Neshanic River Watershed Restoration Plan

Stormwater Infrastructure Inventory

Final Report

Submitted by

Hunterdon County Soil Conservation District
Frenchtown, New Jersey

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Executive Summary

The Hunterdon County Soil Conservation District (HCSCD), along with NJIT and project partners has conducted mapping assessment to locate and document the stormwater infrastructure of the Neshanic River watershed. The Project is funded by the New Jersey Department of Environmental Protection Agency through Section 319 of the Clean Water Act. This task was executed from 2006 through 2009. This report documents the equipment, methodology and staff which were employed in this process.

A total of 12 distinct types of stormwater infrastructure were located and mapped using the global positioning system. Attribute data and observations were recorded for each discrete feature in the dataset. The result is a not inconsiderable collection of data comprised of 8134 distinct individual components. Beyond establishing physical locations for stormwater infrastructure the observation data will help to inform decision making for future retrofits as well as to allow informed decisions to be made concerning maintenance and management practices.

Introduction

This report presents the findings of **Task 4 -Conduct Stormwater Infrastructure Inventory for the Neshanic River Watershed Restoration Plan Project** led by New Jersey Institute of Technology (NJIT). The Neshanic River Watershed Restoration Plan project (RP06-068) is funded by the New Jersey Department of Environmental Protection Agency through Section 319 of the Clean Water Act. This task was executed by the staff of the Hunterdon County Soil Conservation District from 2006 through 2009.

The task endeavors to locate and document the stormwater infrastructure in the Neshanic River Watershed. The Neshanic River Watershed is composed of the Townships of Raritan, Delaware, East Amwell and a small portion of Flemington Borough, in Hunterdon County, New Jersey. The study area is approximately 31 mi^2 and covers the majority of the Neshanic River Watershed. This includes the Walnut Brook, First, Second and Third Neshanic Rivers and the Neshanic River main branch immediately above the Back Brook confluence. The study area consists of five Hydrological Unit Code (HUC) 14 areas, 02030105030010, 02030105030020, 02030105030030, 02030105030040 and a portion of 02030105030060.

The Neshanic River is a tributary of the South Branch of the Raritan River which discharges to the Raritan Bay estuary on the Atlantic coast of New Jersey.

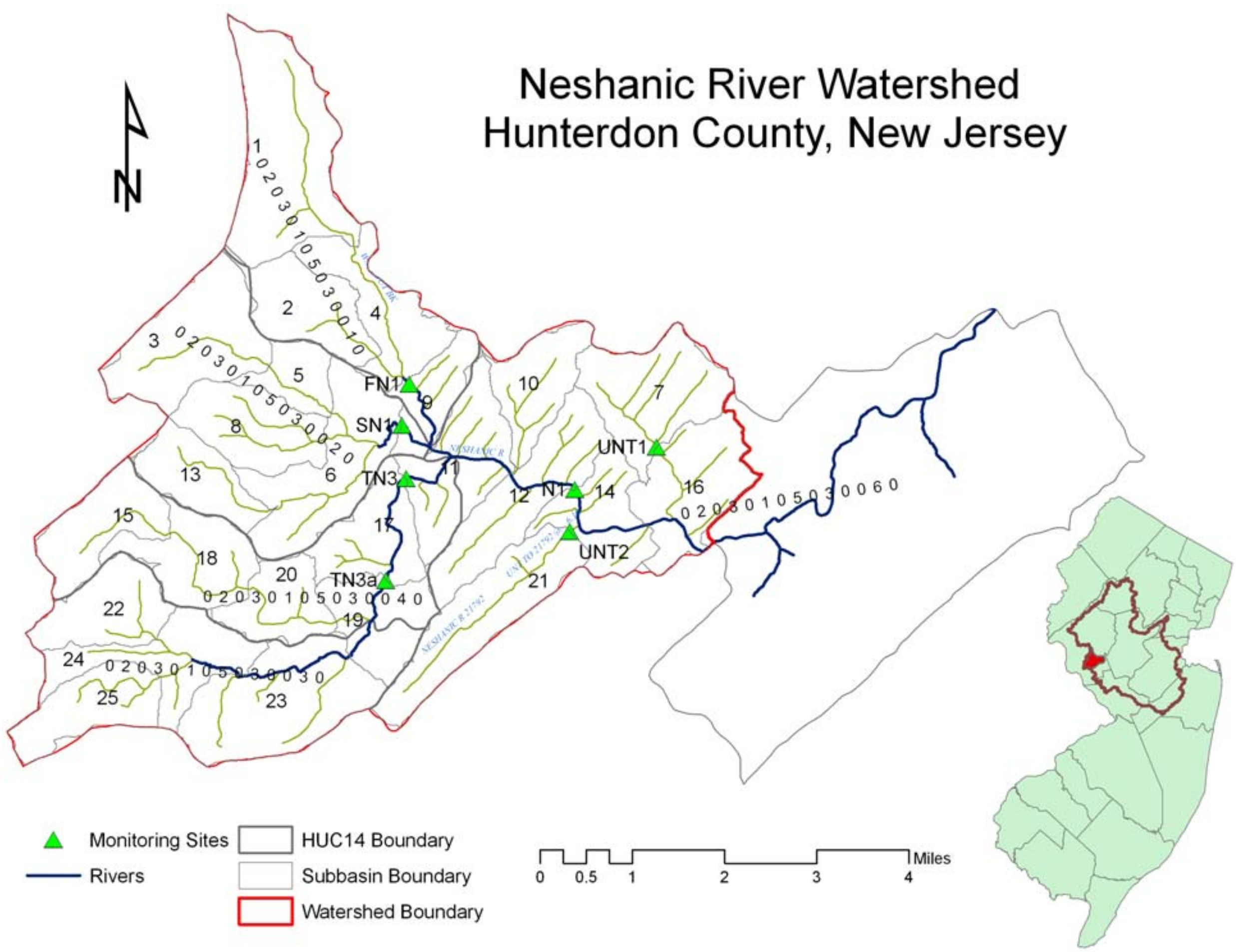

Figure 1: The Neshanic River watershed and study area

The climate of the region is humid subtropical, with typically hot and humid summers and usually cold winters. According to weather data for the period 1955 – 2008, the air temperatures during summers (June to August) show average high of 81 – 86 °F (27 – 30 °C) and lows of 55 – 61 °F (13 – 16 °C) with temperatures that exceed 90 °F (32 °C) on average 19 days each summer, though rarely exceed 100 °F (38 °C). The average high temperatures during winters (December to February) are 37 – 41 °F (3 – 5 °C) and average lows range from 19 – 29 °F (-7 – -5 °C), but temperatures could, for brief interludes, be as low as 10 – 20 °F(-12 – -7 °C) and sometimes rise to 50 – 60 °F (10 – 16 °C). Spring and autumn are transitional seasons and feature wide temperature variations.

