieves certain water quality benefits. The remaining detention basins in the watershed were not constructed to achieve water quality benefits through extended water detention and should be retrofitted to do so.

A common design feature for detention basins is a low flow concrete channel that carries runoff from the inlets to the outlet structure of the detention basin. This feature is intended to force water through the basin during small storm events to avoid ponding and maintenance issues. Due to sediment and debris accumulation in these channels and the lack of regular maintenance, these channels tend to clog, causing ponding of water in the channel. The small stagnant ponds become ideal mosquito breeding habitat, thereby creating a problem they were originally intended to avoid. Low flow concrete channels act as an impediment to improving water quality in a detention basin. It is recommended to remove the concrete channel replacing it with a vegetated swale or a rip-rap stone channel depending on site-specific conditions.

A low-flow vegetated swale should have a 0.1 percent side slope to ensure easy maintenance and a slope not to exceed 3 percent. The swale should be seeded with native grasses to minimize maintenance. Where possible, replacement soils should be installed. The top 1.5 feet of soil should be composed of a bioretention soil mix to encourage infiltration. Below this infiltration media, a 6″ layer of 3/4″ diameter clean stone should be installed. The native vegetation in the swale should be cut once or twice a year. Dense native vegetation creates friction along the flow path of runoff through the detention basin. This friction slows the water allowing sediment to settle out. Water is held in the detention basin longer, increasing infiltration and allowing the vegetation to take up nutrients carried in stormwater runoff. Finally, native vegetation that is allowed to grow taller will develop a deep root structure allowing a much greater infiltration rate than soil with short turf grass. The channel should be designed to infiltrate and pass water through within 48 hours after a storm to prevent mosquito breeding.

A low flow rip-rap stone channel should not be any wider than 10 feet. The bottom should be at least three feet above the seasonal high groundwater elevation and the channel should be designed to hold the runoff volume of the water quality storm from the detention basin's drainage area. Infiltration rate of the soil where the channel is installed should be taken into consideration before sizing. The channel should infiltrate any storm equal to or smaller than the water quality storm within 48 hours.

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 vegetation that requires 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. The height of the grass is directly proportional to the depth of the root structure. Limiting mowing and allowing the grass to grow taller ensures development of a deep root structure. Using native grasses reduces maintenance costs because they require less mowing and improves water quality by increasing infiltration and subsequently decreasing stormwater discharges to nearby waterways.

Many basins throughout New Jersey are over-compacted, thereby limiting their infiltration capacity. Although the root structure of native vegetation may increase infiltration rates, some of these over-compacted basins may need to be deep-tilled to loosen up the soil, and soil amendments may need to be added. Promoting infiltration in these basins would improve water quality in the watershed.

Retrofitting detention basins should take a short amount of time. Although heavy equipment may be needed to remove a concrete channel and install a vegetative channel, precautions should be taken to avoid over-compacting the basin. Deep-tilling may be needed to loosen the soil in areas where heavy equipment is driven. Native grass should be seeded in the basins after the turf grass has been eliminated with an herbicide. Seed will need to be covered and protected from erosion. Detention basins must be inspected for excessive debris and sediment accumulation at least four times per year, as well as after every storm exceeding one inch of rainfall. Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations (Semple et al., 2004).

Mowing of these newly vegetative basins must be performed on a regular schedule, based on specific site conditions; typically once every six months. Vegetated areas must be inspected at least annually for erosion, scour and unwanted growth, which should be removed with minimum disruption to the soil bed and remaining vegetation. When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetative health, density and diversity should be performed during both the growing and non-growing seasons at least biennially. Use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetative health must not compromise the intended purpose of the vegetative filter. Vegetative deficiencies should be addressed without the use of fertilizers and pesticides whenever possible. The vegetative detention basin system should be inspected for excess ponding after significant storm events. Corrective measures should be taken when excessive ponding occurs (Semple et al., 2004).

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 is approximately \$2 to \$4 per ft^2 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 ft^2. Cost estimates vary because there are many detention basin designs. The cost to remove a low flow concrete channel is approximately \$100 per linear foot.

Retrofit designs should target infiltration of runoff generated from the water quality storm of 1.25 inches of rain over two hours. In New Jersey, since approximately 90 percent of all storms in a year are smaller than the water quality storm, retrofit designs should have a dramatic effect on water quality in the watershed. While it is hard to measure the exact effect, the basins should have many of the same characteristics as a vegetated filter strip. It is difficult to estimate the reductions for each pollutant from retrofit designs because many of the functions of the basin will be enhanced by the proposed changes. Targeted reductions of 90 percent of TSS, 60 percent of TN and 30 percent of TP are expected. Depending on the final design of the detention basin, it will function like a bioretention basin or a wetland. Removal rates for bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007; Karathanasis et al., 2003). Since drainage areas for each basin were not readily available, it is impossible to estimate the total pounds of pollutants removed by retrofitting the detention basins in the Neshanic River Watershed.

A stormwater infrastructure inventory completed as part of the project documents the existing conditions of detention basins, including the general condition of the basin, the vegetation on the basin bottom, the type and condition of any low flow concrete channel and/or under drain and the type of basin outlet structure. Such information was used to prioritize the detention basins for retrofitting. Table 7.4 lists criteria for prioritizing detention basins and criteria prioritization scores developed by the project team. The sum of the criteria scores for a detention basin gives the prioritization score. A higher retrofitting priority is given to detention basins with higher prioritization scores.

Table 7.4: Criteria for prioritizing detention basins and prioritization criteria scores

Prioritization Criteria	Prioritization Criteria Score					
	1	2	3	4	5	6
General Condition	Good				Need Repair	Urgent
Basin Bottom Vegetation	Wetlands, Tree Succession	Grasses Natural	Wetland, Turf grass	Turf Grass	Weeds	No Vegetation
Low Flow Channel	Wetland	Turf or Stone			Concrete	Other
Cutoff in Low Flow Channel	Yes					No
Water Quality Outlet	Yes					No

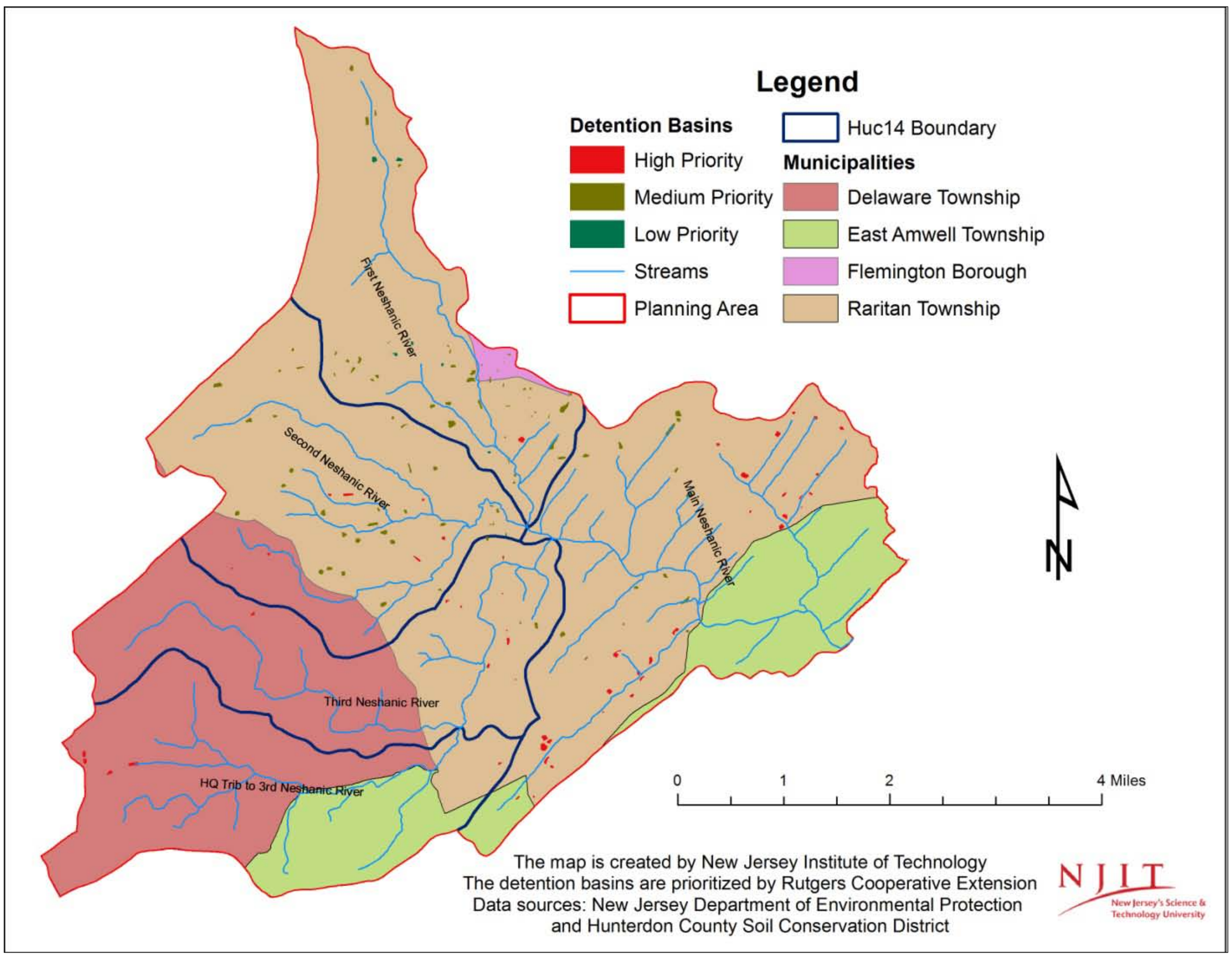


Figure 7.4: Location of detention basins with priority for retrofitting in Neshanic River Watershed

There are 153 detention basins in the watershed mapped by HCSCD. The highest score a detention basin can have is 30 and the lowest score is 5. Any detention basin with a score equal to or less than 8 should be considered a good detention basin with low priority for retrofitting. There are 9 detention basins in this category. A score of 8 is arrived at by assuming that a good detention basin should at least be in good condition (1 point), have a turf grass basin bottom (4 points), a turf or stone low flow channel (2 points) with a cutoff (1 point) and a water quality outlet (1 point). Any detention basin with a score equal to or higher than 20 is prioritized as high priority for retrofitting. There are 51 detention basins in this category. Ninety-three detention basins have a priority score from 9 to 19, which are considered as medium priority for retrofitting. Figure 7.4 shows the location the detention basins with various priorities for retrofitting in the watershed. Appendix 3 lists all detention basins along with their prioritization scores and categories by subwatersheds in the Neshanic River Watershed.

7.2.4. Vegetative Buffers for Non-Agricultural Developed Lands

Non-agricultural land uses such as residential, commercial, industrial, barren lands and park lands contribute to the phosphorus and TSS loads entering streams. Sources of pollutants are typically roadway sediment and lawn fertilizer, as well as soil erosion from unstable areas. The Neshanic River Watershed was once dominated by agriculture and natural landscapes. Over time, more housing developments have been added to the watershed. As the natural landscapes decrease in the watershed, the protective vegetated buffers surrounding the Neshanic River and its tributaries have declined. Residential neighborhoods and commercial and industrial development have been replacing natural landscapes. These developments usually have turf grass as their dominant form of vegetation, some of which comes right up to the shoreline of streams. Streams need a diverse assemblage of vegetation along the shoreline to provide shade, establish habitat and filter stormwater runoff. Streams that run through developments not having vegetated buffers can be sources of nutrients and TSS. The nutrients and bacteria collect on the surface near the shoreline. When a storm event occurs, the stormwater runoff carries the nutrients and bacteria directly to the streams bypassing a vegetated buffer.

A vegetated buffer is an area designed to remove suspended solids and other pollutants, as well as associated pollutants, such as hydrocarbons, heavy metals, and nutrients, from stormwater runoff. Pollutant removal mechanisms include sedimentation, filtration, adsorption, infiltration, biological uptake and microbial activity. Vegetated buffers are designed to receive stormwater runoff as sheet flow for maximum pollutant removal. Pollutant removal rates for vegetated buffers depend upon the vegetative cover in the buffer. They range from 60 to 80 percent for TSS and 30 percent for phosphorus and nitrogen (Semple et al., 2004). Vegetated buffers that are

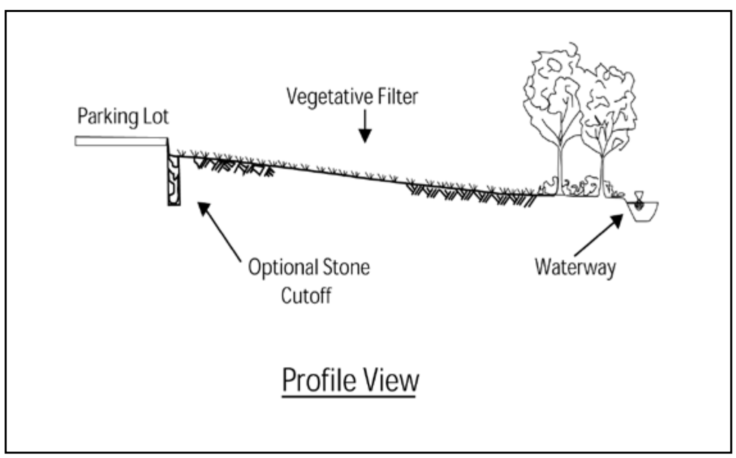


Figure 7.5: Typical profile of a vegetative buffer in a non-agricultural setting (Semple et al., 2004)

planted with woody material may also create shade along water bodies resulting in lower water temperatures, greater detritus and large woody debris for fish and other aquatic organisms, and habitat and protective corridors for wildlife. Figure 7.5 illustrates a typical profile of a vegetated buffer in a non-agricultural setting.

For vegetated buffers to be effective in trapping debris and sediment, they must be inspected for clogging and excessive debris and sediment accumulation at least four times per year and after every storm exceeding one inch of rainfall. Sediment removal should be done when the vegetated buffer is thoroughly dry. Debris and trash should be disposed of only at suitable disposal/recycling sites in a manner that complies with all applicable local, state and federal waste regulations (Semple et al., 2004). Mowing of vegetated buffers must be performed on a regular schedule, based on specific site conditions; typically, once every six months at a minimum. Grass should be mowed at least once a month during the growing season. Vegetated areas must be inspected at least annually for erosion and scour and at least annually for unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation. When establishing or restoring vegetation, biweekly inspections of vegetative health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetative health, density and diversity should be performed during both the growing and non-growing seasons at least twice a year. Use of fertilizers, mechanical treatments, pesticides and other means, done to ensure optimum vegetative health, must not compromise the intended purpose of the vegetated buffer. Whenever possible, vegetative deficiencies should be alleviated without the use of fertilizers and pesticides. Vegetated buffer should be inspected for excess ponding after significant storm events and corrective measures should be taken when excessive ponding occurs (Semple et al., 2004).

Vegetated buffers should be designed and installed so as to remove 70 percent of the TSS and 30 percent of the nitrogen and phosphorus in the runoff that enters the buffers throughout the year. There is no established removal rate for bacteria in a vegetated buffer. However, it is fair to assume that the bacteria act as particles much like sediment, and the removal rate should be similar because the same mechanism that reduces TSS will reduce bacteria. Figure 7.6 is a map of the location of every potential buffer project along developed land uses in the Neshanic River Watershed. Any portion of a stream or waterbody that is surrounded by non-agricultural developed land and appears to have little or no existing vegetation along the stream is considered a potential site for a buffer project.

This project has identified approximately 27,603 feet (5.2 miles) of potential sites for vegetated buffer. Municipalities can partner with local environmental organizations, environmental commissions and other community organizations to reach out to home and business owners to identify neighborhoods and businesses willing to install and maintain vegetated buffers on their properties. A ranking of subwatersheds based on the greatest need for vegetated buffers on non-agricultural developed land uses can be based on the phosphorus ranking in Table 5.5.

The cost of vegetated buffers varies depending on the complexity of their design and size. Vegetated buffers consisting of warm season grasses are considerably less expensive than designs requiring more vegetation and a more complex design. In addition to being inexpensive and attractive, vegetative buffers need to be well-designed and consistent with the property owner's preferences.

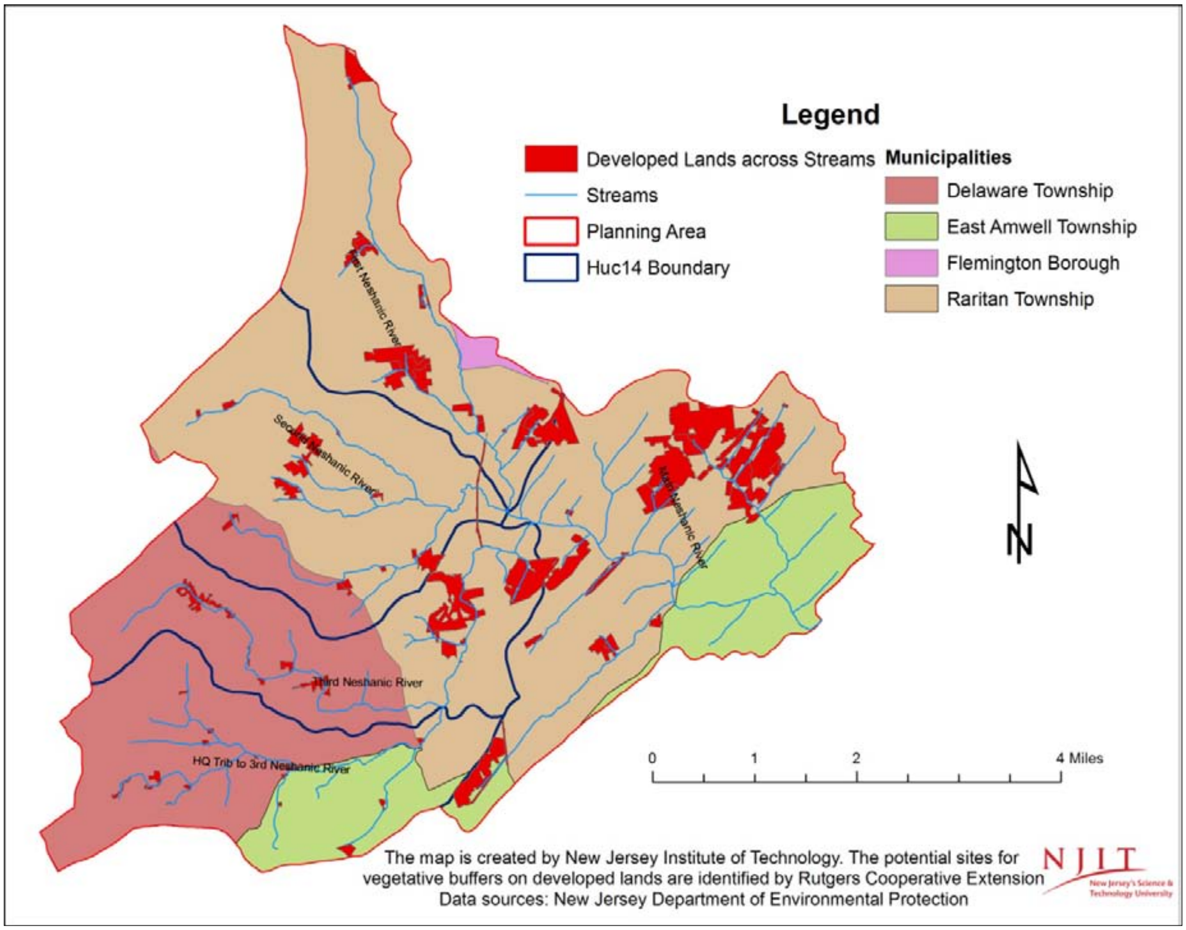


Figure 7.6: Potential sites for vegetative buffers on developed lands in the Neshanic River Watershed

7.3. **Agricultural BMPs and Prioritization**

7.3.1. Livestock Access Control – Exclusion Fencing

Livestock access to streams is a threat to water quality and a potential source of streambank degradation and soil erosion in the Neshanic River Watershed. Nutrients and pathogens from livestock manure can be transmitted to streams via direct deposit and runoff. Installation of exclusion fences along streams where livestock graze would protect streams from such contamination. Additionally, fencing promotes the restoration of riparian areas of streams. A fully functioning riparian area filters pollutants and prevents them from reaching streams. In addition, exclusion fencing should be installed along all waterways that run through pastures used by livestock that have access to those waterways. The NRCS BMP Manual requires installing livestock exclusion fencing at least 35 feet from streambanks, further depending on the stream width and other site-specific conditions. The 35-foot corridor allows for the establishment of a healthy riparian zone that protects streams from pastureland runoff. The type of fencing utilized depends on the type of livestock present and site-specific conditions. Once fencing is installed, livestock are no longer able to deposit manure in the streams during watering or crossing. Moreover, exclusion fencing reduces other damages to streambanks, allowing streams to return to a more natural state.

While fencing may be installed by any contractor or landowner, technical assistance should be obtained from NRCS or another support agency to ensure the effectiveness and longevity of the fence. Fencing costs vary according to livestock type and landowners' preferences. The NRCS approximates the cost of livestock exclusion fencing to be $4.78 per foot. Fencing cost to landowners can be reduced if a landowner applies and qualifies for cost share programs that pay a portion of the cost of fencing. Such programs often fund other practices associated with exclusion fencing such as the installation of an alternate water source for livestock. Currently, there are several state and federal cost-sharing programs. For example, the NRCS Agricultural Water Enhancement Program (AWEP) offers cost share in the Neshanic River Watershed. Currently, cost-sharing rates are as high as 100 percent of the installation cost.

The total length of the stream segments flowing through pasture in the Neshanic River Watershed was estimated based on the pasture locations given in the land use inventory for the watershed. Base on these stream segments, potential exclusion fencing sites cover about 24,663 linear feet of stream segments.

Table 7.5 gives the priority rankings (in terms of reducing pathogenic loads), length and installation cost of potential fencing sites in Neshanic River Watershed by subbasin and subwatershed. The estimated total cost of installing exclusion fencing on both sides of the stream segments associated with those sites is $236,000. Livestock access control fencing should completely eliminate the direct deposit of livestock manure into streams, which should result in 19 percent reduction in pathogenic loads to the Neshanic streams assessed using the SWAT model. Figure 7.7 shows the potential exclusion fencing sites in the Neshanic River Watershed.

Table 7.5: Priority rankings, length and installation cost of potential livestock exclusion fencing sites in Neshanic River Watershed

Subbasin	TP Priority	Subwatershed	TP Priority	Aggregate Ranking	Length (feet)	Installation Cost ($)
3	13	SN1	5	18	1,519.3	14,524.78
6	17	SN1	5	22	1,715.9	16,404.42
10	7	N1	1	8	2,339.1	22,362.06
12	5	N1	1	6	3,165.0	30,257.05
16	6	N2	n/a	6*	4,955.3	47,372.82
17	4	TN3	7	11	1,542.1	14,742.80
22	24	TN3a	2	26	100.3	958.66
23	9	TN3a	2	11	936.0	8,948.22
24	14	TN3a	2	16	7,157.4	68,425.20
25	2	TN3a	2	4	1,232.5	11,782.87
					24,663.1	235,778.88

Note: * aggregate rank is only based on the subbasin ranking.

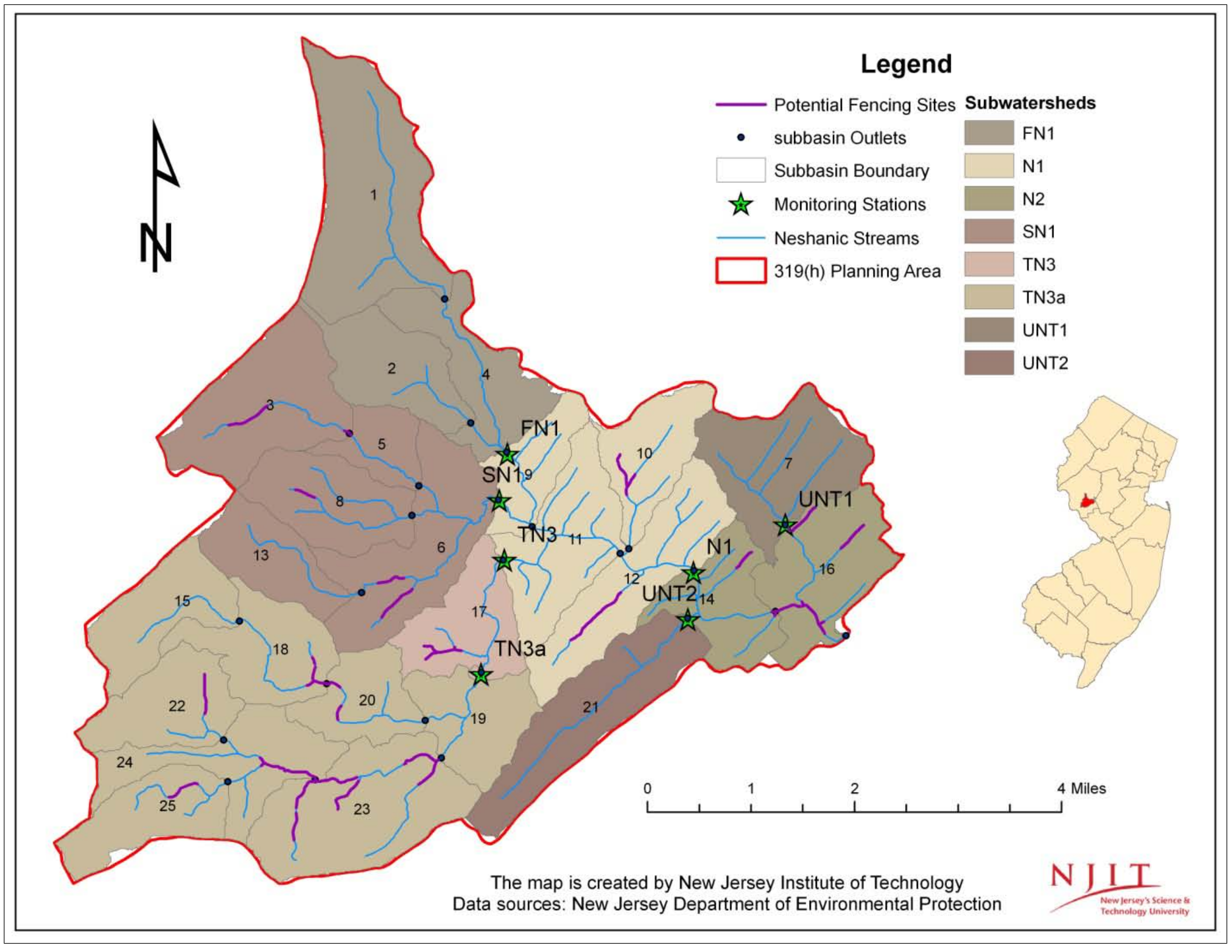


Figure 7.7: Potential sites for livestock exclusion fencing in the Neshanic River Watershed

7.3.2. Conservation Buffers

A conservation buffer is a structural vegetative mixture of trees, shrubs and grasses placed in a 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). These terms tend to be used 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 and 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 are filtered out by the buffers. Buffers dissolve some of the pollutants through complicated chemical and biological processes, promote ground water recharge and evapotranspiration, and reduce runoff.