The mean annual precipitation of the watershed is about 1218 mm (1955-2008), falling on an average of 104 days a year, uniformly spread through the year. Snowfall per winter season is about 5 – 30 inches (12 – 77 cm), but this varies from year to year. During winter and early spring in some years the watershed can experience nor'easters, which are capable of causing blizzards or flooding. The watershed is also known to experience drought and rain-free period for weeks. Hurricanes and tropical storms (such as Hurricane Floyd in 1999) are infrequent, but can bring excessive rainfall which results in flooding (NJWSA, 2000).

The annual mean evapotranspiration, groundwater recharge, and runoff of the Neshanic River watershed are estimated to be 609 mm (23.96 inches), 133 mm (5.25 inches) and 401 mm (15.78 inches), respectively. According to the a long-term water budget analysis for Raritan River Basin, which assumes that long-term stream baseflow is equivalent to long-term groundwater recharge (below the plant root zone) except for the impacts of depletive and consumptive uses within the watershed (NJWSA, 2000).

The Neshanic River is classified as FW2-NT, or freshwater (FW) non-trout (NT). “FW2” refers to water bodies that are used for primary and secondary contact recreation; industrial and agricultural water supply; maintenance, migration, and propagation of natural and established biota; public potable water supply after conventional filtration treatment and disinfection; and any other reasonable uses. “NT” means those freshwaters that have not been designated as trout production or trout maintenance. NT waters are not suitable for trout due to physical, chemical, or biological characteristics, but can support other fish species (NJDEP 2008). The Neshanic River was considered to be one of the worst water bodies in terms of overall water quality in the Raritan River Basin, as it had either the highest concentrations of constituents or the highest frequency of non-attainment for 13 of 17 water quality constituents (Reiser, 2004).

As with much of New Jersey, this Neshanic River Watershed has experienced significant development pressure during the last three decades. Based on the land use/cover database compiled by the New Jersey Department of Environmental Protection (NJDEP), the percentage of the urban land in the watershed had increased from 17.4 percent in 1986 to 30.7 percent in 2002. The increases in urban land primarily came from agricultural land in the watershed. While other land uses were relatively steady (forest: 20 percent; wetlands 7 percent; water 0.2 percent and barren 1.6 percent), the agricultural lands in the watershed had decreased from 55 percent in 1986 to about 40 percent in 2002.

The study area has mixed land uses and varying levels of stormwater infrastructure. As one of the first portions of Hunterdon County to urbanize, the Neshanic River Watershed possesses some of the County’s oldest stormwater infrastructure. In light of this, some elements of the system represent outdated design concepts, but offer good opportunities for retrofit. Other portions of the watershed are still primarily rural and agricultural, and tend to display a far less developed infrastructure. This open ditch system was inherited piecemeal rather then designed, as part of the development process. The result is diverse stormwater system which will present a variety of challenges to efforts to improve water quality.

Methodology

The mapping effort is based on the *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments* (Brown et al., 2004). This document provides excellent background information on mapping and understanding municipal separate storm swear systems (MS4).

Field data was collected using the NJDEP GPS Data Collection Standards for GIS Data Development http://www.state.nj.us/dep/gis/gpsoutstand.html. Some exceptions and deviations were made in the interest of expediency or to compensate for difficult GPS environments including heavy tree cover and other obstructed areas. When they occurred deviations are noted in the data set. Coordinate data was field recorded in the New Jersey State Plane Coordinate System (NJSPCS) in the North American Datum of 1983 (NAD83) horizontal geodetic datum expressed in feet. When elevation data was recorded, it was referenced to the North American Vertical Datum of 1988 (NAVD 88) vertical geodetic datum. Elevations are presented as orthometric heights (relative to mean sea level) determined using the GEOID99 (Continental US) geoid conversion model. It should be noted that the vertical data collected in this study is a product of varied field based approaches to gathering data. The methods utilized were not always consistent. This is a result of variable and often difficult field conditions, and also reflects the diversity of design solutions present in the stormwater system. Under no circumstances should the vertical elevations recorded in this data set be used for design or modeling. Some features were digitized directly into the GIS rather then field located. Digitized data reflects observations made in the field where safety or access issues prevented the data from being cataloged using global positioning data recorders.

Photography

Ten of the thirteen categories of stormwater infrastructure were photographed as part of the inventory. Pipe inlets, catch basins and upstream culverts were not photographed. Photographs are matched to the Global Positioning System date with an alphanumeric name and by the digital photographs date and time stamp, which is automatically recorded with the photograph.

Types of stormwater infrastructure

The following types of stormwater infrastructure were located and characterized in the Neshanic River Watershed.

Catch Basins Catch basins, also known as storm drain inlets, or curb inlets, are the primary collection points where stormwater enters into the municipal stormwater system. Catch basins are more prevalent in areas of newer or more urbanized infrastructure. Due to their relative similarity and the high number of catch basins, they were not individually photographed. A total of 4482 catch basins were located and mapped within the Neshanic River Watershed study area.