Well designed and positioned conservation buffers can achieve at least 50 percent reduction in N, P and sediment loads (Lowrance et al., 1986). In New Jersey, the vegetative filter is expected to achieve 60-80 percent reduction in TSS and 30 percent reduction in TN and TP (Semple et al., 2004).

Research on the effectiveness of buffers in reducing pathogenic loads is not as extensive as for reducing TSS, TN and TP. Some research suggests that conservation buffers can remove up to 60 percent of the pathogens in runoff (SWCS, 2001). Strategically locating conservation buffers is essential to maximize the effectiveness of the buffer in pollutant removal (Dillaha et al., 1989; Dosskey et al., 2002 and 2006; Qiu, 2003 and 2009).

Conservation buffers can be installed by any contractor or landowner. The NRCS has specific guidance for conservation buffer installation and maintenance. Technical assistance should be obtained from NRCS to ensure proper location, plant selection and buffer size. If livestock are present, fencing has to be installed to prevent damage to the buffer. The costs associated with the implementation of conservation buffers include the cost of materials and labor, maintenance and the opportunity cost of the land taken out of production. Various federal, state and local programs provide cost-sharing to implement conservation buffers. In New Jersey, the Conservation Reserve Enhancement Program (CREP) has been the primary funding mechanism for installing conservation buffers on agricultural lands. The $100 million New Jersey CREP offers a one-time sign-up incentive, covers 100 percent of the implementation costs of installing buffers and offers land rental payments for up to 15 years. The program 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 taken out of agricultural production and are determined by soil type and the annual soil rental rate set by the USDA FSA. Other governmental agencies and non-profit conservation groups that are interested in implementing conservation buffers can also become involved by 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 the choice of buffer practices. According to the NRCS AWEP 2010 practice catalog, installation costs of filter strips range from about $292 to $303 per acre, and installation costs of riparian buffers range from about $1,082 to $2,597 per acre. Grassed waterways are the most expensive and least used buffer practice; they often require installation of an engineering structure at the end of the waterway to ensure the proper dispersion of the concentrated runoff into the streams. The general annual maintenance cost of grassed waterways is about $4-$9 per acre.

Qiu (2009) applied the concept of Variable Source Area (VSA) hydrology to target the placement of conservation buffers in agricultural lands in the Neshanic River Watershed. The VSA concepts and modeling tools are used to identify the HSAs. Agricultural lands in the HSAs are targeted for conservation buffer placement. In this project, 875 acres of agricultural lands in HSAs were identified as being suitable for conservation buffers of which 331 acres are located within the riparian area of the Neshanic streams.

The project team members including NJIT, North Jersey RC&D and NJWSA developed another strategy to target agricultural lands for conservation buffers in Raritan Basin under a grant from the NRCS Cooperative Conservation Partnership Initiative (CCPI). The CCPI strategy prioritizes agricultural lands for conservation buffers based on multiple selection criteria, including soil erodibility, hydrological sensitivity, wildlife habitat and impervious surface rate to capture the conservation buffers' benefits in reducing soil erosion, controlling runoff generation, enhancing wildlife habitat and mitigating stormwater impacts, respectively.

989 acres of agricultural lands were identified as being suitable for conservation buffers based on the CCPI approach of which 326 acres are located within the riparian area of the Neshanic streams. Figure 7.8 illustrates the location of agricultural lands for conservation buffer placement under both strategies. As shown in the figure, there is substantial overlap in the areas identified. The overlapping area is about 573 acres.

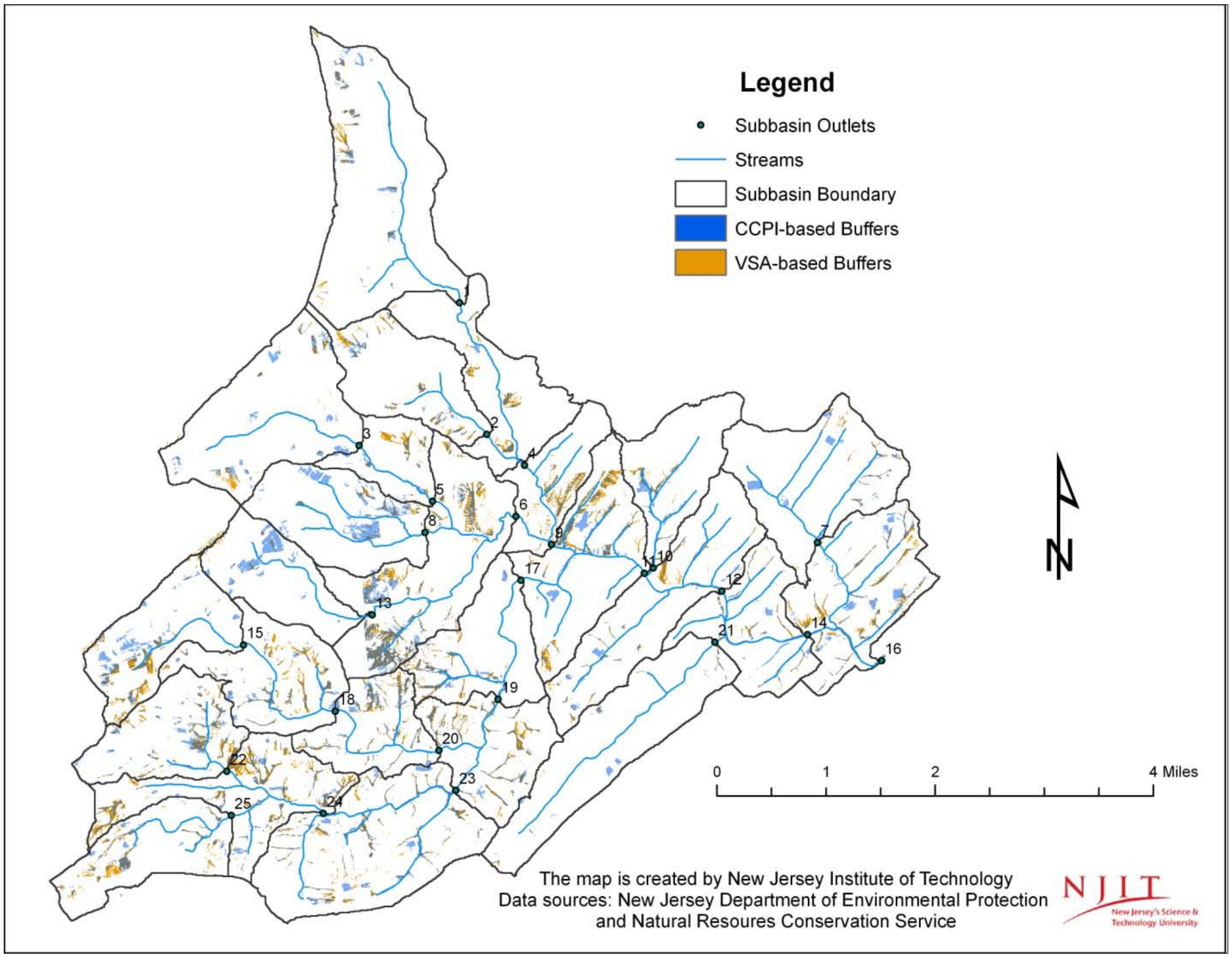


Figure 7.8: Location of the agricultural lands for conservation buffers under two targeting strategies

The cost estimates for the two buffer scenarios are presented in Table 7.6. Assuming the riparian buffers are installed in the identified agricultural lands in the riparian area of the Neshanic streams and the filter strips are installed in other identified agricultural lands, the total costs of installing and maintaining the conservation buffers in those 875 acres of agricultural lands in the watershed for 15 years are estimated at $1.43 million following the current New Jersey CREP rates. The estimate is based on an average installation cost of $300 per acre for filter strips and $1800 per acre for riparian buffers. The program costs can be easily doubled if some expensive buffer practices such as grassed waterways are used. The total estimated program costs to install conservation buffers in those 989 acres of agricultural lands identified by the CCPI strategy are $1.54 million.

Table 7.6: Cost estimates for two conservation buffer scenarios in Neshanic River Watershed

	Units	VSA Buffer Strategy	CCPI Strategy
Agricultural Lands	Acres	874.85	987.83
Ag Lands in Riparian Area	Acres	331.24	326.33
Annual Soil Rental Rate	$/acre	39.73	39.00
Signing Incentive Payments	$/acre	100.00	100.00
Installation Costs	$/acre	867.94	795.52
Annual Maintenance	$/acre	5.00	5.00
Average Program Costs	$/acre	1,638.89	1,555.52
Total Program Costs	$million	1.43	1.54

Table 7.7: Acreage of buffers and their priority ranking by subbasins in Neshanic River Watershed

Subbasin ID	Buffer Area (Acres)		Priority			Priority for buffers
	VSA Buffer	CCPI Buffer	TP	Pathogens	Aggregate	
1	23.2	30.0	25	18	43	17
2	23.0	22.0	14	19	33	12
3	15.1	33.4	24	13	37	14
4	18.0	11.2	13	20	33	12
5	15.9	14.2	18	21	39	16
6	107.6	108.1	17	17	34	13
7	13.2	27.3	15	12	27	10
8	14.5	60.2	21	16	37	14
9	26.8	12.5	2	3	5	1
10	18.6	23.0	12	7	19	7
11	67.5	59.1	11	10	21	8
12	27.3	29.4	6	5	11	5
13	5.4	41.2	20	11	31	11
14	21.9	28.8	16	22	38	15
15	41.1	53.2	22	23	45	18
16	59.3	66.6	1	6	7	2
17	29.9	31.1	5	4	9	4
18	40.5	35.8	7	1	8	3
19	44.5	38.3	8	25	33	12
20	39.0	44.3	4	8	12	6
21	4.7	10.7	23	15	38	15
22	42.0	44.6	19	24	43	17
23	59.3	70.2	10	9	19	7
24	76.0	58.4	9	14	23	9
25	34.5	29.9	3	2	5	1
Total	868.9	983.3				

Table 7.7 presents the acreage of agricultural lands targeted for conservation buffers by subbasin based on the VSA and CCPI strategies in columns 2 and 3, respectively. The last column in Table 7.7 gives the priority for implementing conservation buffers for each subbasin. The subbasin priority is developed from the subbasin priority scores for reducing TP and pathogenic loads, the two most important water quality issues in the watershed. The priority for reducing TP and pathogenic loads developed in Chapter 5 are shown in columns 4 and 5. Column 6 is the sum of the two priority scores in columns 4 and 5. Finally, the subbasin priority for conservation buffers developed from the aggregate score in column 6 is shown in column 7. A lower number indicates a higher priority for implementing conservation buffers in a subbasin.

As discussed previously, conservation buffers have multiple water quality benefits. Based on the assessment using SWAT modeling, a well implemented conservation buffer program will result in a 19 percent reduction in TSS, a 48 percent reduction in TN, a 38 percent reduction in TP, and a 12 percent reduction in pathogen loads to the Neshanic streams. In other words, the conservation buffer program alone would well achieve the required 9 percent reduction in TSS load and over three-quarter of the required 48 percent reduction in TP load, and dramatically reduce the pathogen loads to the Neshanic streams.

7.3.3. Animal Waste Management and Composting Facility

There are many agricultural properties in the Neshanic River Watershed which have livestock that produce more manure than what can safely be spread on the land due to overstocking or limited onsite use. In some cases the manure is being handled in a fashion which can potentially pose an environmental threat. Manure piled in HSAs or without proper distance from streams can leak phosphorus and pathogens into the streams. A remedy is to compost the raw manure to a safe and biologically stable organic material. The NJDA Animal Waste Management Rules must be enforced in the Neshanic River Watershed to properly manage the animal waste and reduce its impacts on water quality. Farms that apply animal manure as fertilizer should follow the nutrient management practices discussed in Section 7.3.7.

Composting facilities are recommended by the NJRC&D (2011) as a possible solution for any livestock operation that cannot safely use or remove manure from the property without negatively impacting water quality. The use of composting facilities can mitigate any potential phosphorus and pathogenic contamination generated by improper manure storage in the watershed. Secondary benefits accrue from turning manure into a safer alternative fertilizer than raw manure.

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

The task of installing a composting facility varies in difficulty and should be done with assistance from NRCS or another support agency so as to ensure the facility is sited properly and designed to handle runoff. There may be local and state ordinances which must be met in installing this practice and cost-share programs to offset expenses incurred by the landowner.

Use of this practice may require training for the operator, as the correct temperatures and the proper ratio of carbon-to-nitrogen must be maintained to encourage biological processes.

The cost of installing a composting facility varies based on the needs and preferences of the landowner. The cost range listed in the NRCS AWEP 2010 practice catalog is 10 cents to $16.73 per square foot. Cost share is not available for some of the equipment which is required to operate the facility, such as a tractor or a windrow turner. If an operator does not own such equipment, it would be an out of pocket expense.

7.3.4. Prescribed Grazing

A prescribed grazing plan manages grazing and browsing of animals to ensure there is adequate ground cover and proper livestock nutrition. Currently in the Neshanic River Watershed, there are agricultural properties which have overstocked livestock and/or poorly managed pasture. These conditions lead to pastures that have insufficient vegetated cover to prevent erosion and manure runoff. Generally, a prescribed grazing plan is written by a pasture professional and may incorporate temporary fencing for rotational grazing activity, pasture reseeding and a reduction in animal units.

Several government agencies can prepare a prescribed grazing plan for farmers, including NRCS. Such plans may require a farmer to install fencing or provide alternate watering as well as well as reseeding, fertilizing and liming pastures. Not all of these practices may be cost shared, but there can be economic benefits to healthy pastures that can further offset costs.

The cost of implementing prescribed grazing varies according to pasture needs and conditions and can include the cost to the operator of learning how to manage prescribed grazing. Prescribed grazing can often result in healthier pastures, which can make the practice worth the cost to the landowner. The AWEP 2010 practice catalog establishes a cost of between $242 and $321 per acre, not including fencing, watering or seeding. An implemented prescribed grazing plan allows pastures to regain healthy vegetation that aids in keeping manure and nutrient runoff out of streams. Healthy pastures reduce phosphorus loading and manure runoff.

The SWAT modeling was conducted to evaluate the impacts of prescribed grazing on water quality in the Neshanic River Watershed. Model results indicate that prescribed grazing would have only limited benefits in terms of improving water quality in the watershed. Specifically, it can reduce TSS by 2.75 percent, TN by 0.84 percent, TP by 1.51 percent and pathogens by 0.12 percent in the Neshanic streams. A prescribed grazing plan should be considered as a possible solution for any livestock operation that has poor pasture conditions, including land that is overstocked. The locations of pastures for prescribed grazing can be prioritized by ranking subwatersheds by their combined fecal coliform and TP loading. The 892 acres of pasture in the Neshanic River Watershed were prioritized by subbasin according to the TP loading. Table 7.8 gives the acreage and the TP priority by subbasin in the Neshanic River Watershed.

Table 7.8: Pasture acreage and priority for grazing management by subbasins in Neshanic River Watershed

Subbasin	Acres	Priority		Subbasin	Acres	Priority
3	33.1	24		15	8.9	22
5	12.6	18		16	169.3	1
6	72.4	17		17	67.7	5
7	14.3	15		18	49.2	7
10	44.6	12		20	72.2	4
11	13.2	11		22	80.6	19
12	27.1	6		23	116.6	10
13	8.8	20		24	54.9	9
14	13.3	16		25	33.9	3
Total					892.4	

7.3.5. Cover Crops

Cover crops are grasses, legumes, forbs or other herbaceous plants established for seasonal cover and other conservation purposes. Cover crops are widely recognized as having many benefits by agricultural professionals and farmers, including water quality improvement. Proper use of cover crops reduces field operation costs, tillage and herbicide uses, and enhances soil health. It is easy to incorporate cover crops into any cropping system applied to fields that are not used for all or part of a year. With proper promotion, education and assistance, cover crops can be implemented watershed-wide with excellent benefits.

Cover crops vary in cost. According to the NRCS AWEP 2010 practice catalog, the least costly is a winter cover crop at a cost of about $71 per acre and the most expensive is a summer legume at a cost of about $443 per acre. Cost share is available for these practices. Benefits of cover crops are lower fertilizer requirements on subsequent crops, lower wind and water erosion and increased soil health. Use of cover crops on barren crop fields reduces runoff. Nutrients left over from previous fertilizer and manure applications in the soil profile will be captured and recycled making them unavailable for runoff. There are 4,333 acres in row crops in the Neshanic River Watershed. Any barren acres in the watershed are potential locations for planting cover crops. Potential locations for cover crops were prioritized by subbasin, and ranked according to TP loading. Table 7.9 lists the acreages in different row crops for each subbasin in column 2 and the subbasin priority for TP load reduction in column 5.

Table 7.9: Acreage of agricultural lands and TP priority by subbasins in the Neshanic River Watershed

Subbasin	Agricultural Lands (Acres)			TP Priority
	Row Crop	Hay and Pasture	Total	
1	70.2	100.9	171.1	25
2	149.0	0.0	149.0	14
3	73.7	64.7	138.4	24
4	40.7	19.4	60.1	13
5	31.9	42.3	74.2	18
6	300.1	170.1	470.2	17
7	161.5	60.9	222.3	15
8	112.5	25.7	138.1	21
9	66.0	54.8	120.8	2
10	57.9	129.7	187.6	12
11	274.0	172.4	446.4	11
12	281.5	134.7	416.2	6
13	36.3	49.2	85.5	20
14	234.8	170.6	405.4	16
15	125.5	143.8	269.3	22
16	344.6	363.7	708.2	1
17	82.8	186.1	268.8	5
18	147.8	195.5	343.3	7
19	343.5	116.8	460.2	8
20	237.4	119.5	356.8	4
21	58.3	60.7	119.0	23
22	125.2	254.0	379.3	19
23	558.9	362.0	920.9	10
24	272.8	199.4	472.2	9
25	146.0	215.7	361.7	3
Total	4,332.9	3,412.6	7,744.5	

7.3.6. Contour Farming

Currently, row crops in the Neshanic River Watershed are planted in straight rows without regard to the contours of the land or slope direction, a practice that tends to increase erosion and fertilizer in 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 designed to change the 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 is most effective on slopes from 2 to 10 percent without excessive rolling topography.

In its simplest form, contour farming changes the direction in which rows are planted from “up and down” the slope to across the slope. Because field conditions vary, the potential benefits of contour farming are highest when planning is done by an agricultural professional. Contour farming might have to be used in conjunction with other practices, such as terraces or filter strips, to realize its full potential. Cost share is not always available for contour farming. However, cost share is often available for practices that need to be instituted in conjunction with contour farming. The learning curve for farmers that use contour farming needs to be taken into consideration. There are no out-of-pocket costs for contour farming because it only involves changing the way rows are formed on the landscape. Cost for support practices are on a field-to-field basis and are often cost shared. A conservation planner from NRCS can provide free technical assistance in making decisions about what supportive practices are necessary and can guide landowners to appropriate cost share programs. Contour farming can reduce erosion, reduce the transport of phosphorus to surface water and increase water infiltration.

Table 7.10: Cropland acreage for contour farming and TP priority ranking by subbasin

Subbasin	Cropland (Acres)	TP Priority	Subbasin	Cropland (Acres)	TP Priority
1	33.4	25	14	128.9	16
2	59.6	14	15	79.4	22
3	42.6	24	16	167.4	1
4	1.4	13	17	21.9	5
5	12.3	18	18	36.5	7
6	37.0	17	19	182.3	8
7	90.6	15	20	117.1	4
8	33.4	21	21	29.4	23
9	4.8	2	22	59.2	19
10	24.5	12	23	297.7	10
11	84.0	11	24	71.2	9
12	154.2	6	25	54.9	3
13	22.6	20	Total	1,846.1	

The effectiveness of contour farming is amplified when incorporated with a strip cropping system, which involves growing small grains and forages in alternating strips. Contour farming should be used on all appropriately sloped agricultural land with row crops; not in a no-till system. Locations of strips can be prioritized by ranking subwatersheds according to their TP loading. Of the 4,333 acres of row-crop lands in the watershed, approximately 1,846 acres have a slope between 2 to 10 percent that can benefit from contour farming. Table 7.10 gives the cropland acreage in each of the 25 subbasins and the TP priority ranking for each subbasin in the watershed. Figure 7.9 illustrates the location of those croplands that are potential targets for contour farming in the watershed.

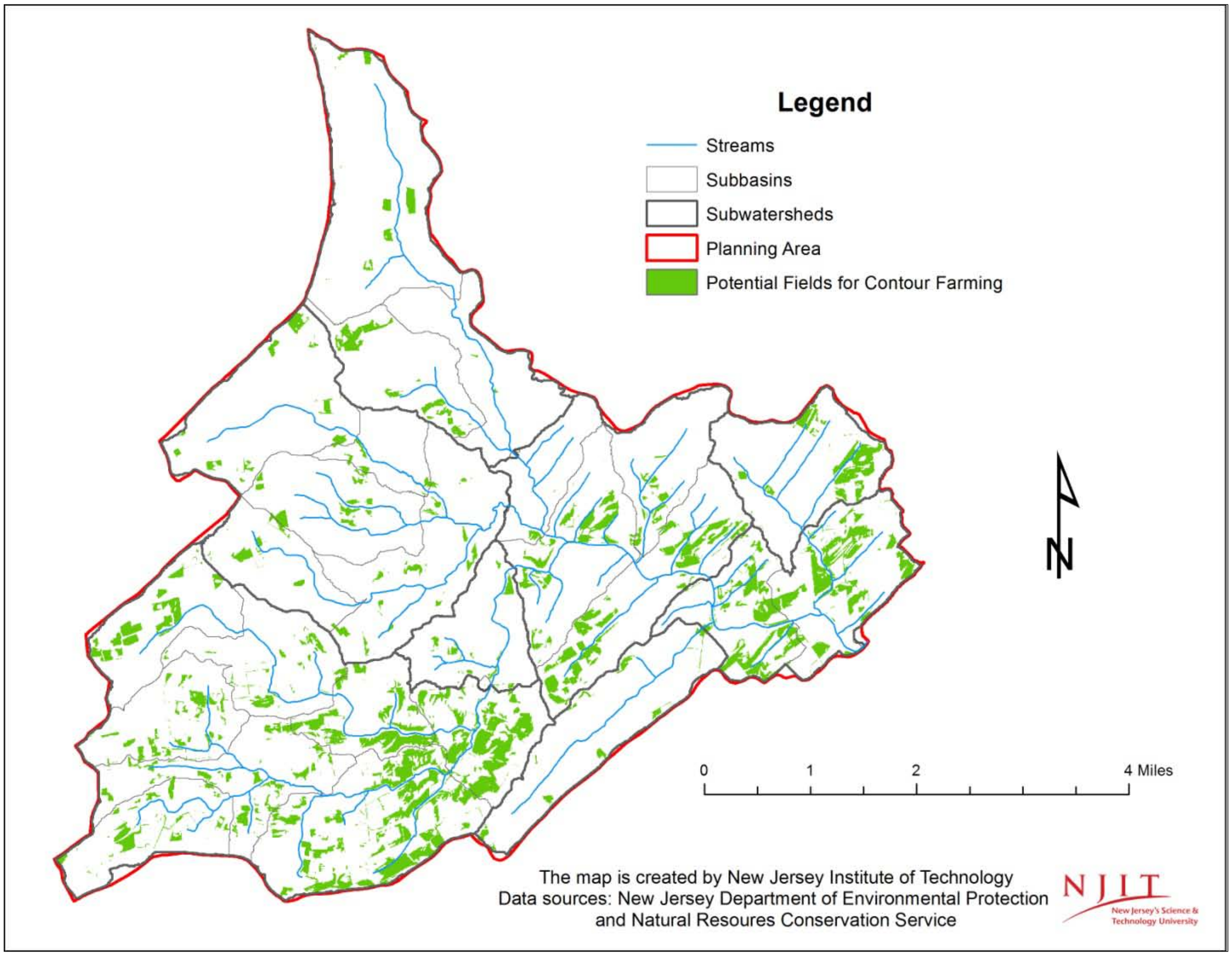


Figure 7.9: Location of potential fields for contour farming in Neshanic River Watershed

7.3.7. Nutrient Management

Currently, in the Neshanic River Watershed, there are agricultural properties which apply fertilizers at a fixed date during the growing season without testing soil nutrients. This practice can lead to over-application, resulting in runoff of excess nutrients into streams. Nutrient management means managing the amount, source, form and timing of the application of nutrients and soil amendments. It includes having a current soil test to determine which nutrients are already in the soil for plant use. This avoids applying more fertilizer than what the crop needs. Nutrient management plans are often developed by a certified professional in nutrient management planning.