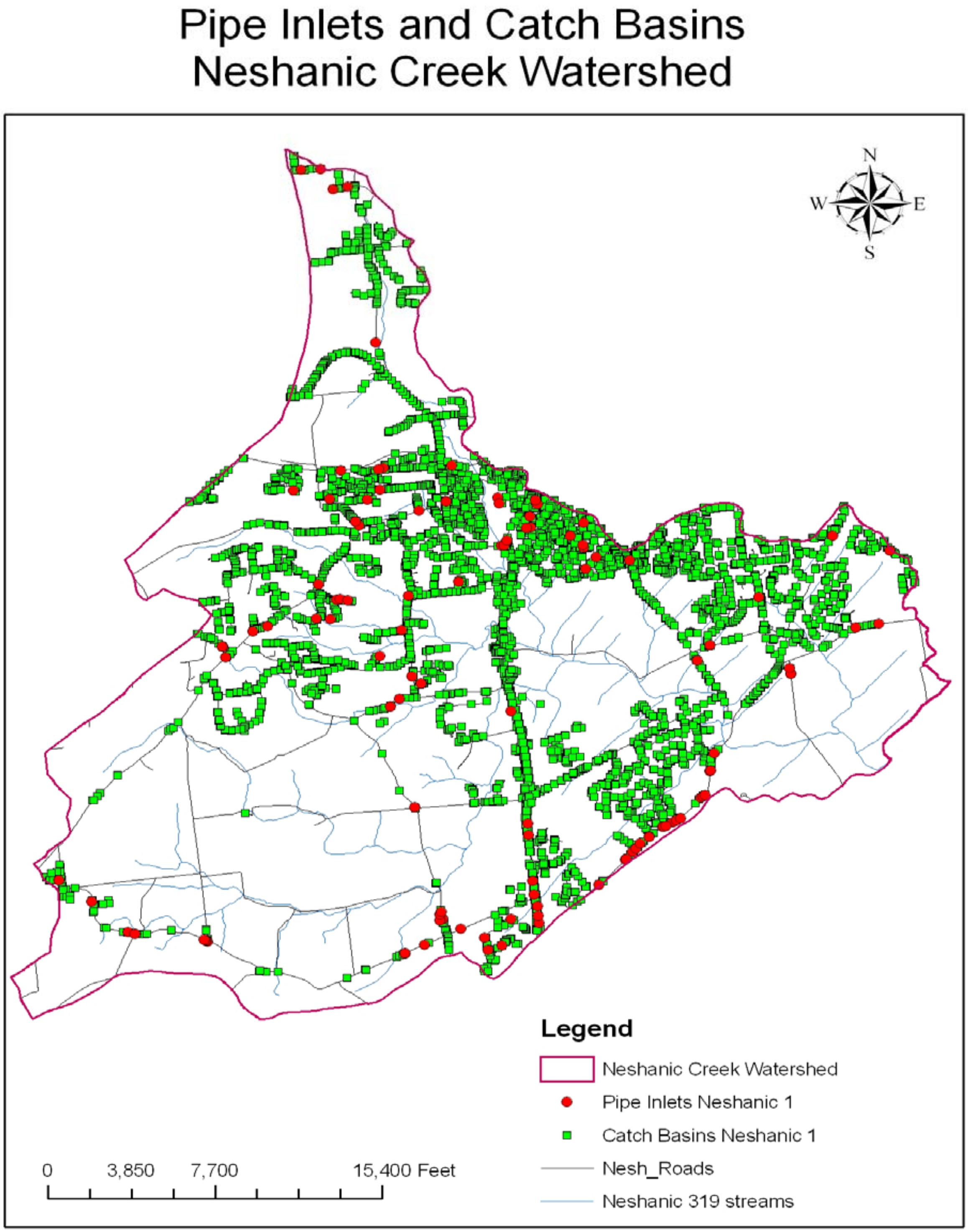

Figure 2: Distribution of Pipe Inlets and Catch Basins in Neshanic River watershed

Figure 3: Catch Basin

Pipe Inlets Pipe inlets serve the same purpose as catch basins or storm drains, but omit the grate, head and sump found on catch basins. These parts of the stormwater system are simple pipes horizontal pipe into which stormwater flows. There were 115 pipe inlets located in the study area. These were also not photographed.

Culvert Upstream A culvert is a conduit used to enclose a concentrated flow. These are commonly employed to allow water to pass under a road, driveway, or railroad. The upstream portion of this feature signifies that this is the point at where water enters the conduit. For the purpose of this study culverts were defined as relatively straight segments – no turns, elbows, or bends. In total 714 downstream culverts were mapped during the study.

Culvert Downstream A culvert is a conduit used to enclose a concentrated flow. These are commonly employed to allow water to pass under a road, driveway, or railroad. The downstream portion of this feature signifies that this is the point at where water exits from the conduit. For the purpose of this study, culverts were defined as relatively straight segments – no turns, elbows, or bends. A total of 714 down stream culverts were mapped during the study

Figure 4: Culvert Down Stream

Discharge pipes Also know as drainage pipes, or pipe outfalls, these are the locations where stormwater exits the stormwater system. Discharge pipes are most commonly located near streams, wetlands or other low lying areas. This category of feature does not include pipes which discharge directly into detention basins. Those features have been separated into their own class of features. A total of 409 discharge pipes were located in the study area**.**

Figure 5: Discharge Pipe

Basin Discharges The point of discharge of a detention basin. These are commonly located in low area adjacent to streams or wetlands. A total of, 118 were mapped in the study area. Since some detention basins discharge back into the MS4 via subsurface piping not every basin had a basin discharge pipe.

Figure 6: Detention Basin Discharge

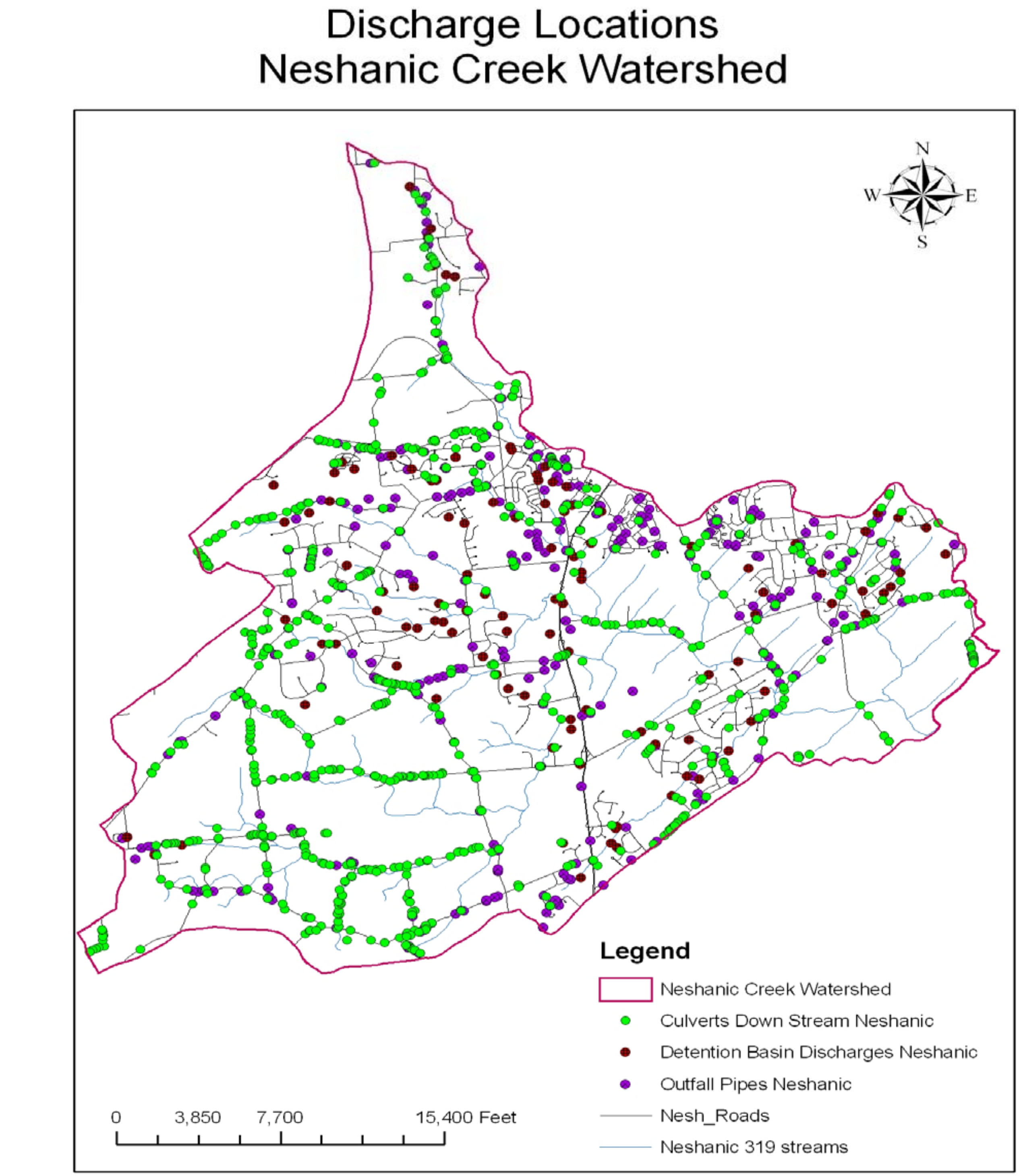

Figure 7: Basin Discharge Locations in Neshanic River Watershed

Ditches and Swales This category indicates the presence of defined flow paths used to direct stormwater flows. Swales and ditches are most common in the more rural portions of the watershed where piped drainage is less prevalent. A total of 853 swale /ditch segments were identified within the study area.

Figure 8: Roadside Swale

Swales and Ditches
Neshanic Creek Watershed

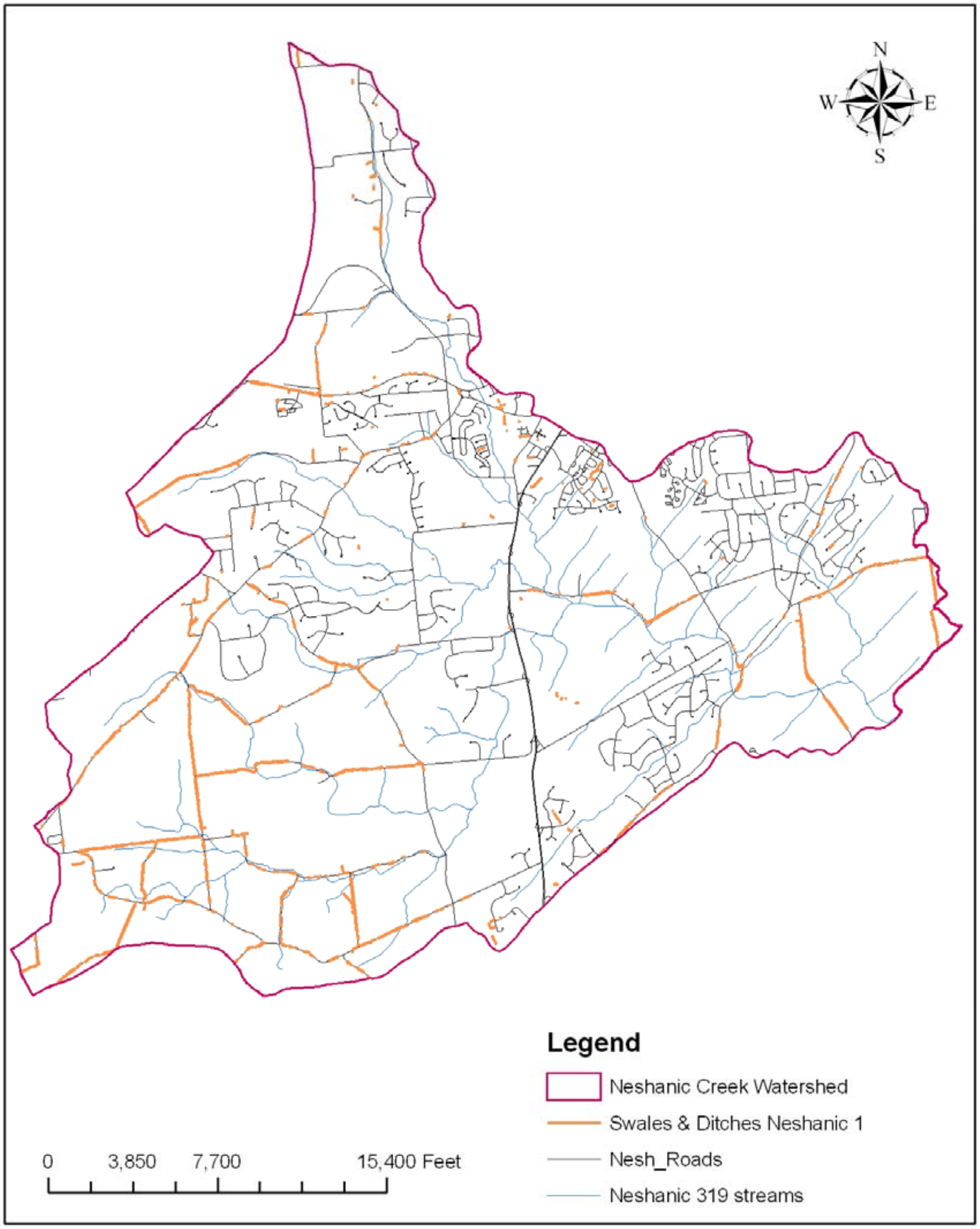

Figure 9: Distribution of Swales and Ditches in Neshanic River Watershed

Detention Basin Is a stormwater management facility. Typically these are constructed impoundments, but may also include bermed stream corridors. Originally these were constructed strictly to reduce flooding and to lower the volume and velocity of stormwater flows. In latter designs water quality enhancements have been included. The most common is the inclusion of a 3 inch water quality orifice which is designed to increase residency time and improve nutrient reductions. A total of 154 Detention Basins were located in the study area.

Figure 10: Detention Basin

Basin Outlet Structure A structure designed to regulate stormwater flows exiting from a detention basin. These have grown in complexity over time. They range from simple concrete weirs regulating flows to complex multi outlet cast concrete towers weighing several tons. A total of 151 detention basin outlet structures were located in the study area.

Figure 11: Detention Basin Outlet Structure

Basin Inflows Are pipes which carry water into a detention basin. These are in effect discharge pipes which empty into a detention facility. While some basins rely strictly on overland flow to direct water to a detention basin, it is not uncommon for a single detention basin to have multiple inflow pipes. A total of 220 were basin inflow pipes mapped in the study area.