Several governmental agencies, including NRCS, prepare nutrient management plans for farmers. In addition, several local agencies and non-profit organizations offer this service for little or no cost. The use of a nutrient management plan can reduce input costs to the farmer. Soil fertility is linked to many agricultural issues. Through the planning process and soil testing, farmers detect not only nutrient deficiencies, but also pH imbalances in fields. Addressing these imbalances can increase yields and avoid potential negative impacts of over fertilization. If properly promoted, nutrient management is one of the most effective practices that can be implemented in the watershed.

The NRCS AWEP 2010 practice catalog estimates the cost of implementing a nutrient management plan to be about $25 per acre for grain crops and $53 per acre for specialty crops. Cost share is available for implementing nutrient management plans. The cost-share rate can be up to 100 percent. This practice is supported by agricultural professionals, agencies and farmers.

Implementation of nutrient management plans in the watershed would reduce the nutrients available for runoff. If fewer nutrients are applied, there will be less nutrients in the runoff. Since manure is a nutrient that can be applied to fields, a nutrient management plan inherently addresses the issues of manure storage and application, creating a dialog with the producers to solve these issues.

Any and all agricultural lands that receive fertilizer amendments are suitable for nutrient management plans. Following the plans is the only assurance that fertilizers are being applied in the proper amounts determined by the soil tests. There are 7,745 acres of agricultural lands in the Neshanic River Watershed. The locations can be prioritized by subbasin ranked according to TP loading. Table 7.9 presents the total acreages of agricultural lands for row crop, hay and pasture in column 4 for each subbasin and the subbasin priority for TP load reduction in Column 5.

7.4. **Site Specific Watershed Restoration Projects**

This section presents several examples of watershed restoration projects assessed by the project team. Assessments were based on site-specific information. In some cases, the location of the sites is intentionally omitted, especially for agricultural management practices.

7.4.1. Rain Garden Projects

7.4.1.1. Individual Residential Rain Garden

Project Name: Individual Residential Rain Garden	
Location: The residence at 1 Robin Hill Way in Raritan Township	Subwatershed Priority: High
BMP Type and Description: Rain Garden	
Issues and Concerns: Roofs and lawns in residential neighborhoods are considered potential sources of nutrients and sediment in a watershed. Pollutants accumulate on streets (sediment, phosphorus, nitrogen and bacteria). The fertilizer used in residential neighborhoods can be a source of phosphorus and nitrogen. Waste from house pets and wildlife found on homeowners properties can be a source of fecal coliform in a watershed. These accumulated pollutants can be carried to local waterways via stormwater runoff.	
Existing Conditions: The house at 1 Robin Hill Way in Raritan Township, New Jersey is similar to the rest of the houses in its development. It is a new home built within the last few years. Each house is on a lot of at least 1.25 acres in size and each lot has some landscaping features with trees and shrubs; development is relatively new and the vegetative features are small. The majority of each lot is covered with turf grass. The	

property is sloped towards the driveway and street. During a storm event, the stormwater runoff carries pollutants from the lawn, roof and driveway to the local waterway. While this individual lot is most likely a small source of pollutant loading, if all the loads from all new houses in the watershed are summed, the source of pollutant loading from residential housing throughout the watershed could be substantial. Additionally, the impervious surfaces associated with residential development increase the volume of stormwater runoff that flows directly into streams. These increases in runoff volume create a flashy hydrology in the stream, causing streambank erosion and channel scouring.
Proposed Solutions:

A rain garden could be used to capture, treat and infiltrate the stormwater runoff from residential development that would ordinarily flow directly to the storm sewer system and the local streams. To capture runoff from the driveway, a small notch will be cut out of the bottom of the driveway and, a drain would be installed in the notch with a grate on top of it. The drain would collect the runoff from the driveway and discharge it to a rain garden just west of the driveway. The rain garden will be large enough to capture all the runoff from the New Jersey Stormwater Quality Storm (1.25 inches). The rain garden will have an outlet for larger storms. That outlet will discharge excess runoff onto the street and route that runoff to a detention basin. The rain garden will be between six inches to 12 inches deep and contain native plants and shrubs.
Anticipated Benefits: Since 90 percent of the rainfall events deliver less than 1.25 inches of rain, the rain garden is expected to capture approximately 90 percent of the stormwater runoff from the drainage area that it was designed to treat. By capturing and infiltrating runoff from approximately 90 percent of all the storms during the course of a year, the rain garden will reduce pollutant loads entering the stream by 90 percent. By installing a rain garden at this site that captures runoff from 1,000 square feet of driveway, this project would reduce TSS by 2.1 pounds per year, TP by 0.012 pounds per year and TN by 0.10 pounds per year. Additionally, the rain garden will capture, treat and infiltrate approximately 25,000 gallons of stormwater runoff per year.
Major Implementation Issues: The most critical step in implementing individual rain gardens is to have the consent of the property owner. The property owner has to agree to have the rain garden installed on their property, keep the rain

garden for a long period of time, and properly maintain the rain garden. If the rain garden is not maintained, it will not work properly. This problem can be overcome by involving the property owner in the design process and incorporating their ideas into the design of the rain garden as much as possible.				
Possible Funding Sources: 319(h) grants from the NJDEP				
Possible Partners/Stakeholders: Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA				
Task	Task Description			Estimated Cost
1	Complete topographic survey and soils test			$500
2	Prepare final design			$500
	Activities for BMP installation	Unit Cost	Quantity	
	Install rain garden (assumes most work completed by volunteers)	$1,000	1	$1,000
	Supervision of volunteers	$500	1	$500
	Contingency (20%)	$150	1	$150
	Total BMP installation cost			$1,650
Estimated total project cost				**$2,650**
Annual operation and maintenance cost				$100

7.4.1.2. Road Side Rain Garden

Project Name: Road Residential Rain Garden	
Location: The Cul-De-Sac by 75 Johanna Farm Road in Raritan Township	Subwatershed Priority: High
BMP Type and Description: Road Rain Garden	
Issues and Concerns: Roofs and lawns in residential neighborhoods are considered potential sources of nutrients and sediment in a watershed. Pollutants (sediment, phosphorus, nitrogen and bacteria) accumulate on streets and can be carried to local waterways via stormwater runoff. Fertilizer use in residential neighborhoods can be a source of phosphorus and nitrogen. Waste from house pets and wildlife found on homeowners' properties can be a source of fecal coliform in the watershed.	
Existing Conditions: This new development, constructed within the past few years, consists of 11 houses on approximately 13.3 acres of land and contains approximately 3.5 acres of impervious surfaces. Approximately one acre of this impervious surface is the road. Just like driveways and other landscapes, roadways accumulate sediment and other pollutants that get washed away into the stream. The entire development drains into a large detention basin. Unfortunately, it has been well documented that detention basins do not treat stormwater runoff very well, especially for small storms. Before the stormwater runoff is routed to the detention basin, it passes over a measurable amount of the roadway to reach a catch basin. The runoff from lawns, roofs, driveways and roadways are combined on the roadway before it reaches the catch basin and ultimately the Neshanic River.	
Proposed Solutions: The roadway for this development routes the stormwater runoff from all the landscapes into the catch basin. Rain gardens can be installed along the roadway to capture the runoff just upstream of the catch basin. Such rain gardens will be strategically placed throughout the development to capture all the runoff	

generated from the development for the New Jersey Stormwater Quality Storm (1.25 inches of rain over two-hours). A curb cut will be made near each catch basin. That cut will allow stormwater runoff to flow off the roadway and into the road rain garden. To accommodate storms that produce more runoff than the road rain gardens can capture, the water elevation in the rain garden will be equal the elevation of the road. This allows runoff to bypass the rain garden and discharge directly to the catch basin. The road rain garden will be vegetated with woody shrubs and herbaceous plugs.

Anticipated Benefits:

Since 90 percent of the rainfall events deliver less than 1.25 inches of rain, the rain garden is expected to capture approximately 90 percent of the stormwater runoff from the drainage area that it was designed to treat. By capturing and infiltrating runoff from approximately 90 percent of all the storms that occur during the course of a year, the rain garden will reduce pollutant loads entering the stream by 90 percent. Installing rain gardens at this site to capture runoff from the entire one acre of roadway will reduce TSS by 180 pounds per year, TP by 0.81 pounds per year and TN by 19.8 pounds per year. Additionally, these rain gardens will capture, treat and infiltrate approximately 1.1 million gallons of stormwater runoff per year.

Major Implementation Issues:

The most critical step in implementing individual rain gardens is to have the consent of the property owner. The property owner has to agree to have the rain garden installed on their property, keep the rain garden for a long period of time, and properly maintain the rain garden. If the rain garden is not maintained, it does not work properly. This problem can be overcome by involving the property owner in the design process and incorporating their ideas into the design of the rain garden as much as possible.

This project may prove difficult because it requires the installation of multiple rain gardens in close

proximity to each home and all of the landowners must be willing to cooperate for the project to be implemented.				
Possible Funding Sources: 319(h) grants from the NJDEP				
Possible Partners/Stakeholders: Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA				
Task	Task Description			Estimated Cost
1	Complete topographic survey and soils test			$2,000
2	Prepare final design			$5,000
	Activities for BMP installation (per rain garden)	Unit Cost	Quantity	
	Install rain garden (assumes most work completed by volunteers)	$2,000	1	$2,000
	Supervision of volunteers	$1,000	1	$1,000
	Contingency (20%)	$200	1	$300
	Total BMP installation cost			$3,300
Estimated total project cost				**$10,300**
Annual operation and maintenance cost				$500

7.4.1.3. Commercial Rain Garden – Shoppes Parking Lot

Project Name: Shoppes Parking Lot Rain Garden	
Location: The Shoppes of Flemington (100 Reaville Avenue Flemington, NJ 08822)	Subwatershed Priority: High
BMP Type and Description: Rain Garden	
Issues and Concerns: Parking lots are considered potential sources of nutrients and sediment in a watershed. Pollutants (sediment, phosphorus, nitrogen and bacteria) accumulate on streets and are deposited on the surface of the parking lot by wildlife (nutrients and bacteria), vehicle wear and tear (sediment), erosion and wind (sediment and nutrients) and atmospheric deposition (sediment and nutrients). These accumulated pollutants can be carried to local waterways via stormwater runoff.	
Existing Conditions: This site is a portion of the parking lot for the Bensi Restaurant and the Shoppes of Flemington strip mall in Flemington, New Jersey off of Reaville Avenue. Vegetation in this portion of the parking lot is primarily decorative street islands with turfgrass and trees. This portion of the parking lot is sloped towards one catch basin. Due to the slope of the parking lot and the placement of the street island, stormwater runoff cuts between the street islands then flows to the catch basin. The slope of the parking lot is approximately 3 to 5 percent. The site is approximately 0.5 acres. Runoff is collected in a detention basin. Detention basins provide minimal water quality treatment of stormwater; they are primarily designed to prevent flooding downstream.	
Proposed Solutions: Transforming two of the street islands into rain gardens would dramatically reduce the amount of runoff produced from the site. There are two places in the site where stormwater runoff has to pass between street islands through a narrow channel. The curbs on the street island will be cut, the street island excavated, and the current vegetation replaced with native warm season grasses, herbaceous plugs and	

woody shrubs. Rain gardens in each island will be designed to capture the stormwater runoff generated from the New Jersey Stormwater Quality Storm (1.25 inches of rain over two-hours). The outlet of each rain garden will be near the inlet of the rain garden. During storms that are larger than the New Jersey Stormwater Quality Storm, the runoff will be routed through the rain garden, treated by the rain garden's vegetation and then discharged out of the rain garden to the catch basin. This design will reduce pollutant loading from the site.

<u>Anticipated Benefits:</u>

Since 90 percent of the rainfall events deliver less than 1.25 inches of rain, the rain garden is expected to capture approximately 90 percent of the stormwater runoff from the drainage area that it was designed to treat. By capturing and infiltrating runoff from approximately 90 percent of all the storms during the course of a year, the rain garden will reduce pollutant loads entering the stream by 90 percent. Installing a rain garden at this site will capture runoff from 0.5 acre parking lot. The project would reduce TSS by 90 pounds per year, TP by 0.41 pounds per year and TN by 9.9 pounds per year. Additionally, the rain garden will capture, treat and infiltrate approximately 550,000 gallons of stormwater runoff per year.

<u>Major Implementation Issues:</u>

The most critical step in implementing individual rain gardens is to have the consent of the property owner. The property owner has to agree to have the rain garden installed on their property, keep the rain garden for a long period of time and properly maintain the rain garden. If the rain garden is not maintained, it will not work properly. This problem can be overcome by involving the property owner in the design process and incorporating their ideas into the design of the rain garden as much as possible.

<u>Possible Funding Sources:</u>

319(h) grants from the NJDEP

<u>Possible Partners/Stakeholders:</u>

Flemington Borough; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Complete topographic survey and soils test			$500
2	Prepare final design			$5,000
	Activities for BMP installation	Unit Cost	Quantity	
	Install rain garden (assumes most work completed by volunteers)	$10,000	1	$10,000
	Supervision of volunteers	$1,000	1	$1,000
	Contingency (20%)	$2,200	1	$2,200
	Total BMP installation cost			$13,200
Estimated total project cost				**$18,700**
Annual operation and maintenance cost				$300

7.4.1.4. Commercial Rain Garden – Shoprite Parking Lot

Project Name: Shoprite Parking Lot Rain Garden	
Location: 272 U.S. 202 in Raritan Township	Subwatershed Priority: High

BMP Type and Description:
Rain Garden

Issues and Concerns:
Parking lots are considered potential sources of nutrients and sediment in a watershed. Pollutants (sediment, phosphorus, nitrogen and bacteria) accumulate on streets. These pollutants are deposited on the surface of the parking lot by wildlife (nutrients and bacteria), vehicle wear and tear (sediment), erosion and wind (sediment and nutrients) and atmospheric deposition (sediment and nutrients). These accumulated pollutants can be carried to local waterways via stormwater runoff.

Existing Conditions:
This site is part of a parking lot for a strip mall on U.S. Route 202 in Flemington, New Jersey. This portion of the commercial parking lot slopes towards a concrete channel and routes water to a catch basin on Route 202. The drainage area for the concrete channel is approximately 0.18 acres. The concrete channel is surrounded by decorative vegetation that offers no storage options for stormwater runoff, and is directly underneath the roadside Shoprite sign for the strip mall. The catch basin collects runoff from Route 202.

Proposed Solutions:
The entire drainage area for this project is a parking lot. Parking lots produce runoff during each storm because there is no opportunity for rainfall to infiltrate. Replacing the concrete channel and decorative vegetation around the channel with a rain garden will allow the runoff from the parking lot to infiltrate into the ground and reduce the amount of runoff generated from the site. The concrete channel will be completely removed, and the decorative vegetation will be removed to install a rain garden.

The rain garden will be designed to capture the 1.25 inch storm, otherwise known was the New Jersey Stormwater Quality Storm. Vegetation for the rain garden will be carefully chosen and designed. Because this landscape feature is one of the first things customers see before they enter the strip mall, it needs to have the same or greater appeal than the existing landscaping. The outlet of the rain garden will discharge to the catch basin. During storms, runoff passing through the rain garden will be treated by the vegetation in the rain garden before it is ultimately discharged to the Neshanic River. This will reduce pollutant loading from the site.

<u>Anticipated Benefits:</u>

Since 90 percent of the rainfall events deliver less than 1.25 inches of rain, the rain garden is expected to capture approximately 90 percent of the stormwater runoff from the drainage area that it was designed to treat. Capturing and infiltrating runoff from approximately 90 percent of all the storms during the course of a year will reduce pollutant loads entering the stream by 90 percent. Installing a rain garden at this site to capture runoff from the 0.18 drainage area will reduce TSS by 32.4 pounds per year, TP by 0.15 pounds per year and TN by 3.6 pounds per year. Additionally, the rain garden will capture, treat and infiltrate approximately 200,000 gallons of stormwater runoff per year.

<u>Major Implementation Issues:</u>

The most critical step in implementing individual rain gardens is to have the consent of the property owner. The property owner has to agree to have the rain garden installed on their property, keep the rain garden for a long period of time and properly maintain the rain garden. If the rain garden is not maintained, the rain garden will not work properly. This problem can be overcome by involving the property owner in the design process and incorporating their ideas into the design of the rain garden as much as possible.

<u>Possible Funding Sources:</u>

319(h) grants from the NJDEP

<u>Possible Partners/Stakeholders:</u>

Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description	Estimated Cost
1	Complete topographic survey and soils test	$500

2	Prepare final design			$1,000
	Activities for BMP installation	Unit Costs	Quantity	
	Install rain garden (assumes most work completed by volunteers)	$5,000	1	$5,000
	Supervision of volunteers	$1,000	1	$1,000
	Contingency (20%)	$200	1	$1,400
	Total BMP installation cost			$8,400
Estimated total project cost				**$14,900**
Annual operation and maintenance cost				$100

7.4.2. Roadside Ditch Retrofitting

7.4.2.1. 50 Kuhl Road in Raritan Township

Project Name: Retrofit of Roadside Ditch SD-187	
Location: To the left of the house addressed 50 Kuhl Road, Flemington, NJ when facing the house.	Subwatershed Priority: High
BMP Type and Description: Vegetated Swale	
Issues and Concerns: Roadways, agricultural lands and residential development generate sediment, phosphorus and bacteria that are carried to local waterways. Between storm events, pollutants settle out of the atmosphere and accumulate on impervious surfaces, such as streets, rooftops and parking lots. These pollutants are carried by stormwater runoff into local streams. Another source of pollution is the phosphorus and nitrogen fertilizers used on agricultural lands and residential lawns. Additionally, manure fertilizer applied to agricultural lands as well as waste generated by farm animals, wildlife and domestic pets can be a source of bacteria and nutrients in the watershed. These pollutants can be washed off the land and carried to the local waterways via stormwater runoff. A roadside ditch is one conveyance system that carries the runoff from these potential sources directly to streams and/or their tributaries.	
Existing Conditions: Roadside Ditch SD-187 has an estimated drainage area of 1.3 acres. The drainage area includes Kuhl Road and agricultural lands. The roadside ditch is approximately 440 feet long and approximately 5 to 10 feet wide. There is scouring along the entire length of the ditch. Where it exists, vegetation in the ditch is turf grass. Bare soil is exposed along the entire bottom of the ditch, which allows the ditch to become a source of sediment during storm events. The outlet of the ditch is a pipe that routes the water underneath Kuhl Road and discharges it to agricultural land. Because there is no inlet to the ditch, runoff flows over the land and enters the ditch along its entire length.	
Proposed Solutions: The general purpose of a roadside ditch is to transport stormwater runoff to a nearby stream. Although they generally are not designed to treat stormwater, roadside ditches can be designed to improve water quality while moving stormwater from one location to another. Currently roadside ditch SD-187 is not only transporting stormwater runoff, but it is also contributing to pollutant loads due to the highly eroded nature of the ditch. In its existing condition, the ditch is degrading water quality by contributing additional sediment to the local waterways. Several factors negatively affect the water quality of the runoff discharged from the ditch: (1) it has a poorly designed shape; (2) it has high steep side slopes that force the elevation to rise quickly in the channel; (3) the runoff travels very quickly through the ditch eroding the ditch's side slopes and bottom	

preventing vegetation from establishing itself there. The ditch needs to be re-graded with a wider bottom and shallower side slopes and re-vegetated. Plants used to re-vegetate the ditch should only be native warm season grasses and herbaceous plants that can survive in both dry and very wet environments. The vegetation will act as a buffer and treat the stormwater runoff that passes through the ditch removing sediment and other pollutants from the stream. Finally, the size of this roadside ditch, like many in the watershed, is constrained by the very small size of ROW, which severely limits the width of the ditch. Narrow widths limit how much the ditch can be shaped during re-grading. If the shape of the ditch cannot be dramatically changed, then other methods should be used to reduce runoff velocity in the ditch.

Gabion mattresses can be used as check dams in the ditch to reduce runoff velocity in the ditch. Gabion mattresses are metal cages in the shape of long, wide and flat boxes that are filled with large stone (rip-rap). Cages are several feet long and several feet wide and only six inches tall. After stones are placed in the metal cage, the cage is closed tight. Approximately every 100 feet, mattresses are placed across the side slopes and bottom of the ditch. They obstruct the flow of the runoff for small storms, thereby reducing runoff velocity. Flow from larger storms is reduced due to the presence of the mattresses. However, most of the runoff flows over the mattresses and is less affected than the flow from larger storms.

Anticipated Benefits:

The ditches are expected to increase infiltration of water during storm events thereby removing nutrients and sediment from runoff. The native vegetation added to the ditches will be allowed to grow taller, which will increase root structure making the soil at the bottom of the ditch more porous and infiltration rates. The latter will allow less water to leave the ditch during storms thereby preventing sediment and nutrients from the entering local waterways. After the retrofits are complete, the ditch is very similar to a

vegetative buffer and is expected to have the same pollutant removal rates. Vegetative buffers typically remove 60 to 80 percent of TSS, and 30 percent of TP and TN. Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project is expected to reduce TSS by 78 to 104 pounds per year, TP by 0.23 pounds per year and TN by 1.95 pounds per year.
Major Implementation Issues: Because the efficacy of this practice rests on having tall vegetation, mowing should only be done once a year instead of the more common once per week. Residents of the township who believe ditches must be mowed more frequently are likely to object to this practice. A concentrated effort needs to be made by the project partners to inform the public about these new projects and the new natural aesthetic.
Possible Funding Sources: 319(h) grants from the NJDEP
Possible Partners/Stakeholders: Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete topographic survey and soils test			$1,000
3	Prepare final design			$2,000
4	Prepare maintenance plan			$500
5	Prepare construction documents and solicit quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Re-vegetate the ditch (assumes installed by volunteers)	$0.5/sq. ft.	4,400 sq. ft.	$2,200
	Supervision of volunteers	$2,000	1	$2,000
	Re-grade ditch	$5,000	1	$5,000
	Rip-rap check dam	$1,000/100 linear feet	2	$2,000
	Soil erosion and sediment control	$1,000	1	$1,000
	Contingency (20%)	2,440	1	$2,440
	Total BMP installation cost			$14,640
Estimated total project cost				**$19,640**
Annual operation and maintenance cost				$500

7.4.2.2. South Side of Kuhl Road in Raritan Township

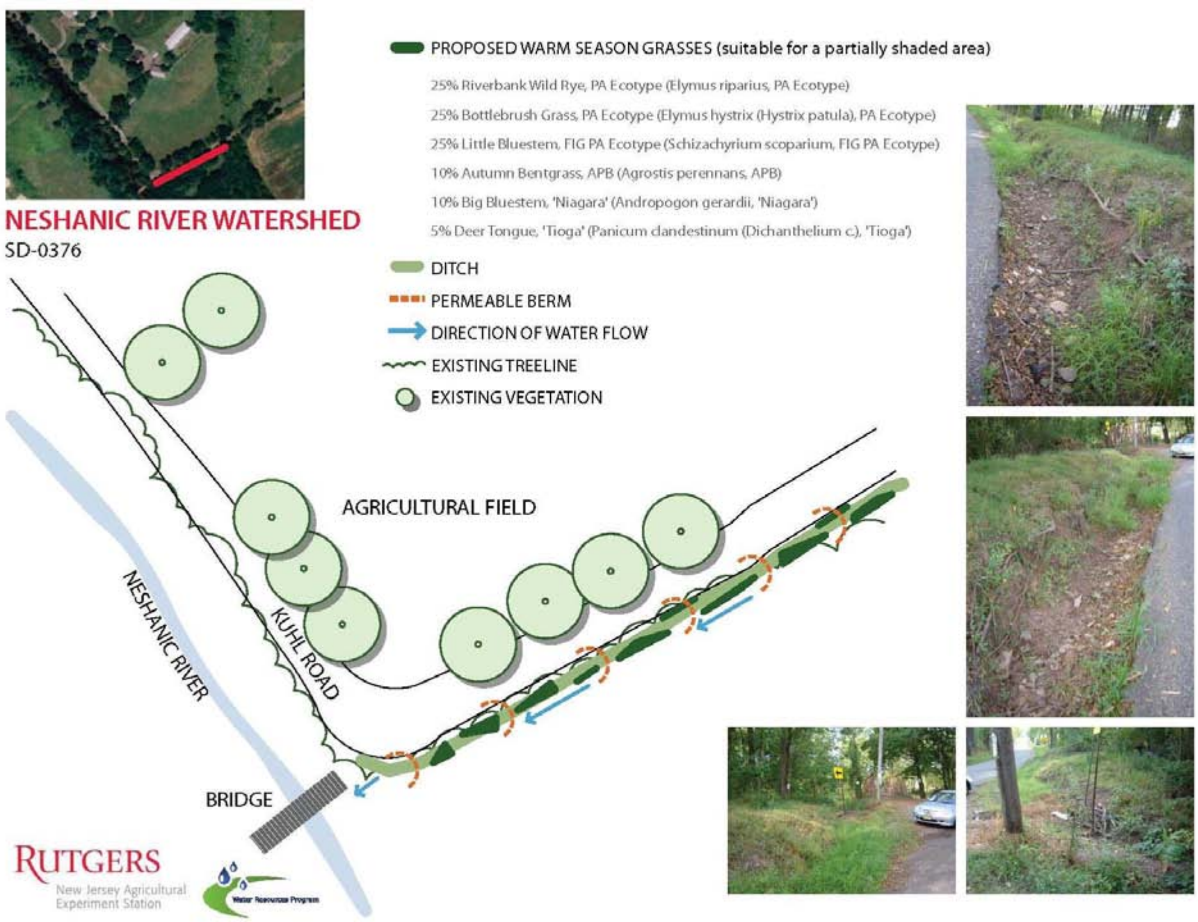
Project Name: Retrofit of Roadside Ditch SD-376	
Location: At the sharp bend in Kuhl Road in Raritan Township (south side of the road)	Subwatershed Priority: High
BMP Type and Description: Vegetated Swale	
Issues and Concerns: Roadways, agricultural lands and residential development can be sources of sediment, phosphorus and bacteria for local waterways. Between storm events, pollutants settle out of the atmosphere and accumulate on impervious surfaces, such as streets, rooftops and parking lots. These pollutants are washed into stormwater runoff and enter local streams during storm events. Another source of pollution, mainly phosphorus and nitrogen, is the fertilizer used on agricultural lands and residential lawns.	

Additionally, manure used as fertilizer on agricultural lands, wastes generated by farm animals, wildlife and domestic pets, are a source of bacteria and nutrient loads in the watershed. These pollutants can be washed off the land and carried to the local waterways via stormwater runoff. Roadside ditches are a conveyance system that carries the runoff from these sources into streams and/or their tributaries.

<u>Existing Conditions:</u>

Roadside Ditch SD-376 has an estimated drainage area of 0.63 acres, which includes Kuhl Road and agricultural lands. The roadside ditch is approximately 355 feet long and approximately 3 to 5 feet wide. There is scouring along the entire length of the ditch. When present, vegetation in the ditch is turf grass. Bare soil is exposed along the entire bottom of the ditch, which allows the ditch to become a source of sediment during storm events. At the outlet of the ditch is a pipe that routes the water directly to the Neshanic River. Because there is no inlet to the ditch, runoff flows over land and enters the ditch along its entire length.

<u>Proposed Solutions:</u>



The general purpose of a roadside ditch is to transport stormwater runoff to a nearby stream. Although generally not designed to treat stormwater, roadside ditches can be upgraded to improve water quality while moving stormwater from one location to another. Currently, roadside ditch SD-376 transports stormwater runoff and contributes to pollutant loads due to the highly eroded nature of the ditch. In its current condition, the ditch is degrading water quality by contributing additional sediment to the local waterways.

Several factors negatively affect the water quality of runoff discharged from the ditch: (1) it has a poorly designed shape; (2) it has high steep side slopes that force the elevation to rise quickly in the channel; and (3) the runoff travels very quickly through the ditch eroding the ditch's side slopes and bottom preventing vegetation from establishing itself there. The ditch needs to be re-graded with a wider bottom and shallower side slopes.

After the ditch is re-graded it needs to be re-vegetated. Plants used to re-vegetate the ditch should only be native warm season grasses and herbaceous plants that can survive in both dry and very wet environments. The vegetation will act as a buffer and treat the stormwater runoff that passes through the ditch removing sediment and other pollutants from the stream. Finally, the size of this roadside ditch, like many in the watershed, is constrained by the very small size of ROW, which severely limits the width of the ditch. Narrow widths limit how much the ditch can be shaped during re-grading. If the shape of the ditch cannot be dramatically changed, then other methods should be used to reduce runoff velocity in the ditch.

Gabion mattresses can be used as check dams in the ditch to reduce runoff velocity in the ditch. Gabion mattresses are metal cages in the shape of long, wide and flat boxes that are filled with large stone (rip-rap). The cages are several feet long and several feet wide and only six inches tall. After the stones are placed in the metal cage, the cage is closed tight. Approximately every 100 feet, the mattresses are placed across the side slopes and bottom of the ditch. They obstruct the flow of the runoff for small storms, thereby reducing runoff velocity. Flow from larger storms is reduced due to the presence of the mattresses. However, most of the runoff flows over the mattresses and is less affected than the flow from larger storms.

Anticipated Benefits:

The ditches are expected to increase infiltration of water during storm events thereby removing nutrients and sediment from the runoff. The new native vegetation added to the ditches will be allowed to grow taller, which will increase root structure making the soil at the bottom of the ditch more porous and infiltration rates. The latter will allow less water to leave the ditch during storms thereby preventing sediment and nutrients from the entering local waterways. After the retrofits are complete, the ditch is very similar to a vegetative buffer and is expected to have the same pollutant removal rates. Vegetative buffers typically remove 60 to 80 percent of TSS, and 30 percent of TP and TN. Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project is expected to reduce TSS by 38 to 50 pounds per year, TP by 0.11 pounds per year and TN by 0.95 pounds per year.

Major Implementation Issues:

Because the efficacy of this practice rests on having tall vegetation, mowing should only be done once a year instead of the more common once per week. Residents of the township who believe ditches must be mowed more frequently are likely to object to this practice. A concentrated effort needs to be made by the project partners to inform the public about these new projects and the new natural aesthetic.

Possible Funding Sources:

319(h) grants from the NJDEP

Possible Partners/Stakeholders:

Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

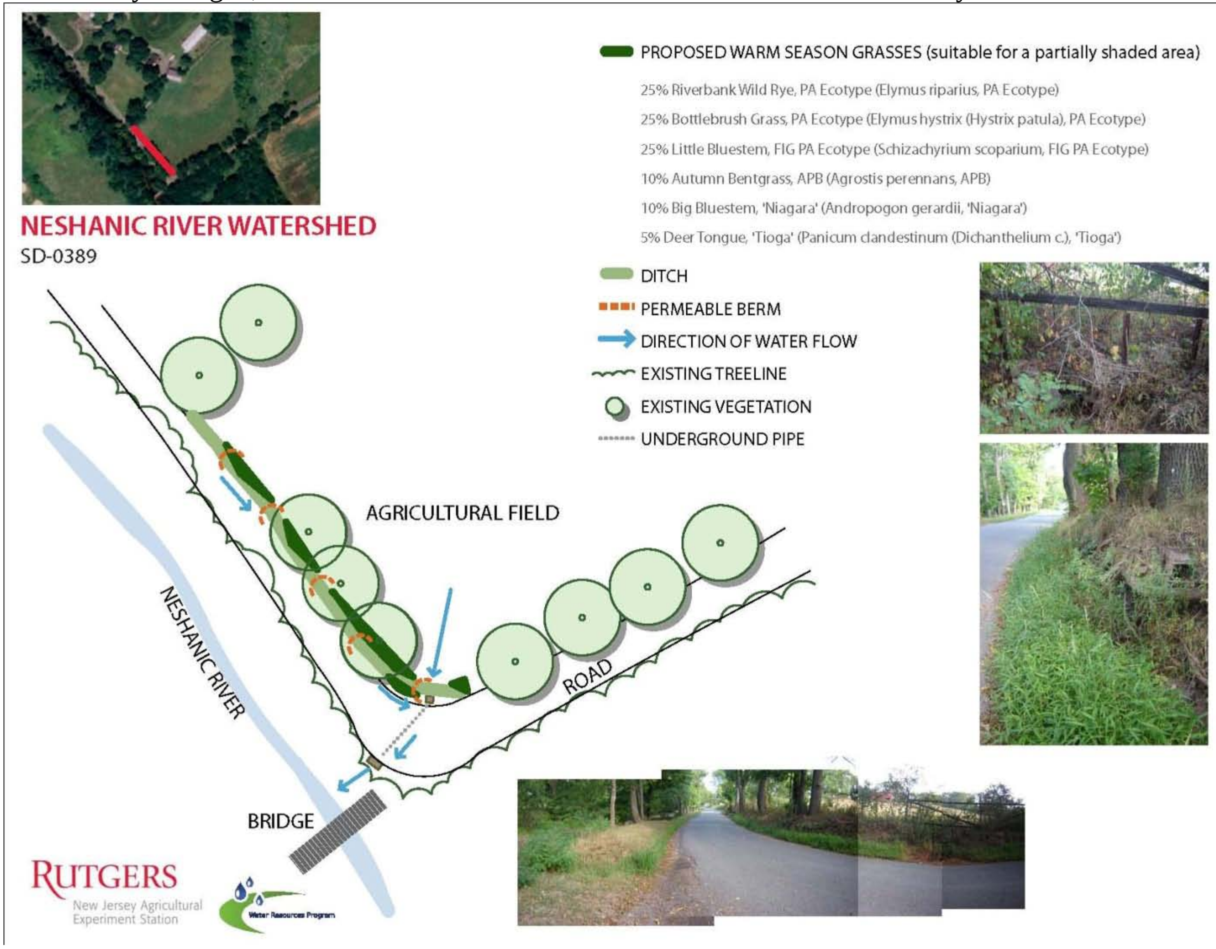
<table>
<tr><th>Task</th><th colspan="3">Task Description</th><th>Estimated Cost</th></tr>
<tr><td>1</td><td colspan="3">Apply for Soil Erosion and Sediment Control Permit</td><td>$500</td></tr>
<tr><td>2</td><td colspan="3">Complete topographic survey and soils test</td><td>$1,000</td></tr>
<tr><td>3</td><td colspan="3">Prepare final design</td><td>$2,000</td></tr>
<tr><td>4</td><td colspan="3">Prepare maintenance plan</td><td>$500</td></tr>
<tr><td>5</td><td colspan="3">Prepare construction documents and solicit quotes from contractors</td><td>$1,000</td></tr>
<tr><td></td><td>Activities for BMP installation</td><td>Unit Cost</td><td>Quantity</td><td></td></tr>
</table>

	Re-vegetate the ditch (assumes installed by volunteers)	$0.5/sq. ft.	1,775 sq. ft.	$888
	Supervision of volunteers	$2,000	1	$2,000
	Re-grade ditch	$5,000	1	$5,000
	Rip-rap check dam	$1,000/100 linear feet	3	$3,000
	Erosion and sediment control	$1,000	1	$1,000
	Contingency (20%)	$2,377	1	$2,377
	Total BMP installation cost			$14,266
Estimated total project cost				**$19,266**
Annual operation and maintenance cost				$500

7.4.2.3. North Side of Kuhl Road in Raritan Township

Project Name: Retrofit of Roadside Ditch SD-389	
Location: At the sharp bend in Kuhl Road in Raritan Township (north side of the road)	Subwatershed Priority: High
BMP Type and Description: Vegetated Swale	
Roadways, agricultural lands and residential development can be sources of sediment, phosphorus and bacteria for local waterways. Between storm events, pollutants settle out of the atmosphere and accumulate on impervious surfaces, such as streets, rooftops and parking lots. These pollutants are washed into stormwater runoff and enter local streams during storm events. Another source of pollution, mainly phosphorus and nitrogen, is the fertilizer used on agricultural lands and residential lawns. Additionally, manure used as fertilizer on agricultural lands, wastes generated by farm animals, wildlife and domestic pets, are a source of bacteria and nutrient loads in the watershed. These pollutants can be washed off the land and carried to the local waterways via stormwater runoff. Roadside ditches are a conveyance system that carries the runoff from these sources into streams and/or their tributaries.	
Existing Conditions: Roadside Ditch SD-389 has an estimated drainage area of 1.7 acres, which includes Kuhl Road and agricultural land uses. The roadside ditch is approximately 225 feet long and approximately 3 to 5 feet wide. There is scouring along the entire length of the ditch. The ditch has very steep side slopes that are mostly bare soil. Vegetation along the bottom of each ditch is sparse. Bare soil and sparse vegetation make the ditch a source of sediment during storm events. At the outlet of the ditch is a pipe that routes the water underneath the Kuhl Road and into the Neshanic River. Because there is no inlet to the ditch, runoff flows over land and enters the ditch along its entire length. The ditch is not connected to any other ditches and is responsible for the runoff from its drainage area.	
Proposed Solutions: The general purpose of a roadside ditch is to transport stormwater runoff to a nearby stream. Although generally are not designed to treat stormwater, roadside ditches can be made upgraded to improve water quality while moving stormwater from one location to another. Currently roadside ditch SD-389 transports stormwater runoff and contributes to pollutant loads due to the highly eroded nature of the ditch. In its current condition, the ditch is degrading water quality by contributing additional sediment to the local waterways. Several factors negatively affect the water quality of runoff discharged from the ditch: (1) it has a poorly	

designed shape; (2) it has high steep side slopes that force the elevation to rise quickly in the channel; and (3) the runoff travels very quickly through the ditch eroding the ditch's side slopes and bottom preventing vegetation from establishing itself there. The ditch needs to be re-graded with a wider bottom and shallower side slopes. Plants used to re-vegetate the ditch should only be native warm season grasses and herbaceous plants that can survive in both dry and very wet environments. The vegetation will act as a buffer and treat the stormwater runoff that passes through the ditch removing sediment and other pollutants from the stream. Finally, the size of this roadside ditch, like many in the watershed, is constrained by the very small ROW, which severely limits the width of the ditch. Narrow widths limit how much the ditch can be shaped during the re-grading process. If the shape of the ditch cannot be dramatically changed, then other methods should be used to reduce runoff velocity in the ditch.



Gabion mattresses can be used as check dams in the ditch to reduce runoff velocity in the ditch. Gabion mattresses are metal cages in the shape of long, wide and flat boxes that are filled with large stone (rip-rap). Cages are several feet long and several feet wide and only six inches tall. After the stones are placed in the metal cage, the cage is closed tight, Approximately every 100 feet, mattresses are placed across the side slopes and bottom of the ditch. They obstruct the flow of the runoff for small storms, thereby reducing runoff velocity. Flow from larger storms is reduced due to the presence of the mattresses. However, most of the runoff flows over the mattresses and is less affected than the flow from larger storms.

Anticipated Benefits:

The ditches are expected to increase infiltration of water during storm events thereby removing nutrients and sediment from the runoff. The native vegetation added to the ditches will be allowed to grow taller, which will increase root structure making the soil at the bottom of the ditch more porous and infiltration rates. The latter will allow less water to leave the ditch during storms, thereby preventing sediment and nutrients from the entering local waterways. After the retrofits are complete, the ditch is very similar to a vegetative buffer and is expected to have the same pollutant removal rates. Vegetative buffers typically remove 60 to 80 percent of TSS, and 30 percent of TP and TN. Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year, and 5 pounds of TN per acre per year, the project is expected to reduce TSS by 144 to 152 pounds per year, TP by 0.34 pounds per year and TN by 2.85 pounds per year.

Major Implementation Issues:
Because the efficacy of this practice rests on having tall vegetation, mowing should only be done once a year instead of the more common once per week. Residents of the township who believe ditches must be mowed more frequently are likely to object to this practice. A concentrated effort needs to be made by the project partners to inform the public about these new projects and the new natural aesthetic.

Possible Funding Sources:
319(h) grants from the NJDEP

Possible Partners/Stakeholders:
Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Re-vegetate the Ditch (assumes installed by volunteers)	$0.5/sq. ft.	1,125 sq. ft.	$563
	Supervision of Volunteers	$2,000	1	$2,000
	Re-grade Ditch	$5,000	1	$5,000
	Rip Rap Check Dam	$1,000/100 linear feet	2	$2,000
	Soil Erosion and Sediment Control	$1,000	1	$1,000
	Contingency (20%)	$2,127	1	$2,127
	Total BMP installation cost			$12,766
Estimated total project cost				**$17,676**
Annual operation and maintenance cost				$500

7.4.2.4. 55 Rittenhouse Road in Delaware Township

Project Name: Retrofit of Roadside Ditch SD-525

Location:	Subwatershed Priority:
By 55 Rittenhouse Road in Delaware Township	High

BMP Type and Description:
Vegetated Swale

Issues and Concerns:
Roadways, agricultural lands and residential development can be sources of sediment, phosphorus and bacteria for local waterways. Between storm events, pollutants settle out of the atmosphere and accumulate on impervious surfaces, such as streets, rooftops and parking lots. These pollutants are

washed into stormwater runoff and enter local streams during storm events. Another source of pollution, mainly phosphorus and nitrogen, is the fertilizer used on agricultural lands and residential lawns. Additionally, manure used as fertilizer on agricultural lands, wastes generated by farm animals, wildlife and domestic pets, are a source of bacteria and nutrient loads in the watershed. These pollutants can be washed off the land and carried to the local waterways via stormwater runoff. Roadside ditches are a conveyance system that carries the runoff from these sources into streams and/or their tributaries.

Existing Conditions:

Roadside Ditch SD-525 has an estimated drainage area of 1.9 acres, which includes Rittenhouse Road and residential land uses. The roadside ditch is approximately 60 feet long and approximately 3 to 5 feet wide. There is scouring along the entire length of the ditch. There is no vegetation along the bottom of the ditch, only bare soil, which allows the ditch to become a source of sediment during storm events. The outlet of the ditch routed underneath Rittenhouse Road and discharged to another ditch, which eventually discharges to a tributary of the Neshanic River. Because there is no inlet to the ditch, runoff flows over land and enters the ditch along its entire length.

Proposed Solutions:

The general purpose of a roadside ditch is to transport stormwater runoff to a nearby stream. Although generally not designed to treat the stormwater, roadside ditches can be upgraded to improve water quality while moving stormwater from one location to another. Currently, roadside ditch SD-525 transports stormwater runoff and contributes to pollutant loads due to the highly eroded nature of the ditch. In its current condition, the ditch is degrading water quality by contributing additional sediment to the local waterways.

Several factors negatively affect the water quality of runoff discharged from the ditch: (1) it has a poorly designed shape; (2) it has high steep side slopes that force the elevation to rise quickly in the channel; and (3) the runoff travels very quickly through the ditch eroding the ditch's side slopes and bottom preventing vegetation from establishing itself there. The ditch needs to be re-graded with a wider bottom and shallower side slopes.

After the ditch is re-graded it needs to be re-vegetated. Plants used to re-vegetate the ditch should only be native warm season grasses and herbaceous plants that can survive in both dry and very wet environments. The vegetation should thrive in the ditch environment, acting as a buffer and treating the stormwater runoff that passes through the ditch removing sediment and other pollutants from the stream.

Anticipated Benefits:
The ditches are expected to increase infiltration of water during storm events thereby removing nutrients and sediment from the runoff. The new native vegetation added to the ditches will be allowed to grow taller, which will increase root structure making the soil at the bottom of the ditch more porous and infiltration rates. The latter will allow less water to leave the ditch during storms thereby preventing sediment and nutrients from the entering local waterways. After the retrofits are complete, the ditch is very similar to a vegetative buffer and is expected to have the same pollutant removal rates. Vegetative buffers typically remove 60 to 80 percent of TSS, and 30 percent of TP and TN. Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project is expected to reduce TSS by 144 to 152 pounds per year, TP by 0.34 pounds per year and TN by 2.85 pounds per year.

Major Implementation Issues:
Because the efficacy of this practice rests on having tall vegetation, mowing should only be done once a year instead of the more common once per week. Residents of the township who believe ditches must be mowed more frequently are likely to object to this practice. A concentrated effort needs to be made by the project partners to inform the public about these new projects and the new natural aesthetic.

Possible Funding Sources:
319(h) grants from the NJDEP

Possible Partners/Stakeholders:
Delaware Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Re-vegetate the Ditch (assumes installed by volunteers)	$0.5/sq. ft.	300 sq. ft.	$150
	Supervision of Volunteers	$2,000	1	$2,000
	Re-grade Ditch	$5,000	1	$5,000
	Soil Erosion and Sediment Control	$1,000	1	$1,000
	Contingency (20%)	$1,630	1	$1,630
	Total BMP installation cost			$9,780
Estimated total project cost				**$14,780**
Annual operation and maintenance cost				$500

7.4.2.5. Yard Road in Delaware Township

Project Name: Retrofit of Roadside Ditch SD-618

<table>
<tr><td><u>Location:</u>
On Yard Road in Delaware Township approximately 4,000 feet east of the Sandbrook Headquarters Road intersection</td><td><u>Subwatershed Priority:</u>
High</td></tr>
<tr><td colspan="2"><u>BMP Type and Description:</u>
Vegetated Swale</td></tr>
<tr><td colspan="2"><u>Issues and Concerns:</u>
Roadways, agricultural lands and residential development can be sources of sediment, phosphorus and bacteria for local waterways. Between storm events, pollutants settle out of the atmosphere and accumulate on impervious surfaces, such as streets, rooftops and parking lots. These pollutants are washed into by stormwater runoff and enter local streams during storm events. Another source of pollution, mainly phosphorus and nitrogen, is the fertilizer used on agricultural lands and residential lawns. Additionally, manure used as fertilizer on agricultural lands, wastes generated by farm animals, wildlife and domestic pets, are a source of bacteria and nutrient loads in the watershed. These pollutants can be washed off the land and carried to the local waterways via stormwater runoff. Roadside ditches are a conveyance system that carries the runoff from these sources into streams and/or their tributaries.</td></tr>
<tr><td colspan="2"><u>Existing Conditions:</u>
Roadside Ditch SD-618 has an estimated drainage area of 1 acre, which includes Yard Road and residential properties. The roadside ditch is approximately 134 feet long and approximately 3 to 5 feet wide. There is scouring along the entire length of the ditch. When present, vegetation in the ditch is turf grass. Most of the vegetation in the ditch is dried out and dead. Bare soil and dead vegetation allow the ditch to become a source of sediment during storm events. Because there is no inlet for the ditch, runoff flows over land and enters the ditch along its entire length. This ditch is just one in a series of ditches along Yard Road. This particular ditch is in very bad condition.</td></tr>
<tr><td colspan="2"><u>Proposed Solutions:</u>
The general purpose of a roadside ditch is to transport stormwater runoff to a nearby stream. Although generally not designed to treat the stormwater, roadside ditches can be upgraded to improve water quality while moving stormwater from one location to another. Currently, roadside ditch SD-618 transports stormwater runoff and contributes to pollutant loads due to the highly eroded nature of the ditch. In its current condition, the ditch is degrading water quality by contributing additional sediment to the local waterways.

Several factors that negatively affect the water quality of the runoff discharged from the ditch: (1) it has a poorly designed shape; (2) it has high steep side slopes that force the elevation to rise quickly in the channel; and (3) the runoff travels very quickly through the ditch eroding the ditch's side slopes and bottom preventing vegetation from establishing itself there. The ditch needs to be re-graded with a wider bottom and shallower side slopes.

After the ditch is re-graded it needs to be re-vegetated. Plants used to re-vegetate the ditch should only be native warm season grasses and herbaceous plants that can survive in both dry and very wet environments. This vegetation should thrive in the ditch environment. The vegetation will act as a buffer and treat the stormwater runoff that passes through the ditch removing sediment and other pollutants from the stream. Finally, the size of this roadside ditch, like many in the watershed, is constrained by the very small ROW, which severely limits the width of the ditch. Narrow widths limit how much the ditch can be shaped during the re-grading process. If the shape of the ditch cannot be dramatically changed, then other methods should be used to reduce the runoff velocity in the ditch.

Gabion mattresses can be used as check dams in the ditch to reduce runoff velocity in the ditch. Gabion mattresses are metal cages in the shape of long, wide and flat boxes that are filled with large stone (rip-rap). The cages are several feet long and several feet wide and only six inches tall. After the stones are</td></tr>
</table>

placed in the metal cage, the cage is closed tight. Approximately every 100 feet, the mattresses are placed across the side slopes and bottom of the ditch. They obstruct the flow of the runoff for small storms, thereby reducing runoff velocity. Flow from larger storms is reduced due to the presence of the mattresses. However, most of the runoff would flows over the mattresses and is less affected than the flow from larger storms.

Anticipated Benefits:

The ditches are expected to increase infiltration of water during storm events thereby removing nutrients and sediment from the runoff. The new native vegetation added to the ditches will be allowed to grow taller, which will increase root structure making the soil at the bottom of the ditch more porous and infiltration rates. The latter will allow less water to leave the ditch during storms thereby preventing sediment and nutrients from the entering local waterways. After the retrofits are complete, the ditch is very similar to a vegetative buffer and is expected to have the same pollutant removal rates. Vegetative buffers typically remove 60 to 80 percent of TSS, 30 percent of TP and TN. Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project is expected to reduce TSS by 60 to 80 pounds per year, TP by 0.18 pounds per year and TN by 1.5 pounds per year.