Figure 12: Detention Basin Inlet Pipe

Low Flow Channel – Are defined flow paths located on the floor of a detention basins. These features channel stormwater flows from a point of entry to the basins outlet structure or discharge point. Some basins have multiple channels while others do not have a low flow channel. A total of 196 separate low flow channel segments were located and mapped in the study area.

Figure 12: Detention Basin Low Flow Channel

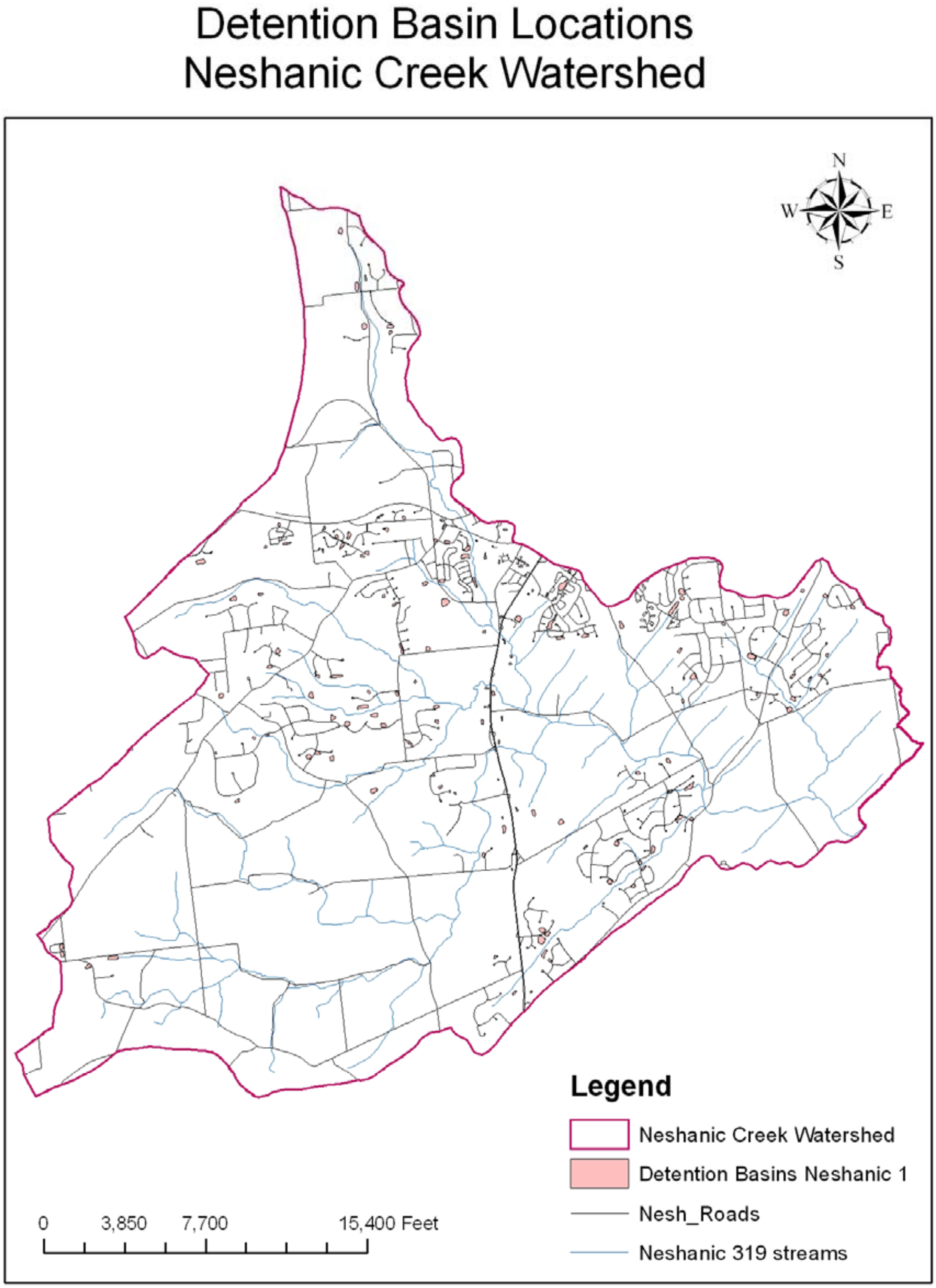

Figure 13: Distribution of Detention Basins in Neshanic River Watershed

Figure 13: Aerial Photography and Stormwater Infrastructure Mapped at Hunterdon County Complex