Major Implementation Issues:

Because the efficacy of this practice rests on having tall vegetation, mowing should only be done once a year instead of the more common once per week. Residents of the township who believe ditches must be

mowed more frequently are likely to object to this practice. A concentrated effort needs to be made by the project partners to inform the public about these new projects and the new natural aesthetic.				
Possible Funding Sources: 319(h) grants from the NJDEP				
Possible Partners/Stakeholders: Delaware Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA				
Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Re-vegetate the Ditch (assumes installed by volunteers)	$0.5/sq. ft.	670 sq. ft.	$338
	Supervision of Volunteers	$2000	1	$2000
	Re-grade Ditch	$5000	1	$5000
	Rip Rap Check Dam	$1000/100 linear feet		$1,000
	Erosion and Sediment Control	$1,000	1	$1,000
	Contingency (20%)	$1,868	1	$1,868
	Total BMP installation cost			$11,206
Estimated total project cost				**$16,206**
Annual operation and maintenance cost				$500

7.4.3. Detention Basin Retrofitting

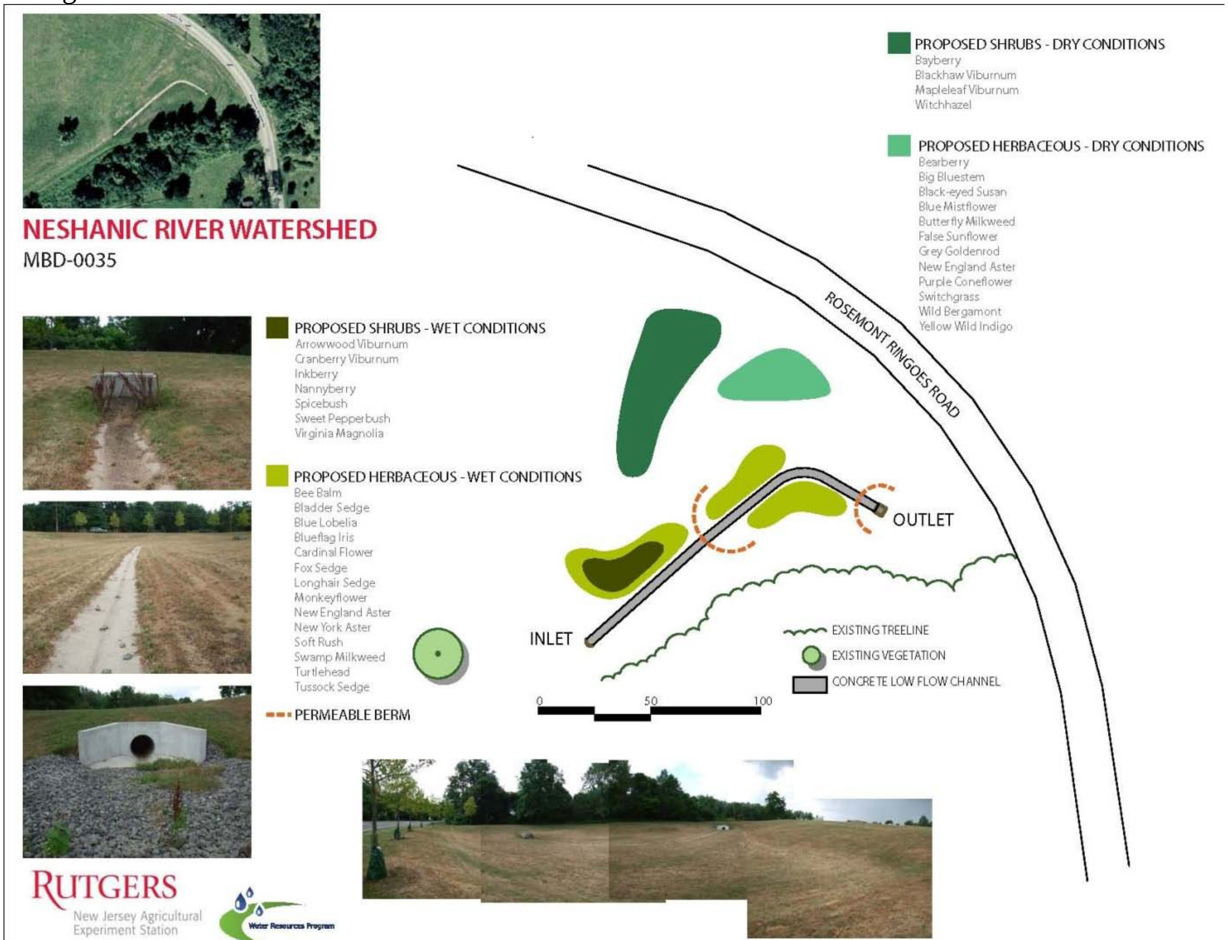
7.4.3.1. Intersection of Rosemont Ringoes Road and Lambert Road in Delaware Township

Project Name: Detention Basin Retrofit of Detention Basin MDB-0035	
Location: Intersection of Rosemont Ringoes Road and Lambert Road in Delaware Township	Subwatershed Priority: High
BMP Type and Description: Bioretention Basin	
Issues and Concerns: Residential neighborhoods can be a source of sediment, phosphorus and bacteria for local waterways. All the surfaces of a residential neighborhood (streets, sidewalks, roofs and lawns) are potential sources of one or more of these pollutants. Pollutants accumulate on roofs, sidewalks and streets. Local wildlife and domestic pet wastes are sources of bacteria and nutrients. Fertilizer used on residential lawns is a source of phosphorus and nitrogen. Accumulated pollutants are carried to local waterways via stormwater runoff.	
Existing Conditions: Detention Basin MDB – 0035 has an estimated drainage area of 20 acres. The drainage area is the Delaware Township Elementary School. The detention basin is approximately 0.84 acres in size. It has one inlet that connects to a low flow concrete channel. Accumulation of sediment in the concrete low flow channel suggests that it is not maintained on any regular basis. The basin is approximately 10 to	

15 feet deep with a side slope of 10 to 15 percent. The detention basin does not have a water quality outlet structure, but the outlet is protected by a trash rack. The detention basin is in clear view of an elementary school.

Proposed Solutions:

The solution for this project is in two parts. The first part is re-vegetating the basin. Clusters of turf grass will be replaced with native warm season grasses, herbaceous plants, sedges, ferns and a minimum of woody vegetation. Over time, the new vegetation will expand past the boundaries of the clusters to cover the entire basin. The new vegetation will increase the infiltration rate of the basin. The basin will not be mowed on a weekly basis as it is now. Vegetation will be allowed to grow tall, increasing its ability to filter nutrients and sediment from stormwater runoff. Tall vegetation has a deeper and more complex root structure, allowing the basin to infiltrate greater amounts of water during storm events.



The second part of the solution is a small berm or series of berms surrounding the outlet of the basin. Each berm would be about one foot high and constructed using a permeable material, such as coconut fiber logs or ¾ inch clean stone secured with fabric. The berm will increase the amount of time runoff remains in the basin. In addition, the berm would constrict the flow of runoff for small, frequent storms, but not interfere with the capacity of the basin to prevent flooding from larger storms because runoff would flow over the berm. Runoff from smaller storms would inundate a larger surface area, increasing infiltration and treatment of runoff.

Anticipated Benefits:

The detention basin is expected to increase infiltration of water and remove more nutrients and sediment from runoff during storm events. Native vegetation will be allowed to grow tall, which results in a larger root structure. Taller plants are expected to increase infiltration of stormwater runoff and remove sediment and nutrients from runoff. The more extensive root structure will make the soil at the bottom of the basin more porous and increase infiltration rates. Increased infiltration rates of the basin will allow less water to leave the basin after storms, which would prevent sediment and nutrients from entering local water ways. After the retrofits are complete, the basin will be very similar to a bioretention basin with the same pollutant removal rates. Bioretention basins typically remove 90 percent of TSS, 60 percent of TP and 30 percent TN. Removal rates for bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007 and Karathanasis et al., 2003). Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year, and 5 pounds of TN per acre per year, the project would reduce TSS by 1,800 pounds per year, TP by 7.2 pounds per year and TN by 30.0 pounds per year.

Major Implementation Issues:
There two impediments to the implementation of this project. The first is permitting. This project requires a permit from the local conservation district, which indicates the district approves the proposed alterations of the basin. The soil conservation district could be a partner on this project, but it would need evidence that the berms planned for the project would not adversely affect how the basin prevents flooding downstream or reduce the storage capacity of the basin.

The second impediment is aesthetics. This detention basin handles the drainage for the stormwater runoff of the Delaware Township Elementary School. School officials may resist the project because they may prefer the look of the basin with mowed turf grass and landscaped shrubs rather than the more natural look proposed in the project. Re-vegetation of the basin could be incorporated into the school's science curriculum and serve as a learning opportunity for students.

Possible Funding Sources:
319(h) grants from the NJDEP

Possible Partners/Stakeholders:
Delaware Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Remove old and install new vegetation (assumes volunteer work)	$0.25/sq. ft.	36,590 sq. ft.	$9,147
	Supervision of Volunteers	$2,000	1	$2,000
	Install berms	$5,000	1	$5,000
	Contingency (20%)	$3,229	1	$3,229
	Total BMP installation cost			$19,376
Estimated total project cost				**$24,376**
Annual operation and maintenance cost				$500

7.4.3.2. Intersection of Johanna Farms Road and Castleton Lane in Raritan Township

Project Name: Detention Basin Retrofit of Detention Basin MDB-0054	
Location:	Subwatershed Priority:

Intersection of Johanna Farms Road and Castleton Lane in Raritan Township	Medium
BMP Type and Description: Bioretention Basin	
Issues and Concerns: Residential neighborhoods can be a source of sediment, phosphorus and bacteria for local waterways. All the surfaces of a residential neighborhood (streets, sidewalks, roofs and lawns) are potential sources of one or more of these pollutants. Pollutants accumulate on roofs, sidewalks and streets. Local wildlife and domestic pet wastes are sources of bacteria and nutrients. Fertilizer used on residential lawns is a source of phosphorus and nitrogen. Accumulated pollutants are carried to local waterways via stormwater runoff.	
Existing Conditions: Detention Basin MDB – 0054 has an estimated drainage area of 14.3 acres. The drainage area is comprised of a low density residential area. The detention basin is approximately 0.81 acres in size. It has one inlet that connects to a low flow concrete channel. Accumulation of sediment in the concrete low flow channel suggests that it is not maintained on any regular basis. The basin is approximately three to five feet deep with a side slope of 2 to 5 percent. The detention basin does not have a water quality outlet structure, but the outlet is protected by a trash rack. The detention basin is in clear view of a commonly used roadway that is near a residential neighborhood.	
Proposed Solutions: The solution for this project is in three parts. The first part is re-vegetating the basin. Clusters of turf grass will be replaced with native warm season grasses, herbaceous plants, sedges, ferns and a minimum of woody vegetation. Overtime, the new vegetation will expand past the boundaries of the clusters to cover the entire basin. The new vegetation will increase the infiltration rate of the basin. The basin will not be mowed on a weekly basis as it is now. Vegetation will be allowed to grow tall, increasing its ability to filter nutrients and sediment from stormwater runoff. The tall vegetation has a deeper and more complex root structure allowing the basin to infiltrate greater amounts of water during each storm event. Rerouting the flow of the runoff is the second part of this solution. Currently, the low flow concrete channel directly connects to the outlet and inlet of the basin, which are very close to each other. The runoff only has to travel 71 feet from the inlet to the outlet. If a section of the low flow concrete channel could be removed, then the water would have to travel more than 71 feet to exit the basin, allowing more time for sediment and nutrients to be filtered out of the water column. The third part of the solution is a small berm or series of berms surrounding the outlet of the basin. Each berm would be about one foot high and constructed of a permeable material, such as coconut fiber logs or ¾ inch clean stone secured with fabric. The berm will increase the amount of time runoff remains in the basin. In addition, the berm would constrict the flow of runoff for small, frequent storms, but not interfere with the capacity of to prevent flooding from larger storms because the runoff would flow over the berm. Runoff from smaller storms would inundate a larger surface area, increasing infiltration and treatment of the runoff.	

<u>Anticipated Benefits:</u>

The detention basin is expected to increase infiltration of water and remove more nutrients and sediment from runoff during storm events. Native vegetation will be allowed to grow tall, which results in a larger root structure. Taller plants are expected to increase infiltration of stormwater runoff and remove sediment and nutrients from runoff. The more extensive root structure will make the soil at the bottom of the basin more porous and increase infiltration rate. Increased infiltration rates of the basin will allow less water to leave the basin after storms, which would prevent sediment and nutrients from the entering local water ways. After the retrofits are complete, the basin will be very similar to a bioretention basin with the same pollutant removal rates. Bioretention basins typically remove 90 percent of TSS, 60 percent of TP and 30 percent TN. Removal rates for bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007 and Karathanasis et al., 2003). Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project would reduce TSS by 1,287 pounds per year, TP by 5.1 pounds per year and TN by 21.5 pounds per year.

<u>Major Implementation Issues:</u>

There two impediments to the implementation of this project. The first is permitting. This project requires a permit from the local conservation district, which indicates the district approves the proposed alterations of the basin. The soil conservation district could be a partner on this project, but they would need evidence that the berms planned for the project would not adversely affect how the basin prevents flooding downstream or reduce the storage capacity of the basin.

The second impediment is aesthetics. This site runs along a commonly used road and is easily visible from the road. Local residents may resist the project because they may prefer the look of the basin with mowed turf grass and landscaped shrubs rather than the more natural look proposed in the project.				
Possible Funding Sources: 319(h) grants from the NJDEP				
Possible Partners/Stakeholders: Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA				
Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Remove old and install new vegetation (assumes volunteer work)	$0.25/sq. ft.	35,283 sq. ft.	$8,820
	Supervision of Volunteers	$2,000	1	$2,000
	Install berms	$5,000	1	$5,000
	Contingency (20%)	$3,164	1	$3,164
	Total BMP installation cost			$18,984
Estimated total project cost				**$23,984**
Annual operation and maintenance cost				$500

7.4.3.3. Intersection of Longbow Terrace and S. Autumn Leaf Blvd in Raritan Township

Project Name: Detention Basin Retrofit of Detention Basin MDB-0069	
Location: Intersection of Longbow Terrace and S. Autumn Leaf Blvd in Raritan Township	Subwatershed Priority: Medium
BMP Type and Description: Bioretention Basin	
Issues and Concerns: Residential neighborhoods can be a source of sediment, phosphorus and bacteria for local waterways. All the surfaces of a residential neighborhood (streets, sidewalks, roofs and lawns) are potential sources of one or more of these pollutants. Pollutants accumulate on roofs, sidewalks and streets. Local wildlife and domestic pet wastes are sources of bacteria and nutrients. Fertilizer used on residential lawns is a source of phosphorus and nitrogen. Accumulated pollutants are carried to the local waterways via stormwater runoff.	
Existing Conditions: Detention Basin MDB – 0069 has an estimated drainage area of 37.2 acres. The drainage area is comprised of a low density residential area. The detention basin is approximately 0.86 acres in size. It has two inlets that connect to a low flow concrete channel. The latter does not appear to be maintained on any regular basis. The basin is approximately five to six feet deep with a side slope of 5 to 10 percent. The detention basin does not have a water quality outlet structure, but the outlet for the basin consists of a trash rack that covers the opening of a concrete pipe. The detention basin is in clear view of a commonly used roadway in the middle of a residential neighborhood.	

Proposed Solutions:
The solution for this project is in two parts. The first part is re-vegetating the basin. Clusters of turf grass will be replaced with native warm season grasses, herbaceous plants, sedges, ferns and a minimum of woody vegetation. Over time, the new vegetation will expand past the boundaries of the clusters to cover the entire basin. The new vegetation will increase the infiltration rate of the basin. The basin will not be mowed on a weekly basis as it is now. The vegetation will be allowed to grow tall, which increases its ability to filter nutrients and sediment from stormwater runoff. Tall vegetation has a deeper and more complex root structure, allowing the basin to infiltrate greater amounts of water during storm events.

The second part of the solution is a small berm or series of berms surrounding the outlet of the basin. Each berm would be about one foot high and constructed using a permeable material, such as coconut fiber logs or ¾ inch clean stone secured with fabric. The berm will increase the amount of time runoff remains in the basin. In addition, the berm would constrict the flow of runoff for small, frequent storms, but not interfere with the capacity of the basin to prevent flooding from larger storms because runoff would flow over the berm. Runoff from smaller storms would inundate a larger surface area, increasing infiltration and treatment of runoff.

Anticipated Benefits:
The detention basin is expected to increase infiltration of water and remove more nutrients and sediment from the runoff during storm events. Native vegetation will be allowed to grow tall, which results in a larger root structure. Taller plants are expected to increase infiltration of stormwater runoff and remove sediment and nutrients. The more extensive root structure will make the soil at the bottom

of the basin more porous and increase infiltration rates. Increased infiltration rates of the basin will allow less water to leave the basin after storms, which would prevent sediment and nutrients from entering local water ways. After the retrofits are complete, the basin will be very similar to a bioretention basin with the same pollutant removal rates. Bioretention basins typically remove 90 percent of TSS, 60 percent of TP and 30 percent TN. Removal rates for bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007 and Karathanasis et al., 2003). Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project would reduce TSS by 3,348 pounds per year, TP by 13.4 pounds per year and TN by 55.8 pounds per year.
Major Implementation Issues: There two impediments to the implementation of this project. The first is permitting. This project requires a permit from the local conservation district, which indicates the district approves the proposed alterations of the basin. The soil conservation district could be a partner on this project, but it would need evidence that the berms planned for the project would not adversely affect how the basin prevents flooding downstream or reduce the storage capacity of the basin. The second impediment is aesthetics. This site runs along a commonly used road, making the site visible from the road. Local residents may resist the project because they may prefer the look of the basin with mowed turf grass and landscaped shrubs rather than the more natural look proposed in the project.
Possible Funding Sources: 319(h) grants from the NJDEP
Possible Partners/Stakeholders: Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Remove old and install new vegetation (assumes volunteer work)	$0.25/sq. ft.	37,461 sq. ft.	$9,365
	Supervision of Volunteers	$2,000	1	$2,000
	Install berms	$5,000	1	$5,000
	Contingency (20%)	$3,273	1	$3,273
	Total BMP installation cost			$19,638
Estimated total project cost				**$24,638**
Annual operation and maintenance cost				$500

7.4.3.4. Hardy Drive in Raritan Township

Project Name: Detention Basin Retrofit of Detention Basin MDB-0136	
Location: Hardy Drive in Raritan Township	Subwatershed Priority: High
BMP Type and Description: Bioretention Basin	

Issues and Concerns:
Residential neighborhoods can be a source of sediment, phosphorus and bacteria for local waterways. All the surfaces of a residential neighborhood (streets, sidewalks, roofs and lawns) are potential sources of one or more of these pollutants. Pollutants accumulate on roofs, sidewalks and streets. Local wildlife and domestic pet wastes are sources of bacteria and nutrients. Fertilizer used on residential lawns is a source of phosphorus and nitrogen. Accumulated pollutants are carried to the local waterways via stormwater runoff.

Existing Conditions:
Detention Basin MDB – 0136 has an estimated drainage area of 35.4 acres. The drainage area is comprised of a low density residential area. The detention basin is approximately 1.26 acres in size. It has one inlet that connects to a low flow concrete channel. The low flow concrete channel does not appear to be maintained on a regular basis. The basin is approximately two to four feet deep with a side slope of 2 to 5 percent. The detention basin does not have a water quality outlet structure, but the outlet is protected by a trash rack. The detention basin is in clear view of a commonly used roadway near a residential neighborhood.

Proposed Solutions:
The solution for this project is in two parts. The first part is re-vegetating the basin. Clusters of turf grass will be replaced with native warm season grasses, herbaceous plants, sedges, ferns and a minimum of woody vegetation. Over time, the new vegetation will expand past the boundaries of the clusters to cover the entire basin. The new vegetation will increase the infiltration rate of the basin. The basin will not be mowed on a weekly basis as it is now. Vegetation will be allowed to grow tall, increasing its ability to filter nutrients and sediment from stormwater runoff. The tall vegetation has a deeper and more complex root structure, allowing the basin to infiltrate greater amounts of water during storm events.

The second part of the solution is a small berm or series of berms surrounding the outlet of the basin.

Each berm would only be about one foot high and constructed using a permeable material, such as coconut fiber logs or ¾ inch clean stone secured with fabric. The berm will increase the amount of time runoff remains in the basin. In addition, the berm would constrict the flow of runoff for small, frequent storms, but not interfere with the capacity of the basin to prevent flooding from larger storms because the runoff would flow over the berm. Runoff from smaller storms would inundate a larger surface area, increasing infiltration and treatment of runoff.

<u>Anticipated Benefits:</u>
The detention basin is expected to increase infiltration of water and remove more nutrients and sediment from the runoff during storm events. Native vegetation will be allowed to grow tall, which results in a larger root structure. Taller plants are expected to increase infiltration of stormwater runoff and remove sediment and nutrients from runoff. The more extensive root structure will make the soil at the bottom of the basin more porous and increase infiltration rates. Increased infiltration rates of the basin will allow less water to leave the basin after storms, which would prevent sediment and nutrients from entering local waterways. After the retrofits are complete, the basin will be very similar to a bioretention basin with the same pollutant removal rates. Bioretention basins typically remove 90 percent of TSS, 60 percent of TP and 30 percent TN. Removal rates for bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007 and Karathanasis et al., 2003). Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year, and 5 pounds of TN per acre per year, the project would reduce TSS by 3,186 pounds per year, TP by 12.7 pounds per year and TN by 53.1 pounds per year.

<u>Major Implementation Issues:</u>
There two impediments to the implementation of this project. The first is permitting. This project requires a permit from the local conservation district, which indicates the district approves the proposed alterations of the basin. The soil conservation district could be a partner on this project, but it would need evidence that the berms planned for the project would not adversely affect how the basin prevents flooding downstream or reduce the storage capacity of the basin.

The second impediment is aesthetics and current use. This site runs along a commonly used road and is easily visible from the road. Local residents may resist the project because they may prefer the look of the basin with mowed turf grass and landscaped shrubs rather than the more natural look proposed in the project. During a site visit, lacrosse and golf balls were found in the basin. Local residents may not want any changes made to the basin because of its recreational value.

<u>Possible Funding Sources:</u>
319(h) grants from the NJDEP

<u>Possible Partners/Stakeholders:</u>
Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA

Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Remove old and install new vegetation (assumes volunteer work)	$0.25/sq. ft.	54,885 sq. ft.	$13,721
	Supervision of Volunteers	$2,000	1	$2,000
	Install berms	$5,000	1	$5,000
	Contingency (20%)	$4,144	1	$4,144

	Total BMP installation cost	$24,865
Estimated total project cost		**$29,865**
Annual operation and maintenance cost		$500

7.4.3.5. Coventry Circle in Raritan Township

<u>Project Name:</u> Detention Basin Retrofit of Detention Basin MDB-0150	
<u>Location:</u> Outside of Coventry Circle in Raritan Township	<u>Subwatershed Priority:</u> High
<u>BMP Type and Description:</u> Bioretention Basin	
<u>Issues and Concerns:</u> Residential neighborhoods can be a source of sediment, phosphorus and bacteria for local waterways. All the surfaces of a residential neighborhood (streets, sidewalks, roofs and lawns) are potential sources of one or more of these pollutants. Pollutants accumulate on roofs, sidewalks and streets. Local wildlife and domestic pet wastes are sources of bacteria and nutrients. Fertilizer used on residential lawns is a source of phosphorus and nitrogen. Accumulated pollutants are carried to local waterways via stormwater runoff.	
<u>Existing Conditions:</u> Detention Basin MDB – 0150 has an estimated drainage area of 17.5 acres. The drainage area is a residential neighborhood in Raritan Township. The detention basin is approximately 0.92 acres in size. It has two inlets that each has their own low flow channel. One channel is comprised of concrete and the other channel is comprised of stone. Accumulation of sediment in the concrete low flow channel suggests that it is not maintained on a regular basis. The basin is approximately three to four feet deep with a side slope of 5 to 10 percent. It does not have a water quality outlet structure, but the outlet has a large concrete weir (see Figure below). The detention basin is in clear view of a commonly used roadway near a residential neighborhood.	
<u>Proposed Solutions:</u> The solution for this project is in two parts. The first part is re-vegetating the basin. Clusters of turf grass will be replaced with native warm season grasses, herbaceous plants, sedges, ferns and a minimum of woody vegetation. Over time, the new vegetation will expand past the boundaries of the clusters to cover the entire basin. The new vegetation will increase the infiltration rate of the basin. The basin will not be mowed on a weekly basis as it is now. Vegetation will be allowed to grow tall, increasing its ability to filter nutrients and sediment from stormwater runoff. Tall vegetation has a deeper and more complex root structure, allowing the basin to infiltrate greater amounts of water during storm events. The second part of the solution is a small berm or series of berms surrounding the outlet of the basin. Each berm would only be about one foot high and constructed using a permeable material, such as coconut fiber logs or ¾ inch clean stone secured with fabric. The berm will increase the amount of time runoff remains in the basin. In addition, the berm would constrict the flow of runoff for small, frequent storms, but not interfere with the capacity of the basin to prevent flooding from larger storms because the runoff would flow over the berm. Runoff from smaller storms would inundate a larger surface area, increasing infiltration and treatment of runoff.	