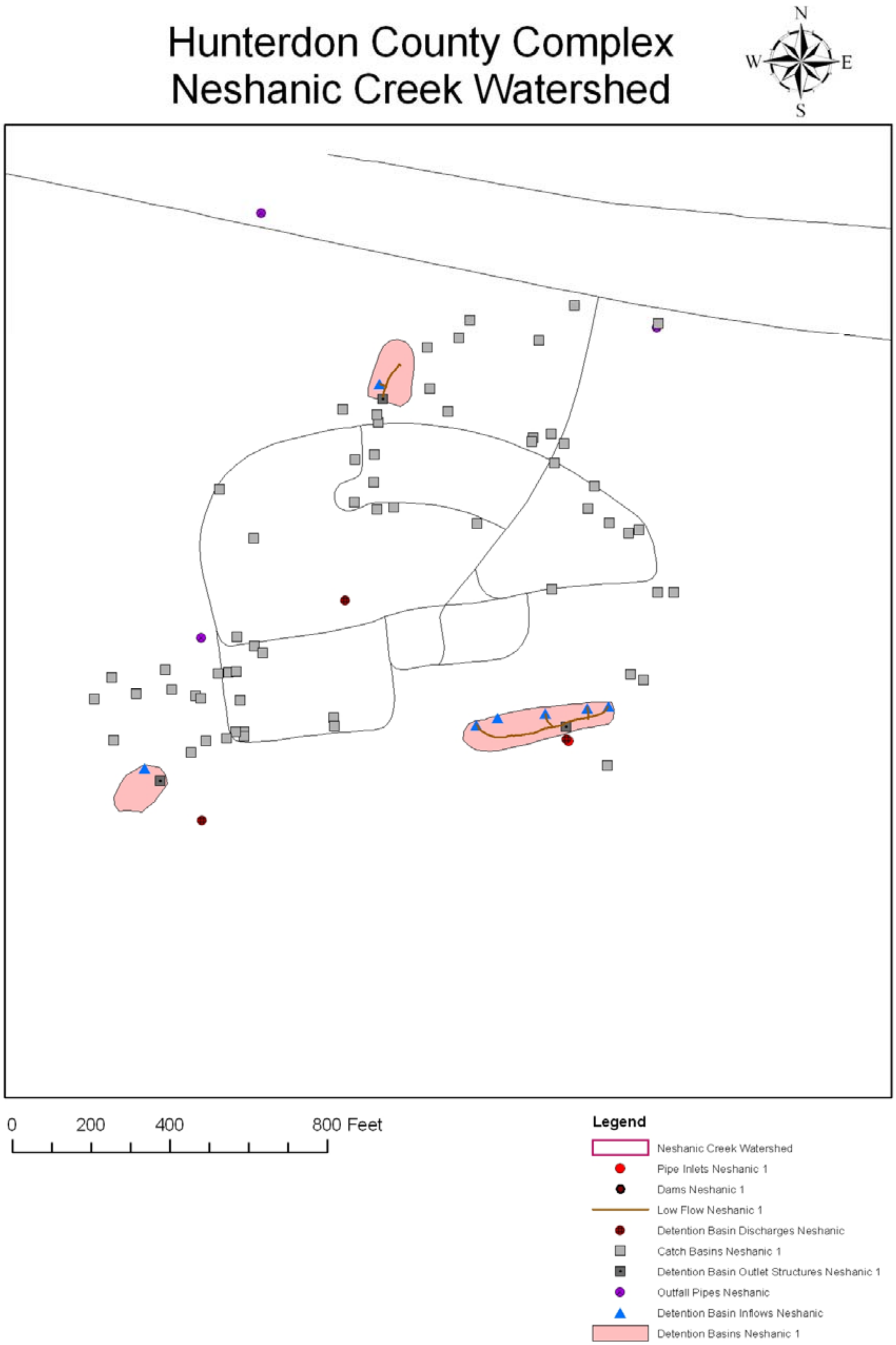

Figure 14: Stormwater Infrastructure Mapped at Hunterdon County Complex

Dams – These are in stream structures which hold back, impound, or restrict flow. Though not typically considered part of a MS4 they were recorded when noted. This may not be a complete list. A total of 8 were mapped in the study area.

Figure 15: Dam

Stream Photo's While locating stormwater infrastructure the stream corridors were walked. During that process 238 photographs of the stream were taken. Though outside the immediate scope of the project these may prove helpful in the future and will help to establish a baseline of conditions between 2006 -2009. No individual attributes were recorded with the stream photos.

Figure 16: Stream Photo

Table 1: Types and Amounts of Stormwater Infrastructure Mapped in Neshanic River Watershed

Catch Basins	4482
Pipe Inlets	115
Culverts Up Stream	714
Culverts Down Stream	714
Discharge Pipes	409
Basin Discharges	118
Swales and Ditches	853
Detention Basins	154
Basin Outlet Structures	151
Basin Inlets	220
Low Flow Channels	196
Dams	8
Stream Photo's	238

Features and Attributes

The Global Positioning System (GPS) recorded stormwater infrastructure in three forms: a point, line, or area feature. Of the 13 distinct features mapped in the study, two are represented as lines, one is displayed as an area, and the remaining ten are displayed as points.

Lines – Swales & Ditches, Low flow Channels
Areas – Detention Basins
Points – Catch basins, discharge pipes, pipe inlets, basin inflows, basin outlet structures, detention basin discharges, dams, stream photos, culvert upstream, culvert downstream,

Each mapped feature is further described by field observations recorded as attributes.

Shared GIS Generated Attributes -These are attributes automatically recorded by the Trimble terrasync software and are common to all features. These primarily reflect the method and accuracy of the data being collected.

FID – A numerical identifier assigned to each individual feature.
SHAPE – Indicates the feature is a line, shape or point
TIME – Indicates time feature was mapped. Format   00:00:00 Am
DATE_LOGG- Indicated the day when the feature was mapped
MAX_PDOP – The highest PDOP value at which a receiver will compute positions. DOP = Dilution of Precision this is an indicator of the quality of a GPS position, which takes account of each satellite's location relative to the other satellites in the constellation, and their geometry in relation to the GPS receiver. A low DOP value indicates a higher probability of accuracy.
MAX_HDO – The highest HDOP value at which a receiver will compute positions for horizontal dilution of precision

CORR_TYPE – Indicates the type of data correction
RCVR_TYPE – Indicates the type of data receiver was used to collect the rover files
GPS_DATE – Temporal indication of when the data was recorded (calendar date)
GPS_TIME – Temporal indication of when the data was recorded (time of day)
UPDATE_STA – Indicates if the data has been updated
FEAT_NAME – Indicates what type of feature has been recorded
DATAFILE – The name of the rover file from which the data originated
UNFILT_POS – Number of unfiltered field positions
FILT_POS – Indicates the number of field positions recorded after filtering
DATA DICT – The name of the data dictionary used to collect data
GPS_WEE – Indicates what week the feature was mapped
GPS_HEIGHT- Vertical location relative to mean sea level
VERT_PREC – A measure of vertical precision
HORZ_PREC - A measure of horizontal precision
STD_DEV - A measure of positional accuracy
NORTHING – Latitude is an angular measurement made from the center of the earth to north or south of the equator. It comprises the north/south component of the latitude/longitude coordinate system, which is used in GPS data collection. Traditionally, north is considered positive, and south is considered negative
EASTING - Longitude is an angular measurement made from the center of the earth to the east or west of the Greenwich meridian (London, England). It comprises the east/west component of the latitude/longitude coordinate system, which is used in GPS data collection. Traditionally, east is considered positive, and west is considered negative.
Avg_Vert_P - Average vertical precision - A measure of positional accuracy
Avg_Horz_P- Average horizontal precision - A measure of positional accuracy
Worst Vert -Worst vertical precision- A measure of positional accuracy
Worst Horz-Worst vertical precision- A measure of positional accuracy

Attributes of mapped features

Catch Basins Specific attributes recorded for each catch basin include:

Catch basin ID – An individual identifier assigned to each catch basin (##)
Type – Type of catch basin
Head Type – Type of head on the catch basin
Grate type- Determines if the grate is a bicycle grate or a stream flow grate
Condition – Indicates the physical (structural) condition of the gate
In Road - Indicates if the catch basin is located in a paved area such as a road or parking lot as apposed to a basin located in a grass or vegetated area.
Stormdrain Marker – Indicates if the basin has a storm drain marker which are a stormwater rule requirement in some residential areas with sidewalks.
Pipes – Indicates the number of pipes that were observed discharging into the sump portion of the catch basin.
Clean Out- Is there sufficient material in the catch basin to require a clean out
Material in Basin- If there is material present in the catch basin what is it?
Name – Left blank – allows for additional naming.
Notes- Observation notes
Date- The date when the feature was mapped

Time- The time when the feature was mapped

Pipe Inlets Specific attributes recorded for each pipe inlet include:

Pipe Inlet ID – An individual alpha-numeric identifier assigned to each pipe inlet (IP- #)
Type- Describes the type of pipe
Pipe- GE – Pipe Geometry – Describes the shape of the pipe
Size - Describes the shape of the pipe in inches
Size if other – Allows for an uncommon pipe size, or one which was not programmed into the data dictionary
Condition Describes the physical condition of the pipe
Trash Rack /Cover -Indicates if a trash rack is present
Name- Unfilled –Allows for additional naming
Date - The date when the feature was mapped
Time- The time when the feature was mapped

Culvert Upstream Specific attributes recorded for each culvert upstream include:

Culvert ID- An individual identifier given to each culvert (Cus-#)
Deposition- Indicates if the culvert is experiencing a depositional environment
Scour - Indicates if the culvert is experiencing is scour
Maintenance needed - Indicates if maintenance is needed
Condition- Describes the physical condition of the culvert
Time- The time when the feature was mapped
Notes- Observation notes
Date - The date when the feature was mapped
County Name- Provides for the inclusion of the alpha numeric identifier assigned to structures owned and operated by the County of Hunterdon

Culvert Down Stream Specific attributes recorded for each culvert down stream include:

Culvert ID- An individual identifier given to each culvert (Cds-#)
Piped Stream- Indicates if the culver is a piped stream or natural drainage with more permanent flows
Type- Describes the type of pipe
Pipe- GE – Pipe Geometry – Describes the shape of the pipe
Size - Describes the shape of the pipe in inches.
Size if other – Allows for an uncommon pipe size, or one which was not programmed into the data dictionary
Type not pipe - Describes the type of pipe
Width not Pipe- Indicates the width of the culvert in inches
Height not pipe - Indicates the height of the culvert in inches
Scour?- Indicates if the culvert is experiencing scour
Deposition - Indicates if the culvert is experiencing a depositional environment
Debris- Indicates is there are debris obstructing flow through this culvert
Maintenance needed?- Indicates if maintenance is needed
Condition- Describes the physical condition of the culvert

Time- The time when the feature was mapped
Notes- observation notes
Date - The date when the feature was mapped
County Name- Provides for the inclusion of the alpha numeric identifier assigned to structures owned and operated by the County of Hunterdon

Discharge Pipes Specific attributes recorded for each discharge pipe include:

Pipe ID- An unique name assigned to each discharge pipe (ofp-##)
Type- Describes the type of pipe
Pipe- GE – Pipe Geometry – Describes the shape of the pipe
Size - Describes the shape of the pipe in inches
Size if other – Allows for an uncommon pipe size, or one which was not programmed into the data dictionary
Condition- Describes the physical condition of the pipe
Condition Notes – Describes the physical condition of the pipe – notes any structural failing
Trash Rack /Cover –Indicates if a trash rack is present
COP- Is there conduit outlet protection installed at the point of discharge
COP type- Indicates the type of conduit outlet protection
Standing Water- Indicates if there standing water located at the discharge point
Erosion- Indicates if there is evidence of erosion at the point of discharge
Deposition - Indicates if there is evidence of a depositional environment at the point of discharge
Illicit Connection- This is a determination check for a dry weather flow. Per DEP illicit connection protocol
Photo taken-Indicates is a photo was taken at of this feature.
Notes- Observation notes
Name- Unfilled –Allows for additional naming
Date - The date when the feature was mapped
Time- The time when the feature was mapped

Basin Discharges Specific attributes recorded for each detention basin discharge pipes include:

Pipe ID – A unique identifier assigned to each detention basin discharge pipe (DB OFP ##)
Type- Describes the type of pipe
Pipe- GE – Pipe Geometry – Describes the shape of the pipe
Size - Describes the shape of the pipe in inches
Size if other – Allows for an uncommon pipe size, or one which was not programmed into the data dictionary
Condition- Describes the physical condition of the pipe – notes any structural failing
Condition Notes – Describes the physical condition of the pipe – notes any structural failing
Trash Rack /Cover- Indicates if a trash rack is present
COP- Is there conduit outlet protection installed at the point of discharge
COP type- Indicates the type of conduit outlet protection
Standing Water- Indicates if there standing water located at the discharge point
Erosion- Indicates if there is evidence of erosion at the point of discharge
Deposition - Indicates if there is evidence of a depositional environment at the point of discharge
Illicit Connection- This is a determination check for a dry weather flow. Per DEP illicit connection protocol

Photo taken-Indicates is a photo was taken at of this feature.
Notes- Observation notes
Name- Unfilled –Allows for additional naming
Date - The date when the feature was mapped
Time- The time when the feature was mapped

Ditches and Swales Specific attributes recorded for each ditch or swales include:

Ditch & Swales - An individual alpha-numeric identifier assigned to each swale
Ditch Rating -Swales were evaluated for erosion potential and general stability- Good, needs repair, urgent
Type – Describes the surface of the swale, Answers the question of what is water nature of the surface of the swale over which water is flowing
Designed – Indicates if the swale shows evidence of being designed in accordance with the NJ Standards for Soil Erosion and Sediment Control
Notes - Observation notes
Name- Unfilled –Allows for additional naming
Date - The date when the feature was mapped
Time- The time when the feature was mapped
GPS Second- Indicates time feature was mapped
GPS length- Indicates the length of the line segment

Detention Basin Specific attributes recorded for each detention basin include:

Basin ID- A unique name given to each individual detention basin (DB-#)
Name- Unfilled –Allows for additional naming in the database
Basin bottom- Description of the type of bottom found in this the detention basin
Condition of bottom- Describes condition of the bottom of the detention basin
Maintenance needed- Identifies the most pressing maintenance issue found in this structure
Maintenance needed2-Identifies the type of additional maintenance needed
Maintenance needed3-Identifies the type of additional maintenance needed
Add note here-Notes regarding the detention basin bottom
Emergency spillway - Description of the type of emergency spillway found in this the detention basin.
Cond. Of spillway- Describes condition of the emergency spillway of the detention basin
Maintenance needed - Indicates if maintenance is needed.
Add note here- Notes regarding the detention basin emergency spillway.
Berms - Description of the type of berms or walls found in the detention basin
Cond. Of berms- Describes condition of the emergency spillway. Indicates if maintenance is needed
Maintenance needed? - Identifies the most pressing maintenance issue found with the emergency spillway
Maintenance needed2 - Identifies the type of additional maintenance needed
Add note here- Notes regarding the detention basin berms
Date - The date when the feature was mapped
Time- The time when the feature was mapped
GPS_AREA –A GPS calculation of the area mapped
GPS_PERIMETER- A GPS calculation of the perimeter of the area mapped
GPS_3DPERIMETER- A GPS calculation of the 3D perimeter of the area mapped