Anticipated Benefits:

The detention basin is expected to increase infiltration of water and remove more nutrients and sediment from runoff during storm events. Native vegetation will be allowed to grow tall, which results in a larger root structure. Taller plants are expected to increase infiltration of stormwater runoff and remove sediment and nutrients from runoff. The more extensive root structure will make the soil at the bottom of the basin more porous and increase the infiltration rates. Increased infiltration rates of the basin will allow less water to leave the basin after storms, which would prevent sediment and nutrients from the entering local water ways. After the retrofits are complete, the basin will be very similar to a bioretention basin with the same pollutant removal rates. Bioretention basins typically remove 90 percent of TSS, 60 percent of TP and 30 percent TN. Removal rates for bioretention basins and wetlands are at or above 90 percent for fecal coliform (Rusciano and Obropta, 2007 and Karathanasis et al., 2003). Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.6 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project would reduce TSS by 1,575 pounds per year, TP by 6.3 pounds per year and TN by 26.3 pounds per year.

Major Implementation Issues:

There two impediments to the implementation of this project. The first is permitting. This project requires a permit from the local conservation district, which indicates the district approves the proposed alterations of the basin. The soil conservation district could be a partner on this project, but it would need evidence that the berms planned for the project would not adversely affect how the basin prevents flooding downstream or reduce the storage capacity of the basin.

The second impediment is aesthetics. This detention basin handles the drainage for the stormwater

runoff of a residential neighborhood. Local residents may resist the project because they may prefer the look of the basin with mowed turf grass and landscaped shrubs rather than the more natural look proposed in the project. The Water Resources Program would work with township officials and local residents to develop a design that is acceptable to the neighborhood.				
Possible Funding Sources: 319(h) grants from the NJDEP				
Possible Partners/Stakeholders: Raritan Township; NJRC&D; HCSCD; RCE; NJIT; and NJWSA				
Task	Task Description			Estimated Cost
1	Apply for Soil Erosion and Sediment Control Permit			$500
2	Complete Topographic Survey and soils test			$1,000
3	Prepare Final Design			$2,000
4	Prepare Maintenance Plan			$500
5	Prepare construction Documents and Solicit Quotes from contractors			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Remove old and install new vegetation (assumes volunteer work)	$0.25/sq. ft.	40,075 sq. ft.	$10,018
	Supervision of Volunteers	$2,000	1	$2,000
	Install berms	$5,000	1	$5,000
	Contingency (20%)	$3,404	1	$3,404
	Total BMP installation cost			$20,422
Estimated total project cost				**$25,422**
Annual operation and maintenance cost				$500

7.4.4. Vegetative Buffers for Non-agricultural Developed Lands

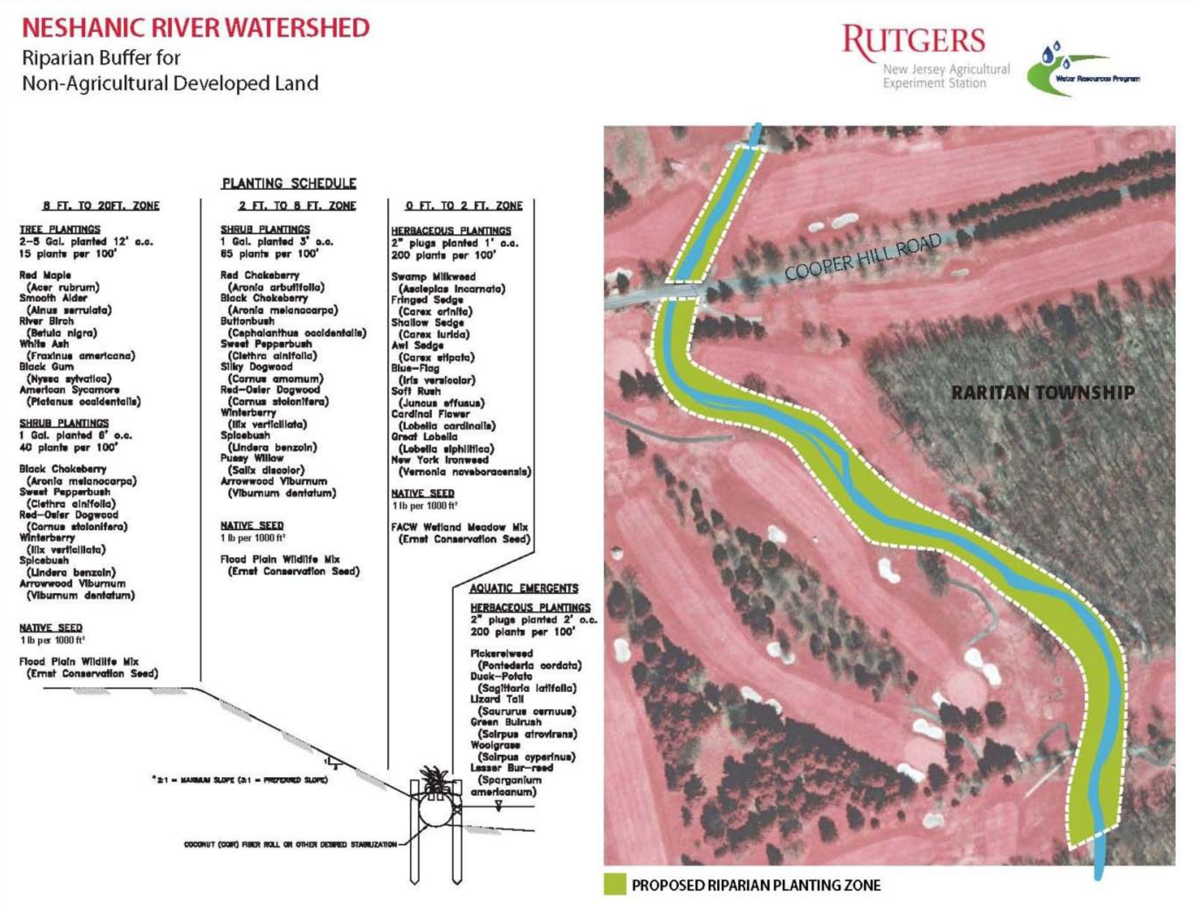
7.4.4.1. Copper Hill Country Club (Golf Course) in Raritan Township

Project Name: Non-Agricultural Developed Land Vegetative Buffer	
Location: Copper Hill Country Club (Golf Course) in Raritan Township	Subwatershed Priority: High
BMP Type and Description: Vegetative Buffer	
Issues and Concerns: Golf courses are considered potential sources of nutrients, bacteria and sediment in a watershed. The amount of fertilizer used at these facilities greatly increases the potential for golf courses to become a source of phosphorus and nitrogen. Additionally, geese that feed in these large grassed areas deposit feces, which is high in nutrients and pathogens. Accumulated pollutants can be carried to the local waterways via stormwater runoff.	
Existing Conditions: The proposed site for this project is a small tributary in Raritan Township that runs through the Copper Hill Country Club. The stream is approximately 1,900 feet long at this site. Despite a few trees and small shrubs along the edge of the shoreline, there is no buffer along either side of the tributary. The portion of the tributary in the golf course has an approximate drainage area of 44.15 acres. Vegetation on both sides of the tributary is mostly turf grass, which does not provide a high level of treatment for stormwater runoff from the golf course. In addition, turf grass attracts geese, which leave behind feces high in nutrients and pathogens. Golf courses are mowed every day and heavily fertilized. Stormwater	

runoff carries the lawn cuttings, excess fertilizer and waste from wildlife to the stream.

Proposed Solutions:

The golf course does not have any subsurface drainage system; stormwater from the site travels as runoff over the land until it reaches the tributary. The landscape of the golf course cannot be altered drastically without interfering with its architecture. This drastically limits the BMPs options for to improving water quality of the stormwater runoff generated onsite. While the landscape cannot be drastically changed, there is flexibility to add vegetation along the shoreline of the tributary. The recommended solution for this site is a vegetated buffer between 30 and 50 feet wide. The buffer would have a dynamic design that integrates it into the existing vegetation and landscape design of the golf course. Vegetation in the buffer will be diverse, comprised of warm season grasses, herbaceous plugs, woody shrubs and trees. This buffer will treat all of the stormwater runoff that passes through it. Vegetation will reduce the velocity of the stormwater runoff passing through the buffer, causing sediment, nutrients and bacteria to fall out of suspension and be deposited in the buffer. Deposited pollutants will be used by the vegetation to grow, thereby increasing the filtering and treatment potential of the buffer.



Anticipated Benefits:

The vegetative buffer is expected to treat and filter the stormwater runoff from every storm event. Vegetative buffers typically remove 60 to 80 percent of TSS, 30 percent of TP and 30 percent TN. Based upon aerial loading calculations for the drainage area of 100 pounds of TSS per acre per year, 0.2 pounds of TP per acre per year and 5 pounds of TN per acre per year, the project would reduce TSS by 2,649 to 3,532 pounds per year, TP by 2.65 pounds per year and TN by 66.23 pounds per year.

Major Implementation Issues:

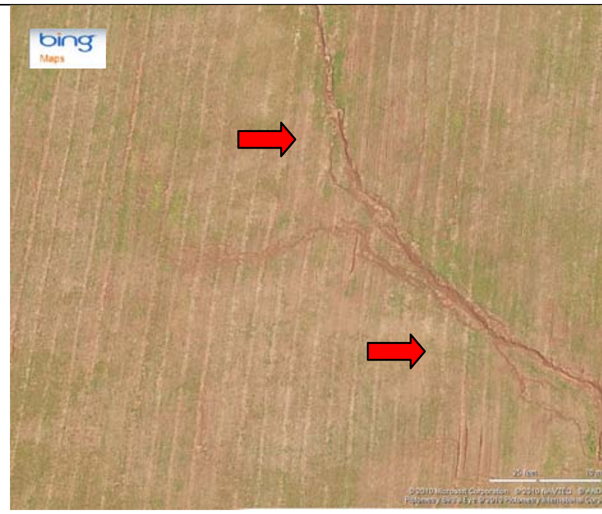
A major obstacle to implementing a vegetative buffer is convincing the golf course to install this BMP

on its property. Once funding is secured, the golf course owner can be approached about installing the vegetative buffer. The golf course owner has to agree to keep and maintain the vegetative buffer for a long period of time. If the vegetative buffer is not maintained, it will not achieve the potential water quality benefits. This problem can be overcome by incorporating the property owner's ideas in the design of the buffer. The golf course owner is likely to require that the buffer design match the existing landscape of the golf course, which could raise the total cost of the project.				
Possible Funding Sources: 319(h) grants from the NJDEP				
Partners/Stakeholders: NJRC&D; HCSCD; RCE; NJIT; NJDEP and NJWSA				
Task	Task Description			Estimated Cost
1	Complete topographic survey and soils test			$500
2	Prepare final design			$1,000
	Activities for BMP installation	Unit Cost	Quantity	
	Install vegetative buffer (assumes most work completed by volunteers)	$5,000	1	$5,000
	Supervision of volunteers	$1,000	1	$1,000
	Contingency (20%)	$200	1	$200
	Total BMP installation cost			$6,200
Estimated total project cost				**$7,700**
Annual operation and maintenance cost				$100

7.4.5. Project for Agricultural Lands

7.4.5.1. Cover Crops

Project Name: Cover Crops
Location: Watershed wide
BMP Type and Description: Cover crops include grasses, legumes, forbs or other herbaceous plants established for seasonal cover and other conservation purposes.
Issues and Concerns: Exposed soil particles are vulnerable to being dislodged by rainfall and swept away. Eroded soil particles may carry phosphorus and other adsorbed contaminants to local waterways.
Existing Conditions: The images shown below illustrate some of the current crop field conditions in the Neshanic River Watershed that contribute to water quality degradation. Seasonally, some crop fields have inadequate vegetative cover. Bare soil is susceptible to becoming dislodged and carried into streams by runoff during storm events. Suspended soil particles contain phosphorus and other contaminants. Erosion is indicated in the images below by the red arrows. Cover crops protect the soil particles from becoming dislodged, helping to reduce erosion and retain soil nutrients for future crop use.



Proposed Solutions:

Cover crops would be planted on fields that are seasonally barren. Examples of cover crops are: Hairy Vetch (*Visa villosa Roth),* Winter Wheat (*Triticum vulgare),* Sorghum-sudangrass (*Sorghum bicolor*), Rye Grass (*Lolium spp.*) and Buckwheat (*Fagopyrum esculentum Moench*). The NRCS New Jersey Field Office Technical Guide (FOTG) practice code for cover crops is 340.

Anticipated Benefits:

Planting cover crops on barren fields reduces runoff, and wind and water erosion. Such crops absorb nutrients left from previous fertilizer and manure applications to the soil, making them unavailable for runoff. In addition, cover crops enhance overall soil health, reduce compaction and increase infiltration. Cover crops are especially beneficial in areas of the watershed where streams run dry during the summer.

The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 4,011 acres of row crops in the watershed, yielding on average approximately 1.3 pounds of TP per acre annually for a watershed total of 5,223 pounds per year. The Chesapeake Bay Water Quality Model showed that early planting of cover crops reduced TP by 15 percent. Based on reduction rates determined by the Chesapeake Bay Model and assuming row crop acres are beneficial, indicates that cover crops would reduce TP loading in the watershed by 0.195 pounds per acre or 769 pounds per year for the watershed.

The 4,011 acres of row crops in the watershed have an annual average sediment yield of approximately 0.10 tons of per acre or 396 tons for the watershed. The Chesapeake Bay Water Quality Model showed that early planting of cover crops reduces sediment yield by 20 percent. Based on reduction rates determined by the Chesapeake Bay Model and assuming row crop acres reduce sediment loads, indicates that cover crops would reduce annual sediment loads by 0.02 tons per acre or 99 tons per year for the watershed.

Major Implementation Issues:

Use of cover crops involves a cost for materials and time. The time period between the harvesting of row crops and seeding of cover crops is very short, which may be problematic for some farmers. State and federal agencies have cost-share programs that cover some of the implementation cost of cover crops. In some cases, a cover crop can be harvested to generate additional revenue. There is also a cost savings when a cover crop provides nutrient credits for the subsequent crop.

Possible Funding Sources:

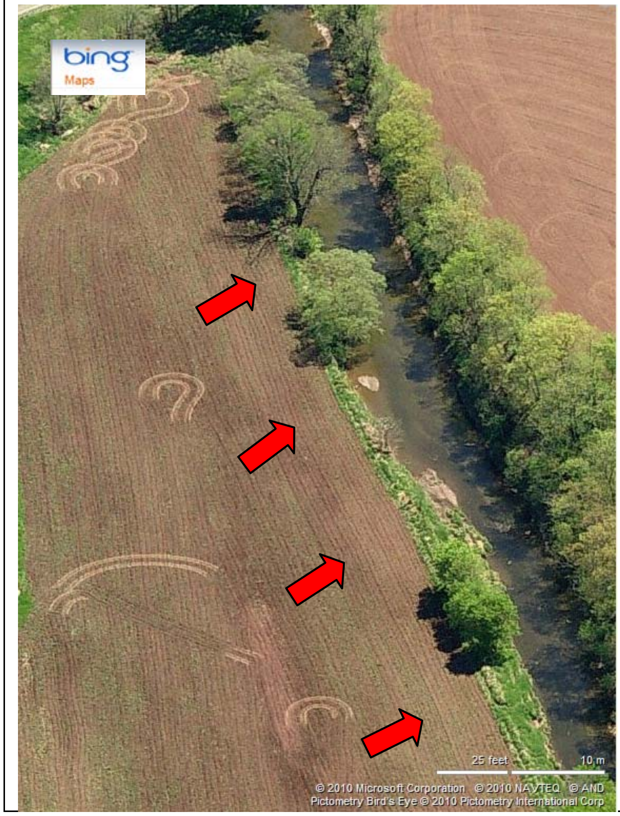
EPA 319(h) through NJDEP, Private, NJDA State Cost share, USDA Farm Bill Programs such

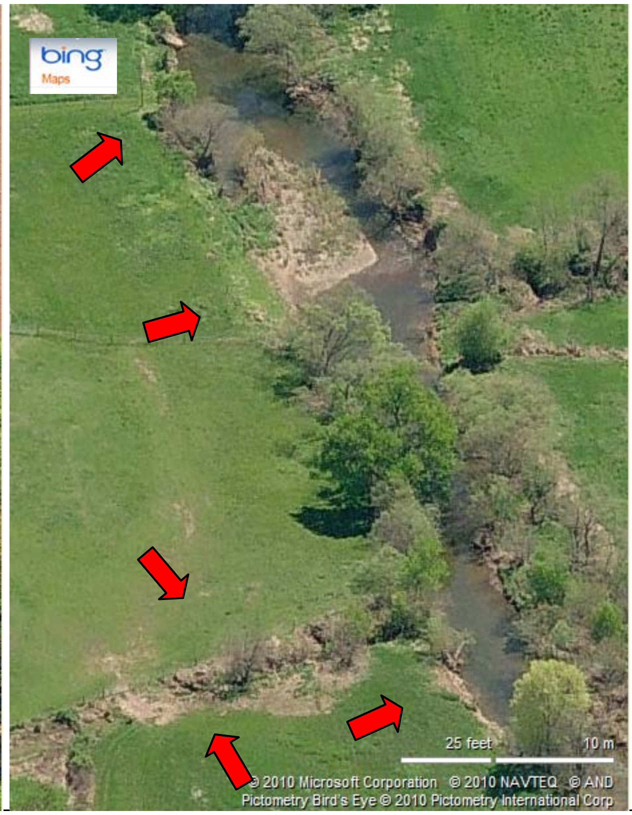
as CREP, EQIP, AWEP, and other cost share programs.				
Partners/Stakeholders: NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA and SBWA				
Task Description for a "Sample" Farm*				
Task	Task Description			Cost
1	Outreach to Producer			$550
2	Technical Assistance			$250
3	Project Plan			$100
4	Implementation oversight			$100
5	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Cover crop seeding	$83 average per acre for three years	62	$15,438
	Contingency (20%)			$3,088
	Total BMP Installation Cost			$18,526
Estimated total project cost				$19,526
* This "sample" farm is not indicative of every farm in the watershed. It is only a guideline used to estimate the cost of implementing cover crops. It is assumed that the sample farm has the equipment needed for field preparation and seeding of cover crops. The acreage for the sample farm is 62 acres, which is the average farm size in Hunterdon County (NASS, 2007). Cost of BMP installation was estimated using cost data from the New Jersey Farm Bill Program 2011 Practice Catalog. The unit cost is an average over five different seed types and plantings from the NRCS AWEP practice catalog. If program eligibility requirements are met, tasks 2, 3 and 4 may be provided at no cost to the landowner through NRCS technical assistance.				

7.4.5.2. Conservation Buffers

Project Name: Conservation Buffers
Location: Watershed wide
BMP Type and Description: A conservation buffer is an area of grasses, grass-like plants, forbs, trees and/or shrubs located adjacent to and up-gradient from streams or HSAs prone to generating runoff and other pollutants. Buffers help to protect these areas by trapping, slowing, filtering and uptaking potential pollutants. Whenever possible, vegetation in conservation buffers should be native plants, which provide good wildlife habitat. Examples of native plants used in buffers are Red Maple (*Acer rubrum*), Serviceberry (*Amelanchier arborea*), Silky Dogwood (*Cornus amomum*) and Reed Grass (*Calamagrostis canadensisx*).
Issues and Concerns: Runoff in streams and/or from HSAs with insufficient buffer areas is likely to have more phosphorus, pathogens and other contaminants than runoff in streams and/or from HSAs that have conservation buffers. Additionally, lack of conservation buffers makes these areas more susceptible to soil erosion. Streams without forested riparian buffers are likely to have higher water temperature than streams with forested riparian buffers. Higher water temperatures can impair aquatic species, particularly trout.
Existing Conditions: Streams in the Neshanic River Watershed have riparian areas or borders that have either insufficient or non-existent buffers. Some of those streams are adjacent to pastures, heavy livestock-use areas and crop fields, making them susceptible to agricultural runoff containing phosphorus, bacteria and

sediment; these pollutants are of concern in the watershed. The images below illustrate some of the current riparian conditions in the Neshanic River Watershed. Streams adjacent to agricultural crop fields and pastures lacking riparian buffers are indicated by the red arrows. Conservation buffers would trap sediment and filter out phosphorus, bacteria and other contaminants in runoff from agricultural lands before that runoff reaches a stream. To compound the issue, a stream without a proper buffer adjacent to pasture can be further degraded by livestock trampling of streambanks. Riparian buffers can be planted and a healthy riparian corridor established. Conservation buffers should, at a minimum, extend 35 feet on both sides of the streambank and contain suitable vegetation.





Proposed Solutions: Creating conservation buffers on HSAs and/or in riparian areas of streams adjacent to agricultural land will reduce water quality contamination from agricultural runoff. Buffers need to be designed, installed and maintained. Some of the NRCS New Jersey FOTG standards that may apply to conservation buffers are Riparian Forest Buffer (391), Riparian Herbaceous Cover (390), Critical Area Planting (342), Grassed Waterway (412) and Filter Strip (393).
Anticipated Benefits: Conservation buffers can reduce TP in runoff by up to 75 percent, protect waterbodies from pesticide drift and stabilize streambanks and shorelines. In addition, conservation buffers can reduce water temperatures, improve fish and wildlife habitat and improve groundwater quality. The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 7,645 acres of hay, pasture and croplands in the watershed. These acres produce annual average TP loads of approximately 0.97 pounds per acre and 7,400 pounds for the watershed. The Chesapeake Bay Water Quality Model showed that conservation buffers reduce TP by at least 50 percent. Assuming all streams located in hay land, pastures and croplands have conservation buffers, annual TP loading in the Neshanic River Watershed would decrease by 0.484 pounds per acre or 3,700 pounds for the watershed. These estimates assume that all runoff from these lands enter the buffer as sheet flow as opposed to concentrated flow. Many areas of the watershed have concentrated flow whose reduction would require implementation of other erosion control practices. Runoff entering buffer areas as concentrated flow will not achieve the phosphorus reduction levels indicated above. The 7,645 acres of hay, pasture and row crops in the watershed yield approximately 0.066 tons of sediment per acre per year or 500.9 tons per year for the watershed. The Chesapeake Bay Water Quality Model showed that conservation buffers can reduce sediment by at least 50 percent. Based on reduction rates determined by the Chesapeake Bay Model, installing conservation buffers in the watershed would reduce annual sediment loading by 0.033 tons per acre or 250.4 tons for the watershed. These estimates assume that all runoff entering conservation buffers is from sheet flow as opposed to concentrated flow. Some areas of the watershed generate concentrated flow whose control would require the implementation of other erosion control practices. Runoff entering buffer areas as concentrated flow will not achieve the expected sediment reduction given above.
Major Implementation Issues: There are multiple landowner costs associated with the installation of conservation buffers, including both time and material costs. Initial installation cost is often cost shared, sometimes up to 100 percent, through various state and federal programs. Establishing conservation buffers can also be challenging due to intense deer pressure. Precautions have to be taken to discourage and prevent deer from browsing when establishing conservation buffers. Maintenance costs vary by sites and are not always cost shared. In cases where the streams are the primary water source for livestock, there is the challenge as well as cost of providing alternative water sources. Often, the land in the conservation buffers is taken out of production and no longer generates revenue for the farmer. Some programs compensate for the production loss on an annual basis. Also, landowners are concerned about losing farmland tax assessment status of lands converted to conservation buffers. Obtaining the permits from NJDEP and other agencies needed to establish buffers is a complicated process that often discourages farmers from participating in programs that support installation of conservation buffers.
Possible Funding Sources: EPA 319(h) through NJDEP, National Fish and Wildlife Foundation's Five Star Restoration Challenge Grants, NJDEP Corporate Business Tax, Private Sources, NJDA State Cost share, US Fish and Wildlife Service's Partners for Fish and Wildlife Program, USDA Farm Bill Programs such as CREP, EQIP,

AWEP, WHIP and other cost share programs.				
Partners/Stakeholders: NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA; NJDEP and SBWA				
Task Description for a "Sample" Farm*				
Task	Conservation Buffer Task Description			Cost
1	Outreach to Producer			$1,000
2	Technical Assistance			$2,000
3	Project Design			$1,000
4	Applicable permits			$200
5	Implementation oversight			$1,000
6	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Invasive Removal	$1,250 per acre	1	$1,250
	Site Preparation	$250 per acre	1	$250
	Planting	$4,000 per acre	1	$4,000
	Plant protection/weed suppression	$1,000 per acre	1	$1,000
	First year monitoring and maintenance	$750 per acre	1	$750
	Filter Strip with cool season grass	$180 per acre	2	$360
	Contingency (20%)			$1,522
	Total BMP Installation Cost			$9,132
Estimated total project cost				$14,332
Annual Operation and Maintenance Cost				$250
* This "sample" farm is not indicative of every farm in the watershed. It is only a guideline used to estimate the cost of implementing conservation buffers. The size of buffers, plant selection, protection from livestock and deer browse, and invasive control varies from site to site. These cost estimates assume the use of five-gallon containerized plant material to reduce plant mortality. Costs of BMP installation were estimated from cost data provided by North Jersey RC&D, which are based on past implementation projects. If program eligibility requirements are met, tasks 2, 3 and 5 may be provided at no cost to the landowner through NRCS technical assistance. Increased permanent easement incentive payments should be considered to encourage participation and implementation from landowners.				

7.4.5.3. Prescribed Grazing

Project Name: Prescribed Grazing
Location: Watershed wide
BMP Type and Description: Prescribed grazing is a system that allows agricultural producers to manage grazing and browsing of animals so as to ensure adequate ground cover and proper livestock nutrition.
Issues and Concerns: Over grazing and overstocked pastures lead to conditions of bare or inadequately covered and compacted soil. These conditions are conducive to soil erosion, nutrient runoff and fecal contamination of surface water.
Existing Conditions: Some pastures in the Neshanic River Watershed show signs of over grazing and overstocking.

Pastures need to rest between grazing to allow vegetation to recover. Grazing that is too frequent leaves the soil in a bare condition. Bare soil is more likely to be dislodged and eroded during storm events. Further exacerbating the situation is the fact that unprotected soil becomes compacted by livestock traffic making post-grazing recovery of vegetation even more difficult. Trampled areas may eventually experience gully erosion if channels are created by livestock paths. The images below illustrate some of the current conditions in the Neshanic River Watershed. The two pastures illustrate areas of poor vegetative cover and bare earth due to overgrazing and overstocking of livestock. Such conditions are likely to increase erosion and runoff.

Proposed Solutions:
Prescribed grazing systems developed by a grazing specialist and implemented by an agricultural producer is a possible solution to poor pasture conditions. Such prescribed grazing plans may include reducing the number of livestock, more frequent rotation of livestock, and using temporary fencing to exclude livestock from pastures recovering from frequent grazing activity. Some of the NRCS New Jersey FOTG standards that may apply to a prescribed grazing system are Prescribed Grazing (528), Watering Facility (614), Pest Management (595), Brush Management (314) and Pasture Planting (512).

Anticipated Benefits:
The use of well-designed prescribed grazing plans will help maintain healthy and productive pastures. Healthy pastures protect soil from erosion and reduce the resultant phosphorus and fecal in runoff. In

addition, an actively growing pasture has greater uptake of nutrients and water infiltration. A prescribed grazing plan designates stocking numbers, the timing of field rotations, and actions to restore pasture health. Benefits of healthy pastures include high quality forage and healthy livestock.

The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 892 acres of pasture in the watershed, yielding, on average, approximately 1.70 pounds of TP per acre annually or 1,521 pounds per year for the watershed. The Chesapeake Bay Water Quality Model showed that prescribed grazing reduces TP by 25 percent. If implemented in all pasture lands in the watershed, prescribed grazing would reduce annual TP loading by 0.425 pounds per acre or 380 pounds for the watershed.

The 890 acres of pasture in the watershed yield approximately 0.08 tons of sediment per acre per year, which amounts to 70 tons per year for the watershed. The Chesapeake Bay Water Quality Model showed that prescribed grazing reduces sediment by 25 percent. Prescribed grazing could reduce annual sediment loading in the watershed by 0.02 tons per acre or 17.5 tons for the watershed.

Major Implementation Issues:
A prescribed grazing plan often requires a farmer to make operational changes. Implementing these changes may make the operation more labor intensive. Fencing, alternate watering sources and other costs are typically incurred when implementing a prescribed grazing plan. In addition, a plan may require a farmer to graze fewer animals, which could reduce farm revenue. Some of the cost of prescribed grazing may be offset by a lower need for supplemental feed. Such costs and benefits are likely to vary by farming operation.

Possible Funding Sources:
EPA 319(h) through NJDEP, Private, NJDA State Cost share, USDA Farm Bill Programs such as CREP, EQIP, AWEP, and other available cost share.

Partners/Stakeholders:
Township officials; NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA and SBWA

Task Description for a "Sample" Farm*

Task	Task Description			Cost
1	Outreach to Producer			$1,000
2	Technical Assistance			$1,500
3	Grazing plan			$750
4	Implementation oversight			$500
5	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Managed system including polywire fence, forage monitoring every other day, relocation of livestock, and necessary documentation based on 30 acres as described by NRCS practice 528	$93 per acre	30 acres	$2,790
	Over-seeding	$173 per acre	30 acres	$5,190
	Contingency (20%)			$1,596
	Total BMP Installation Costs			$9,576
Estimated total project cost				$13,326

* This "sample" farm is not indicative of every farm in the watershed. It is only a guideline used to estimate the cost of implementing cover crops. Acreage will vary from farm to farm. This example does not include alternative water sources, permanent fencing or other practices that might be necessary to implement prescribed grazing on some farms. Cost of BMP installation was estimated using cost data

from the New Jersey Farm Bill Program 2011 Practice Catalog. If program eligibility requirements are met, tasks 2, 3 and 4 may be provided at no cost to the landowner through NRCS technical assistance.

7.4.5.4. Livestock Access Control

Project Name: Livestock Access Control

Location: Watershed wide

BMP Type and Description:
Access control is temporary or permanent exclusion of animals from riparian areas of streams.

Issues and Concerns:
Livestock with direct access to streams often deposit manure to those streams that causes nutrient and bacteria contamination, causes soil erosion of streambanks and elevates TSS concentrations in streams. Grazing in riparian areas of streams compacts soils and prevents the establishment of vegetation that can potentially filter the runoff.

Existing Conditions:
In some livestock operations, streams are the primary watering source for livestock, causing frequent, uncontrolled livestock access to and defecation in those streams. Livestock access to streams also degrades and creates channels for concentrated runoff. Soil compaction from grazing in riparian areas stifles growth of riparian vegetation; the latter filters pollutants from runoff in pastures.

Oblique aerial photos from Microsoft Bing Maps illustrate some of the current conditions in the Neshanic River Watershed. Livestock have open access to streams as indicated by the red arrows, which allows for direct deposit of manure in streams and streambank degradation. Access control fencing or a similar barrier would prevent livestock from defecating in streams. Re-establishment of riparian vegetation would reduce pasture runoff into streams. For such regeneration to occur, the fencing or barrier should be placed a minimum of 35 feet from the streambanks or more depending on site-specific conditions.

Proposed Solutions:
Exclusion fences should be used to eliminate livestock from access to streams and riparian zones in pastures. NRCS recommends the fencing be at least 35 feet from the streams. A greater distance may be required depending on site-specific conditions, such as land slope and intensity of adjacent land uses. NRCS New Jersey FOTG standards that may apply to livestock access control are Access Control (472), Fence (382), Stream Crossing (578), Watering Facility (614), Riparian Forest Buffer (391), Riparian Herbaceous Cover (390) and Filter Strip (393).

Anticipated Benefits:
Exclusion fencing will completely eliminate livestock manure from entering streams and permit the re-establishment of riparian vegetation that will filter runoff from adjacent pastures.

The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 892 acres of pasture within the watershed, yielding approximately 1.70 pounds of TP per acre annually or 1,521 pounds per year for the watershed. The Chesapeake Bay Water Quality Model showed that access control fencing reduces TP by 60 percent. Applying access control fences along all streams that cross pastures would reduce TP loading by 1.02 pounds per acre or 913 pounds per year for the watershed.

The 892 acres of pasture in the watershed yield approximately 0.08 tons of sediment per acre annually or 70 tons per year for the watershed. The Chesapeake Bay Water Quality Model showed that access control fencing reduces sediment by 75 percent. This suggests that access control fencing could potentially reduce sediment loading in the watershed by 0.06 tons per acre or 52.4 tons per year for the watershed.

Major Implementation Issues:
This BMP will create new challenges for landowners in terms of requiring extra labor and learning how to maintain the BMP. Fencing must be routinely inspected and maintained, especially after flood events. Installing fencing would reduce the size of pastures, possibly resulting in a reduction in the number of livestock on pasture. In addition, excluding livestock from streams requires developing an alternative water source.

Possible Funding Sources:

EPA 319(h) through NJDEP, Private Sources, NJDA State Cost share, US Fish and Wildlife Service's Partners for Fish and Wildlife Program, USDA Farm Bill Programs such as CREP, EQIP, AWEP, and other cost share programs.

Partners/Stakeholders:

Township officials; NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA and SBWA

Task Description for a "Sample" Farm*

Task	Task Description			Cost
1	Outreach to Producer			$1,000
2	Technical Assistance			$500
3	Project Plan			$200
4	Implementation oversight			$200
5	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Fencing Installation	$4.78 per ft.	500 ft	$2,500
	Contingency (20%)			$478
	Total BMP Installation Cost			$2,868
Estimated total project cost				$4,768
Annual Operation and Maintenance Cost				$100

* This "sample" farm is not indicative of every farm in the watershed. It is only a guideline used to estimate the cost of implementing access control fencing. The "sample" farm assumes that the only fencing needed is on one side of the stream and that there is an alternate, pre-existing water source for livestock. See the Livestock BMP sheet for a more detailed account of possible additional measures that may be needed when implementing access control fencing. Costs of BMP installation were estimated from the cost data in the New Jersey Farm Bill Program 2011 Practice Catalog. If program eligibility requirements are met, tasks 2, 3 and 4 may be provided at no cost to the landowner through NRCS technical assistance.

7.4.5.5. Contour Farming

Project Name: Contour Farming

Location: Watershed wide

BMP Type and Description:

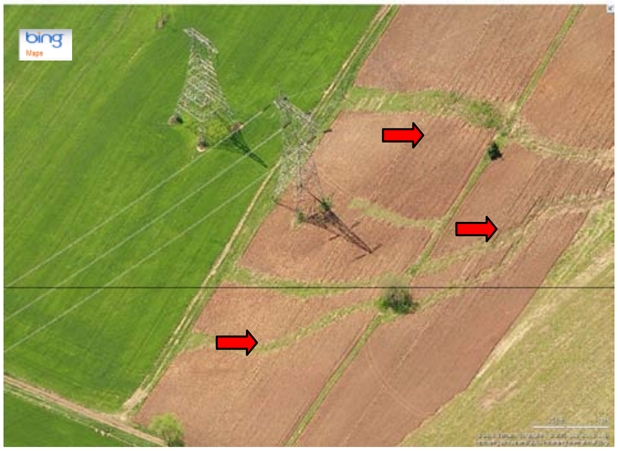
Contour Farming uses ridges and furrows formed by tillage, planting and other farming operations to change direction of runoff from directly downslope to around the hill slope.

Issues and Concerns:

Crop planting without regard to the topography of the landscape can create conditions that lead to erosion and excessive nutrient runoff.

Existing Conditions:

Currently, some crops in the Neshanic River Watershed are planted in straight rows without regard to the contour of the land or slope direction. This condition is conducive to increased erosion and fertilizer runoff. The situation can be improved by contour farming. The images below illustrate some of the current conditions in the watershed. The photo on the left shows crops planted in straight rows without regard to the topography of the landscape. The red arrows indicate points where water flows and soil erodes during storm events. The photo on the right is an example of contour farming, which negates or reduces soil erosion in agricultural fields.



Proposed Solutions:
Use contour farming when field conditions allow. The NRCS New Jersey FOTG standards that may apply to contour farming are Contour Farming (330) and Field Border (386).

Anticipated Benefits:
Contour farming can reduce sediment from gully erosion and slow down surface water runoff. This will effectively reduce the transport of phosphorus and other contaminants to streams.

The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 4,011 acres of croplands in the watershed of which 1,846 acres have slopes from 2 to 10 percent making them ideal sites for contour farming. SWAT modeling results indicate that cropland produces approximately 1.3 pounds of TP per acre annually in the watershed. Potter et al. (2006) estimated that contour farming reduced TP by 20 percent. It is estimated that contour farming would reduce annual TP loads by 0.26 pounds per acre or 480 pounds when implemented on 1,846 acres of cropland in the watershed.

Cropland in the watershed produces approximately 0.10 tons of sediment per acre per year. Potter et al. (2006) estimated that contour farming reduced sediment runoff by 40 percent. Assuming contour farming is implemented on the 1.846 acres of suitable cropland, contour farming would reduce annual TP loading by 0.04 tons per acre or 73.84 tons for the watershed.

Major Implementation Issues:
Contour farming will pose new challenges to operators. Initially, farmers may need assistance in using contour farming. Such assistance is available from NRCS. There are currently no federal financial incentive programs for farmers who practice contour farming. Farmers are less likely to change their cropping practices without financial incentives. Future incentive payments for contour farming might encourage adoption.

Possible Funding Sources:
EPA 319(h) through NJDEP, Private and other available cost share. Cost share funding is not available for this practice. This practice does require a learning curve, requires effort on the part of farmers to implement, and can result in revenue loss. Future incentive payments should be considered to promote contour farming.

Partners/Stakeholders:
NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA and SBWA

Task Description for a “Sample” Farm*

Task	Task Description	Cost
1	Outreach to Producer	$1,000

2	Technical assistance			$250
3	Project plan			$200
4	Implementation oversight			$200
5	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Incentive payment ($25.00/acre/year for three years)	$75.00	62	$4,650
	Contingency (20%)			$930
	Total BMP Installation Cost			$5,580
Total estimated project cost				$7,230

* This "sample" farm is not indicative of every farm in the watershed. It is only a guideline used to estimate the cost of implementation contour farming. The "sample" farm assumes that the necessary equipment is available and that no additional practices are necessary to implement contour farming. There are no out-of-pocket costs to install this BMP because installation only involves changing the direction of tillage and planting of fields (i.e., crops are planted along the contour lines of the landscape). Currently, there are no incentive payments to farmers for the practice. Considering the benefits of contour farming, future incentive payments should be explored as described above. The sample farm size of 62 acres is the average farm size in Hunterdon County (NASS, 2007). If program eligibility requirements are met, NRCS technical assistance would allow tasks 2, 3 and 4 to be performed at no cost to landowners.

7.4.5.6. Integrated Crop Management

Project Name: Integrated Crop Management

Location: Watershed wide and applicable to crop, hay and pastures.

BMP Type and Description:
ICM is a soil test-based agricultural assistance program that allows farmers to better manage nutrients in crop production so as to achieve both environmental and economic goals.

Issues and Concerns:
Agricultural operations take place on a significant portion of the lands in the Neshanic River Watershed. These operations contribute to water quality problems in the watershed, including sedimentation, bacterial contamination, thermal pollution and nutrient enrichment. Sediments from agricultural operations result from agricultural tillage, lack of riparian buffers, animals with direct access to the streams and/or over-grazing on pasture. Bacterial contamination results when livestock have direct access to waterways, animal manure is improperly applied to croplands and concentrated manure runoff is carried into the streams. Thermal pollution results when riparian areas lack sufficient vegetative cover to provide shade to streams. Nutrient enrichment occurs when the timing, amount and methods of fertilizer application are such that excessive fertilizers (chemical or organic) enter streams.

Some farms in the watershed are small operations with limited capital and knowledge to implement current agronomic BMPs such as nutrient management, pest management, conservation buffers, access control, manure management and erosion control practices.

Existing Conditions:
Soil nutrients are critical to crop growth. Crop growth could deplete and/or enrich certain nutrients in soils and causes imbalance in soil nutrients. Fertilizers are often used to correct such imbalances and promote crop growth. Ideally, fertilizer application should be based on nutrient availability in soils.

However, most fertilizer application rates are determined without soil testing in the Neshanic River Watershed and many other regions in New Jersey. Many continually farmed fields are over limed with pH levels above the optimum level. Other fields require lime, indicating that lime is applied without evaluating crop requirements for lime. Optimizing pH levels maximizes nutrient availability and crop growth, while reducing the amount of nutrients in runoff. Balanced nutrient levels reduce nutrient runoff by maximizing crop growth. Phosphorus is usually found at or above optimal levels. Yet, farmers still apply fertilizers that contain it. Potassium, which aids in nutrient uptake, is seldom found near optimal levels and is either very low or excessive. Manure is often applied without a soil test and without knowledge of nutrient levels in soil and/or crop needs for nutrients. Use of herbicides and pesticides is typically based on the presence of a pest or a weed rather than the economic and biological damage thresholds.
Possible Solutions: A comprehensive targeted agricultural assistance program is recommended to address agricultural water quality problems in the watershed. The program should be voluntary for landowners, but provide funding to initiate planning and implementation of efforts to minimize the impacts of agriculture on streams. The comprehensive agricultural assistance program would include: nutrient management plans; pest management services; an implementation coordinator; focused outreach; conservation planning; and use of a secondary fund source to augment existing farm bill assistance programs for the implementation of complementary BMPs. Many features of the proposed comprehensive agricultural assistance program are already present in the Neshanic River Watershed. Providing additional funding and coordinated effort would allow proper administration of the proposed program. The program would have several phases and sufficient resources would be allocated to the different phases of the program as dictated by the conditions in the watershed. Phase 1: Property Identification and Initial Outreach Agricultural properties must be identified within the watershed so that initial outreach can be conducted. Once identified using hydrological modeling, agricultural properties can be further prioritized according to runoff potential. Owners of prioritized properties would be contacted using a door-to-door approach. Phase 2: Free Soil Testing, Nutrient Management, ICM and River-Friendly Farm Certification Program Identified agricultural properties will be offered free soil testing with an accompanying ICM Plan. Farmers that accept free soil testing will be required to participate in the River-Friendly Farm Program. A free ICM Plan is currently offered in the Mulhockaway watershed, a nearby watershed. A similar project could be initiated in the Neshanic River Watershed. Free plans are valuable to agricultural producers because they allow producers to identify agricultural fields that are high in nutrients. Plans have been shown to help producers reduce costs of both nutrient and pesticide applications. After the first year, producers would receive these services at a reduced rate over the course of the next three years depending on funding availability. Implementation funding would be sought through EQIP and other Farm Bill assistance programs and supplemented by secondary funding sources. The River-Friendly Farm Certification Program is available in the Raritan River Basin, which includes the Neshanic River Watershed. The River-Friendly Farm Program conducts property assessments that help producers identify areas with potential resource problems. The program will help farmers to

develop strategies and find funding to address these problems.

Phase 3: Soil Test Results, Property Assessments, Model Comparison and BMP Selection

By combining the soil testing results, River-Friendly Assessment results and VSA Hydrology modeling results, project partners can determine which areas within the watershed to consider for CSAs. These CSAs are HSAs are more likely to generate pollutant contaminated runoff. Once these areas are identified, suitable BMPs can be identified for reducing or eliminating pollutant runoff.

Phase 4: BMP Prioritization and Secondary Implementation Funding Source

Identified CSAs and corresponding BMPs will be prioritized according to pollutant reduction potential. By prioritizing CSAs and BMPs, it can be determined which projects offer the greatest pollution reduction per dollar.

A common barrier to the implementation of BMPs is the lack of sufficient funding available to producers and landowners. In many cases, existing cost share is sufficient for a landowner to recapture the costs of implementing a BMP. High ranking BMP projects offer the greatest opportunity for achieving water quality benefits in a cost effective manner. Creation of secondary funding sources and use of those sources to fund high priority projects will ensure cost effective on-the-ground implementation of conservation efforts.

The goal is to increase the cost share rate to 90 to 100 percent of the installation costs for targeted practices that improve water quality in the watershed. Eligible practices that should be funded include: fencing animals from the stream; establishing or improving riparian buffers; manure management; and erosion control

Anticipated Benefits:

The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 4,010 acres of cropland in the watershed that produces approximately 1.3 pounds of TP per acre per year or 5,213 pounds per year for the watershed. Gitau et al. (2005) indicated that nutrient management reduces TP by 47 percent. This suggests that active nutrient management would reduce annual TP loading by 0.61 pounds per acre or 2,450 pounds for the watershed. Considering nutrient management plans are only Phase 1 of the program. If this comprehensive agricultural assistance program was successful, the pollutant loading reduction potential would be significant.

A successful nutrient management program would build positive relationships between the agricultural community and conservation community. Such relationships would nurture and promote the future success of both agriculture and agricultural conservation in the region, ensuring the lasting effects of conservation efforts.

Major Implementation Issues:

The success of the program depends largely on the willingness of landowners and agricultural operations to participate in the program. Agricultural operations are often a part of a family’s heritage and tradition. Frequently, a producer lives on his/her farm. Time is needed to build trust and relationships with farmers.

Possible Funding Sources:

EPA 319(h) through NJDEP, National Fish and Wildlife Foundation’s Five Star Restoration Challenge Grants, NJDEP Corporate Business Tax, Private Sources, NJDA State Cost share, US Fish and Wildlife Service’s Partners for Fish and Wildlife Program, USDA Farm Bill Programs, such as CREP, EQIP, AWEP, WHIP and other available cost share.

<table>
<tr><td colspan="5">Partners/Stakeholders:
NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA and SBWA</td></tr>
<tr><td colspan="5">Task Description for a “Sample” Farm*</td></tr>
<tr><td>Task</td><td colspan="3">Task Description</td><td>Cost</td></tr>
<tr><td>1</td><td colspan="3">Outreach to Producer</td><td>$1,000</td></tr>
<tr><td>2</td><td colspan="3">Technical assistance</td><td>$250</td></tr>
<tr><td>3</td><td colspan="3">Project plan</td><td>$200</td></tr>
<tr><td>4</td><td colspan="3">Implementation oversight</td><td>$200</td></tr>
<tr><td>5</td><td colspan="3">BMP Installation</td><td></td></tr>
<tr><td></td><td>Activities for BMP Installation</td><td>Unit Cost</td><td>Quantity</td><td></td></tr>
<tr><td></td><td>Nutrient Management
($25.00/acre/year for three years)</td><td>$75.00</td><td>62</td><td>$4,650</td></tr>
<tr><td></td><td colspan="3">Contingency (20%)</td><td>$930</td></tr>
<tr><td></td><td colspan="3">Total BMP Installation Cost</td><td>$5,580</td></tr>
<tr><td colspan="4">Total estimated project cost</td><td>$7,230</td></tr>
<tr><td colspan="5">* This “sample” farm is not indicative of every farm in the watershed. It is only a guideline used to define estimate the cost of implementing ICM. The acreage in the sample farm is 62 acres, which is the average farm size in Hunterdon County (NASS, 2007). If program eligibility requirements are met, it would be possible to do tasks 2, 3 and 4 at no cost to landowners by using the NRCS technical assistance program.</td></tr>
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7.4.5.7. Application of Multiple BMPs for Row Crop Farm

Project Name: Multiple BMPs for Row Crop Farm
Location: Watershed wide
BMP Type and Description: A cover crop includes grasses, legumes, forbs or other herbaceous plants established for seasonal cover and other conservation purposes. Contour farming uses ridges and furrows formed by tillage and planting and other farming operations that change direction of runoff from directly downslope to around the hill slope. Riparian buffers are areas of grasses, grass-like plants, forbs, trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies that help protect surface water from runoff and contaminants. Nutrient management manages the amount, source, form and timing of application of nutrients and soil amendments. The above image illustrates how these practices could be implemented.
Issues and Concerns: Row crops planted without proper BMPs in place can potentially lead to nutrient rich soil becoming dislodged and eroding into streams. These particles carry with them phosphorus, bacteria and other pollutants which contribute to poor water quality.
Existing Conditions: Some crop fields in the watershed may be over fertilized, sometimes with manure, and planted without using BMPs that protect streams. These conditions can contribute to phosphorus and bacterial contamination in the Neshanic River Watershed.

Proposed Solutions:
By applying proper BMPs to row crops in the watershed, the potential for phosphorus and bacterial runoff can be reduced or eliminated. BMPs have been shown to work better in tandem. Streams can be protected by implementing a nutrient management plan designed to avoid over application of fertilizer, followed by cover crops that protect the land, contour farming that reduce erosion and riparian buffers that filter agricultural runoff.

Anticipated Benefits:
Proper fertilizer application reduces fertilizer application costs and excess nutrient runoff to streams. In addition to reducing soil erosion, cover crops have a myriad of other benefits. Cover crops promote healthy soils by increasing microbial activity, infiltration and nutrient absorption, and can increase farm revenue. Cover crops enhance water quality by reducing dislodgement of soil particles from the landscape. Contour farming reduces erosion and channelization on farm fields, which in turns reduces the transport of pollutants to streams. Riparian buffers act as the final barrier to filter agricultural runoff.

The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 4,011 acres of cropland in the watershed that produces approximately 1.3 pounds of TP per acre per year or 5,223 pounds per year of TP for the watershed. The Chesapeake Bay Water Quality Model showed that conservation buffers reduce TP by at least 50 percent. Provided conservation buffers are applied to all cropland in the watershed, annual TP loading would decrease by 0.975 pounds per acre or 3,910 pounds for the watershed. This estimate assumes that all runoff enters conservation buffers as sheet flow as opposed to concentrated flow. Many properties in the watershed have areas of concentrated flow. Those areas would require further erosion control practices. Any runoff entering the buffer area as concentrated flow will not undergo the same phosphorus reduction as expected for sheet flow.

The 4,011 acres of cropland produce approximately 0.10 tons of sediment per acre per year or 396 tons per year for the watershed. The Chesapeake Bay Water Quality Model showed that conservation buffers reduce sediment runoff by at least 50 percent. This suggests that conservation buffers could reduce annual sediment loads by 0.05 tons per acre or 200.5 tons for the watershed assuming that all runoff enters the buffers as sheet flow as opposed to concentrated flow. Areas of the watershed that experience concentrated flow would require further erosion control practices. Any runoff entering the buffer area as concentrated flow will undergo the same sediment reduction as expected for sheet flow.

While it is difficult to determine the total load reduction when multiple BMPs are used in concert, the SWAT model indicate that using multiple BMPs improves water quality. This implies that a row crop system using multiple BMP's will reduce loading more than the reductions achieved by conservation buffers alone as listed above.

Major Implementation Issues:

Changing farm operations is often difficult for farmers. There is a learning curve and a cost associated with the implementation and maintenance of BMPs. Use of some BMPs requires land to be taken out of production (e.g., riparian buffers). Although cost share and technical assistance available are from the Natural Resources Conservation Service and other state, local and non-profit agencies, not all farms qualify for these programs. Continual outreach, educational and promotion of BMPs will be required to facilitate the transition to environmentally sound farming practices in the watershed.

Possible Funding Sources:

EPA 319(h) through NJDEP, National Fish and Wildlife Foundation's Five Star Restoration Challenge Grants, NJDEP Corporate Business Tax, Private Sources, NJDA State Cost share, US Fish and Wildlife Service's Partners for Fish and Wildlife Program, USDA Farm Bill Programs, such as CREP, EQIP, AWEP, WHIP and other available cost share programs. In the case of contour farming, cost share funding is not available. Farmers would need to learn how to use the practice and make the effort to implement the practice and absorb an initial loss in farm revenue. Future incentive payments should be considered to help promote contour farming.

Partners/Stakeholders:

NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA; NJDEP and SBWA

Task Description for a "Sample" Farm*

Task	Task Description			Cost
1	Outreach to Producer			$1,000
2	Technical Assistance			$3,000
3	Project design			$2,000
4	Applicable permits			$200
5	Implementation oversight			$1,750
6	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Riparian Buffer	$12,750 per acre	1	$7,750
	Cover Crop	$113 per acre	62	$7,006
	Contour Farming	No cost	No cost	
	Nutrient Management	$22.00 per acre	62	$1,364
	Total BMP Installation Cost			$16,120
	Contingency (20%)			$4,814
Total estimated project cost				$28,884
Annual Operation and Maintenance Cost				$250

* This "sample" farm is not indicative of every farm in the watershed. It is only a guideline used to

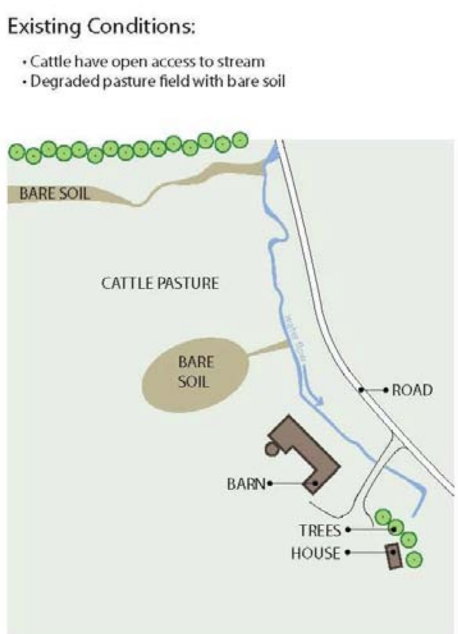
estimate the cost of implementing contour farming. The 62-acre size of the sample farm is the average farm size in Hunterdon County (NASS, 2007). Costs for BMP installation were estimated based on cost data from the New Jersey Farm Bill Program 2011 Practice Catalog and provided by North Jersey RC&D. The latter costs are based on past implementation projects. If program eligibility requirements are met, tasks 2, 3 and 5 could be done at no cost to landowners by using NRCS technical assistance.

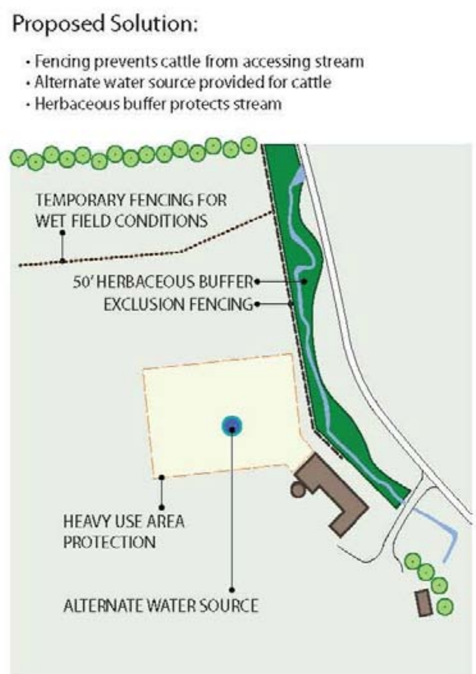
7.4.5.8. Application of Multiple BMPs for Livestock Farm

Project Name: Livestock Operation

Location: Watershed wide

BMP Type and Description:
Livestock access control is a temporary or permanent exclusion of animals from streams and their riparian areas. A riparian buffer is an area of grasses, grass-like plants, forbs, trees and/or shrubs located adjacent to and up-gradient from streams that protect streams from runoff and contaminants. Prescribed grazing is a plan that manages grazing and browsing of animals to ensure adequate ground cover and proper livestock nutrition.





Issues and Concerns:
Livestock with direct access to streams, runoff from overgrazed pasture, streambank erosion and poor pasture condition are conducive to manure being directly deposited into streams and being washed into streams as runoff. The picture on the left illustrates a livestock operation that generates erosion, degrades the stream bed and pastures conditions, and allows cattle to enter the stream.

Existing Conditions:
Pastures show signs of over grazing and damage indicative of high animal stocking numbers. Livestock directly access streams for water. There are areas where animals congregate in high numbers causing bare earth in pastures and signs of erosion.

<u>Proposed Solutions:</u> Install exclusion fence along the streams in the pasture to eliminate direct access of livestock to streams. The fence would be installed at least 35 feet away from both sides of the streams or more depending on site-specific conditions. Such fencing would also protect riparian areas of the streams. Create alternative watering sources for livestock. To allow rotational grazing, stream crossing structures for livestock may need to be installed along some stream segments. A pasture management plan should be created to ensure that overgrazing is eliminated. A manure management strategy should be implemented. Manure management measures include establishing and maintaining manure storage structures and/or composting facilities. Farms are encouraged to participate in the River-Friendly Farm Program. NRCS New Jersey FOTG has numerous standards for implementing the proposed BMPs on livestock farms.		
<u>Anticipated Benefits:</u> The exclusion fence would completely eliminate direct deposits of manure into streams. Pasture management will reduce manure runoff and erosion. Buffers will further reduce and treat any runoff. The SWAT model was used to simulate pollution loads in the Neshanic River Watershed. There are approximately 890 acres of pastures that produce approximately 1.7 pounds of TP per acre per year or 1,513 pounds of TP per year for the watershed. The Chesapeake Bay Water Quality Model showed that conservation buffers reduce TP by at least 50 percent. This suggests that conservation buffers can reduce annual TP loading by 0.85 pounds per acre or 756 pounds on pastures in the watershed if conservation buffers are installed along all streams in pastures. This estimate assumes that runoff enters the buffer as sheet flow as opposed to concentrated flow. Some areas of the watershed generate concentrated flow; erosion control in such areas requires implementing other erosion control practices. Runoff entering buffer areas as concentrated flow will have the same phosphorus reduction as expected for areas with sheet flow. The 890 acres of pasture produce approximately 0.08 tons of sediment per acre per year or 71.2 tons per year for the watershed. The Chesapeake Bay Water Quality Model showed that conservation buffers reduce sediment at least 50 percent. If buffers are installed along all streams flowing through pastures, annual sediment load would decline by 0.04 tons per acre or 35.6 tons per year for pastures in the watershed. It is difficult to determine total load reduction when multiple livestock BMPs are used in concert. Preliminary results of the SWAT model indicated water quality improves when BMPs are used together. A livestock farm using multiple BMPs will experience greater reductions in pollutant loads than those achieved by conservation buffers alone as listed above.		
<u>Major Implementation Issues:</u> Use of these BMPs will be challenging form farmers. It will require more labor and learning how to use the practices. Use of conservation buffers will require taking land out of production. In order to maintain water quality, farmers may need to reduce the number of livestock on pasture. These challenges will affect farmers' willingness and ability to implement some or all of the recommended BMPs.		
<u>Possible Funding Sources:</u> EPA 319(h) through NJDEP, Private Sources, NJDA State Cost share, US Fish and Wildlife Service's Partners for Fish and Wildlife Program, National Fish and Wildlife Foundation's Five Star Restoration Challenge Grants, NJDEP Corporate Business Tax, USDA Farm Bill Programs, such as CREP, EQIP, AWEP and other available cost share.		
<u>Partners/Stakeholders:</u> Township officials; NRCS; NJRC&D; HCSCD; RCE; NJIT; NJWSA; NJDEP and SBWA		
Task Description for a "Sample" Farm*		
Task	Task Description	Cost
1	Outreach to Producer	$1,000

2	Technical Assistance			$4,000
3	Project Design			$3,000
4	Applicable permits			$1,000
5	Implementation oversight			$1,500
6	BMP Installation			
	Activities for BMP Installation	Unit Cost	Quantity	
	Access control fencing	$4.78 per ft.	500 feet	$2,390
	Riparian Buffer establishment	$7750 per acre	1 acres	$7,750
	Prescribed grazing	$7980 per 30 acres	1	$5,190
	Alternate Livestock Water Source	$12.68 per animal unit	30 AU	$380
	Heavy use area protection	$14.00 per sf	3000 sf	$42,000
	Filter Strip	$285 per acre	1 acre	$285
	Composting facility	$2.85 per sf	7500 sf	$21,375
	Total BMP Installation Cost			$79,370
	Contingency (20%)			$17,974
Total estimated project cost				$107,844
Annual operation and maintenance cost				$500
* This “sample” farm is not indicative of every farm in the watershed. It is only a guideline used to estimate the cost of implementing multiple BMPs for a livestock farm. Costs for BMP installation were estimated using cost data from the New Jersey Farm Bill Program 2011 Practice Catalog and North Jersey RC&D. The latter costs are based on past implementation projects. If program eligibility requirements are met, tasks 2, 3 and 5 could be done at no cost to landowners by using NRCS technical assistance There are multiple manure management strategies applicable to livestock. Composting livestock manure has been shown to significantly reduce bacterial contamination.				

7.5. **Project Prioritization**

Section 7.4 presents detailed information about individual BMPs at specific sites in the watershed or for representative farms. Information for individual BMP projects is scaled up to estimate watershed reductions in TP and sediment, and the total and annual costs at the watershed scale. The cost effectiveness of these BMPs in reducing TP and sediment is calculated by dividing the annual watershed cost by the reduction in TP and sediment.

Table 7.11 summarizes the water quality effects, the costs and cost-effectiveness of the agricultural BMPs in Neshanic River Watershed assuming each BMP is individually applied to suitable land types in the watershed. The scale-up for cover crops, riparian buffers, prescribed grazing, livestock access control, contour farming and nutrient management are based on the information in Section 7.4.5. Information on the assessment unit, reduction in TP and sediment, assessment costs and land type suitable for BMP implementation are taken from the agricultural project descriptions given in Section 7.4.5. Reductions in TP and sediment for the agricultural BMPs are based on the reduction rates from literature, the SWAT-estimated pollutant loads, and the land suitable for BMP implementation as specified in Table 7.11. Total watershed costs are the product of total assessment costs and the applicable unit divided by the assessment unit. The assessment unit is the acreage of a representative farm used for estimating the BMP implementation cost. The applicable unit is the total acreage of the agricultural lands the BMP can be potentially applied to.

Table 7.11: Water quality effects, costs and cost-effectiveness of agricultural BMPs in the Neshanic River Watershed

		Cover Crop	Presc. Grazing	Access Control	Contour Farming	Nutrient Mgmt.	Conser. Buffers
1	Assessment Unit	62 acres	30 acres	500 feet	62 acres	62 acres	3 acres
2	TP Reduction Rate (%)	15	25	60	20	47	50
3	Sediment Reduction Rate (%)	20	25	75	40	0	50
4	Installation Cost ($)	18,526	9,576	2,868	5,580	5,580	9,132
5	Maintenance Cost ($)			1,000			3,750
6	Other Costs ($)	1,000	3,750	1,900	1,650	1,650	5,200
7	Total Assessment Unit Cost ($)	19,526	13,326	5,768	7,230	7,230	18,082
8	Land Type Suitable for BMP	Row crops	Pasture	Riparian areas of pasture	Row Crops	Crops, hay, pasture	HASs
9	Applicable Unit	4,011 acres	892 acres	24,663 feet	1,846 acres	7,645 acres	988 acres
10	Annual TP Reduction (lbs)	784	380	913	507	3,478	3,700
11	Annual Sediment Reduction (tons)	79	16	52	73	0	250
12	Total Watershed Cost ($)	1,263,180	396,226	284,512	215,267	891,548	5,955,005
13	Lifespan of BMP (years)	3	5	10	3	3	15
14	Annual Watershed Cost ($)	421,060	79,245	28,451	71,756	297,183	397,000
15	Cost-eff. of TP Reduction (lbs/$1,000)	1.861	4.799	32.083	7.066	11.703	9.320
16	Priority Rank for TP Reduction	6	5	1	4	2	3
17	Cost-eff. of Sed. Reduction (T/$1,000)	0.188	0.198	1.842	1.016		0.630
18	Priority Rank for Sed. Reduction	5	4	1	2	6	3

The total watershed costs are calculated based on the life span of the BMPs. Water quality effects are measured by the annual average reduction in TP and sediment. The cost-effectiveness of these BMPs is based on the annual watershed costs of these BMPs estimated based on the following assumptions. First, the implementation costs for cover crops, contour farming and nutrient management are estimated assuming farmers enter into three-year contracts to maintain the BMPs once enrolled in the programs. Second, life spans are five years for the facilities used in prescribed grazing and ten years for livestock access control. After the initial program period, farmers are assumed to continue using those practices due to the added economic benefits, their increased environmental awareness and tighter regulatory requirements. Third, the lifespan for riparian buffers and conservation buffers is assumed to be 15 years.

The annual watershed cost equals the total watershed cost divided by the years in the effective assessment period plus annual operation and maintenance costs, if any. Cost-effectiveness for TP reduction equals the annual average TP reduction divided by the annual watershed cost. Cost-effectiveness for sediment reduction is the annual average sediment reduction divided by the annual watershed cost. Therefore, cost-effectiveness measures the reduction in TP or sediment per $1,000 spent on the BMP in the watershed. For example, every $1,000 of expenditure would reduce TP by 1.86 pounds if spent on cover crops and 32.08 pounds if spent on livestock access control. BMPs were prioritized based on their cost-effectiveness with BMPs resulting in a larger reduction in pollutant load receiving a higher priority for implementation.

Table 7.11 gives the priority ranks for BMPs in reducing TP and sediment. Livestock access control is ranked first in reducing both TP and sediment. Nutrient management is ranked second in reducing TP and contour farming is ranked second in reducing sediment. Conservation buffer and contour farming are ranked third and fourth, respectively, in reducing TP whereas conservation buffers and prescribed grazing are ranked third and fourth, respectively, in reducing sediment. The cost-effectiveness indicates the order in which BMPs should be selected to reduce pollutant loads when there is a limited budget for watershed restoration. Pollution load reductions are estimated assuming BMPs are applied individually. When multiple BMPs are applied to the same fields, the pollutant reduction from those fields will increase, but the total reduction in pollutant loads at the watershed scale is expected to be smaller because of the overlapping effects.

Table 7.12 presents the resulting water quality effects, costs and cost-effectiveness for stormwater BMPs in Neshanic River Watershed. Estimation of the effects assumes each BMP is individually applied to suitable agricultural lands in the watershed. The watershed has 3,545 potential sites for rain gardens and 27,603 feet of riparian segments suitable for vegetative buffers in the non-agricultural, developed lands. The stormwater infrastructure inventory identified 853 segments of roadside swales and ditches with an average length of 240 feet and 153 detention basins with the average size of 0.68 acres. The scale-up for rain gardens, roadside ditch retrofitting, detention basin retrofitting and vegetative buffers in developed lands is based on the information in Section 7.4 on the site specific projects. Information on the assessment unit, reduction rates for TP and sediment, and assessment costs come from the project descriptions given in Section 7.4. Specifically, the information on individual rain gardens given in Section 7.4.1.1 is used to estimate the water quality impacts and watershed costs for all 3,545 rain gardens in the watershed. Because its size is close to the average size of ditches in the watershed, information for retrofitting roadside Ditch_SD_389 in Section 7.4.2.3 was scaled up to estimate the impacts of retrofitting all ditches. The scale-up for detention basins is adjusted using the information on retrofitting DB_MDB_0035 in Section 7.4.3.1. Information on the vegetative buffer project in Section 7.4.4 was used to scale up to the watershed effects of installing 27,603 feet of buffers in the non-agricultural developed lands. Total annual reductions in TP and sediment are the products of the reductions achieved by individual projects and the applicable units divided by the assessment unit. The total watershed cost is the product of the total assessment cost and the applicable units divided by the assessment unit. The lifespans for all stormwater BMPs are assumed to be 15 years. Annual watershed cost is total watershed cost divided by 15 years, which is the life span of the BMPs.

Table 7.12: Water quality effects, costs and cost-effectiveness of stormwater BMPs in Neshanic River Watershed

		Rain Garden	Roadside Ditch Retrofitting	Detention Basin Retrofitting	Vegetative Buffers on Developed Lands
1	Assessment Unit	1 unit	1 unit	1 unit	1,900 feet
2	TP Reduction Rate (%)	50	30	50	30
3	Sediment Reduction Rate (%)	90	60	90	60
4	Installation Cost ($)	1,650	13,000	17,000	6,200
5	Maintenance Cost ($)	1,500	7,500	7,500	1,500
6	Other Costs ($)	1,000	3,000	5,000	1,500
7	Total Assessment Cost ($)	4,150	23,500	29,500	9,200
8	Applicable Unit	3,545 units	853 units	153 units	27,603 feet
9	Annual TP Reduction (lbs.)	44	196	1102	38
10	Annual Sediment Reduction (tons)	4	33	138	19
11	Total Watershed Costs ($)	14,711,750	20,045,500	4,513,500	133,657
12	Life span of BMP (years)	15	15	15	15
13	Annual Watershed Cost ($)	980,783	1,336,367	300,900	8,910
14	Cost-eff. for TP Reduction (lbs./$1,000)	0.045	0.147	3.661	4.321
15	Priority Rank for TP Reduction	4	3	2	1
16	Cost-eff. for Sediment Reduction (T/$1,000)	0.004	0.025	0.458	2.160
17	Priority Rank for Sediment Reduction	4	3	2	1

Similarly, the cost-effectiveness of TP reduction is the annual average TP reduction divided by the annual watershed cost for each stormwater BMP. Cost-effectiveness of sediment reduction is the annual average sediment reduction divided by the annual watershed cost. Cost-effectiveness measures the average reduction in TP or sediment per $1,000 of expenditure on each stormwater BMP in the watershed. For example, if $1,000 is spent on vegetative buffers on developed lands, TP would decrease by 4.32 pounds and sediment would decline by 2.16 tons. Rain gardens would only reduce TP by 0.045 pounds and sediment by 0.004 tons per $1,000 spent on each practice. BMPs were prioritized based on their cost-effectiveness. The BMPs resulting in a larger reduction in pollutant load are given a higher priority for implementation.

Table 7.12 gives the priority ranks for these stormwater BMPs in reducing TP and sediment, respectively. Priority ranks for reducing TP and sediment are the same for the four stormwater BMPs. Vegetative buffers and the detention basin retrofitting are ranked first and second, respectively, and the roadside ditch retrofitting and rain gardens are ranked third and fourth, respectively, in reducing TP and sediment. There are dramatic differences in the cost-effectiveness of the four stormwater BMPs. Detention basin retrofitting is almost as cost-effective as the vegetative buffers in reducing TP. Rain gardens are almost 100 times more cost effective than vegetative buffers in reducing TP. A comparison of the cost effectiveness of stormwater and agricultural BMPs indicated that all stormwater BMPs except vegetative buffers are much more expensive than the agricultural BMPs in reducing TP and sediment.

All BMPs have other hydrological and water quality benefits. For example, stormwater BMPs, such as rain gardens, result in large reductions in the amount of stormwater runoff and runoff velocity in receiving streams. As discussed in Section 7.1.1, one of the most significant water quality issues in the Neshanic River Watershed is pathogenic contamination. The SWAT model indicates that failing OSDSs contribute 46 percent of the pathogenic load, animal manure applied to row-crop fields contributes 31 percent of the annual pathogenic load to Neshanic streams, and livestock access to streams contributes 19 percent of the annual pathogenic load in the Neshanic River Watershed. Fate and transport of pathogens are not as well understood as fate and transport of TP and sediment. Therefore, the effectiveness of the BMPs in reducing pathogenic loads to the streams cannot be assessed as precisely as reductions in TP and sediment. Cost-effectiveness of BMPs for reducing the pathogenic loads was assessed differently.

Table 7.13: Costs of three major BMPs for reducing pathogenic loads in Neshanic River Watershed

Types of BMPs	Applicable Units	Unit Costs ($/unit)	Life span (years)	Total Cost ($)	Annual Cost ($/year)
OSDS Management					
System Inspection and Maintenance	1,490 units	600	3	894,000	298,000
Retrofitting on Failed Systems	447 units	15,000	15	6,705,000	447,000
Subtotal				7,599,000	745,000
Manure Management					
Regional Anima Waste Storage and composting Structure	5 units	90,000	10	450,000	45,000
Manure Application Incorporation Technology	330 acres	156	1	51,480	51,480
Subtotal				501,480	96,480
Livestock Stream Access Control					
Livestock Access Control	24,663 feet	11.54	10	284,512	28,451
Subtotal				284,512	28,451

Table 7.13 gives the costs of three BMPs for reducing pathogenic loads: OSDS management, manure management and livestock stream access control. OSDS management involves two integral components of the OSDS education and management strategies discussed in Section 7.1.1.1: system inspection and maintenance; and failing system retrofitting. Total cost

of OSDS management is $7.6 million and annual cost is $745,000. Improving OSDS management in the watershed will reduce pathogenic loads to streams by 46 percent at an annual average cost of $16,196 for each 1 percent reduction in pathogenic load. Manure management includes establishing and operating 5 regional animal waste storage and composting structures and implementing manure application incorporation technology for row-crop fields in the watershed, in addition to being compliant with the New Jersey Animal Waste Rules. Total cost for the two BMP projects for manure management is $501,480 and the annual cost is $96,480. Manure management is expected to reduce pathogenic loads to streams from manure application by 31 percent. The cost of reducing pathogenic loads by 1 percent is $3,112 for manure management. As discussed before, the annual cost of livestock stream access control is $28,451; such control will reduce pathogenic loads to streams in the watershed by 19 percent. The cost of reducing pathogen loads to streams by 1 percent is $1,497 for the livestock access control practice. In summary, livestock access control, manure management and OSDS management are the highest, second highest and lowest cost-effective BMPs for reducing the pathogenic loads, respectively.

Table 7.14 summarizes the priority ranks of all BMP projects in terms of their cost-effectiveness in reducing TP, sediment and pathogens in the Neshanic River Watershed. The highest-ranked BMP in terms of cost-effectiveness has the highest priority for implementation.

Table 7.14: Priority ranks for all BMP projects in Neshanic River Watershed

BMP Project		Priority Rank in Reducing		
		TP	Sediment	Pathogens
1	Cover Crops	8	7	
2	Prescribed Grazing	5	6	6
3	Livestock Access Control	1	2	1
4	Contour Farming	4	3	
5	Nutrient Management	2		9
6	Conservation Buffers in Agricultural Lands	3	4	10
7	Livestock Waste Storage and Composting Structure	12		2
8	Manure Application Incorporation Technology	11		4
9	Rain Gardens	10	9	
10	Road Ditches	9	8	11
11	Detention Basin Retrofitting	7	5	7
12	Vegetative Buffers on Developed Lands	6	1	8
13	OSDS Inspection and Maintenance	13		3
14	Failed OSDS Retrofitting	14		5

Note: A shaded area indicates the BMP has an insignificant impact on the reduction of the pollutant.

The top 5 ranked BMPs for reducing TP loads are:

1. Livestock access control;
2. Nutrient management;
3. Conservation buffers on agricultural lands;
4. Contour farming; and
5. Prescribed grazing.

The top 5 ranked BMPs for reducing sediment are:

1. Vegetative buffers in developed lands;
2. Livestock access control;
3. Contour farming;
4. Conservation buffers on agricultural lands; and
5. Detention basin retrofitting.

The top 5 ranked BMPs for reducing pathogenic loads to the streams are

1. Livestock access control;
2. Livestock waste storage and composting structures;
3. OSDS inspection and maintenance;
4. Manure application incorporation technology; and
5. Failed OSDS retrofitting.

Additional criteria can be used to rank BMP projects. These criteria may include

- Landowner access and cooperation;
- Permitting requirements;
- Site constraints (topography, wetlands, stream encroachment, etc);
- Funding sources;
- Expected time frames;
- Project partners needed;
- Ecological benefits; and
- Long term maintenance/monitoring needs.

Use of those criteria needs more site-specific information. Although they cannot be used in the plan to rank the BMPs due to the limited site-specific information, they can be used to rank any proposed implementation projects when more site-specific information is collected for implementation.