Basin Outlet Structure Specific attributes recorded for each basin outlet structure include:

Basin OS ID# - An unique name assigned to each basin outlet structure (Bos-#)
In Berm – Indicates if the BOS is located in the detention basin Berm.
Orifice or Weir- Indicates if stormwater exits the basin through a weir or orifice which are used to control the flow rate from the basin
Underdrain- Indicates if a subsurface drain has been installed in the detention basin.
Water Quality- Indicates if the BOS has a 3”water quality orifice
Trash rack- Indicates if a trash rack is present
Maintenance required- Indicates if the BOS requires maintenance
Clean Out – Indicates if there is debris or sediment impeding flow from the BOS.
Date - The date when the feature was mapped
Time- The time when the feature was mapped

Basin Inflows Specific attributes recorded for each detention basin inflow include:

B_Inlet _ID – A unique name given to each individual detention basin inlet (IP #)
Type- Describes the type of pipe
Pipe- GE – Pipe Geometry – Describes the shape of the pipe
Size - Describes the shape of the pipe in inches
Size if other – Allows for an uncommon pipe size, or one which was not programmed into the data dictionary.
Condition- Describes the physical condition of the pipe – notes any structural failing
Condition Notes – Describes the physical condition of the pipe – notes any structural failing
Trash Rack /Cover- Indicates if a trash rack is present
COP- Is there conduit outlet protection installed at the point of discharge
COP type- Indicates the type of conduit outlet protection
Standing Water- Indicates if there isanding water located at the discharge point
Erosion- Indicates if there is evidence of erosion at the point of discharge
Deposition - Indicates if there is evidence of a depositional environment at the point of discharge
Illicit Connection- This is a determination check for a dry weather flow. Per DEP illicit connection protocol
Photo taken-Indicates is a photo was taken of this feature.
Notes- Observation notes
Name- Unfilled –Allows for additional naming
Date - The date when the feature was mapped
Time- The time when the feature was mapped

Low Flow Channel Specific attributes recorded for each low flow channel include:

Basin ID- Left empty allows for the indication of which detention basin the low flow channel resides
Name- An unique name assigned to each low flow channel (LF-#)
Type- Describes they type of low flow channel
Cutoff- Indicates if the low flow is cut short of the basin outlet structure- a design feature which aided in the formation of wetland hydrology in the lowest portion of a detention basin
Maintenance needed- Identifies the most pressing maintenance issue found for this structure
Maintenance needed2-Identifies the type of additional maintenance needed

Maintenance needed3-Identifies the type of additional maintenance needed
Condition- Describes the physical condition of the low flow channel – notes any structural failing
Notes- Observation notes
Date - The date when the feature was mapped
Time- The time when the feature was mapped
GPS Second- Indicates time feature was mapped.
GPS length- Indicates the length of the line segment

Dams Specific attributes recorded for each dam include:

Type- Describes the type of dam
Maintenance needed?- Indicates if maintenance is needed
Time- The time when the feature was mapped
Notes- Observation notes
Date - The date when the feature was mapped

Stream Photo's- No individual attributes were recorded with the stream photos.

Equipment

This project would not have been possible without technological advances, most importantly the development of GPS receivers and field data loggers.

Global Positioning System Equipment

This project utilized 2 GPS Units:

- Trimble GeoExplorer GEOXT Sn 4717443714 running Windows Moble OS and terasync v3.01
- Trimble GeoExplorer GEOXT sn 4346a37528 running Windows CE OS and terasync v2.8 (Note: this unit experienced a failure in 2008, and was no longer used in the project)

Data dictionary development and data transfer utilized Trimble Pathfinder Office V5.1

GIS files were generated using ESRI ArcMap v 9.1

Photo Equipment

Two different camera types were used:

- Kodak EasyShare Z1012 IS – SD media (http://store.kodak.com/store/ekconsus/en_US/pd/Z1012_IS_Digital_Camera/productID.145101000)
- Sony Mavica MCV-CD500 – MiniCD's (http://esupport.sony.com/US/perl/select-system.pl?PRODTYPE=39&NAVDISP=di) (Note: *The mavica performed poorly under field conditions and experiencd several write failures*

which resulted in lost data and that required reshooting several disks worth of data (sometimes over 100 photographs). This model of camera is not recommended).

Field Equipment

In addition to the electronics, a variety of traditional field equipment was utilized for the project. These included boots, safety vests, brush pants, insect repellant, hats, gloves, waders, hip boots, and machetes.

Staff

Several Hunterdon County Soil Conservation District staff members participated in the project.

- Chris Testa - Special Projects Coordinator, project manager
- Zach Oliver - Intern, data collection
- Tim Freiday- Intern, data collection
- John Bower- Agricultural technician, data collection, plan review, data collection

Funding

NJIT provides $58,600 for the task through its Neshanic River Watershed Restoration Plan Project from NJDEP. An additional $50,000 worth of funding was supplied to the project from Raritan Township. Raritan Township funded the project as part of the Tier A requirements of The New Jersey Department of Environmental Protection's Municipal Stormwater Regulation Program.

Discussion

The stormwater infrastructure of the Neshanic River Watershed has a life and history all of it own. As the area has developed, the system has expanded and evolved with changing regulations. In its current form the stormwater system is designed to gather rainwater from rooftops, roadways, parking lots, lawns and landscapes and convey it to the Neshanic River. The system as a whole lacks a universal design goal beyond moving water during storm events. In its current form the stormwater infrastructure system represents a cumulative investment of tens of millions of dollars. (Center for Neighborhood Technology, 2009)

Beyond private ownership and homeowner associations, there are 4 municipalities (Townships of Raritan, Delaware, East Amwell and Flemington Borough) and 2 highway agencies- the County of Hunterdon and The New Jersey Department of Transportation; which own and maintain the interconnected stormwater system. The diversity of ownership presents different levels of resources, expertise, legislated management requirements, and design philosophies. In order to be successful a watershed remediation plan must consider who will be maintaining the stormwater infrastructure.

There are three types of stormwater infrastructure systems in the watershed

- **Ditch and Pipe System** Found primarily in the more rural areas of the watershed in the south and west this system is the least developed and is largely municipal. It is characterized by open roadside ditches, driveway culverts, and an absence of detention basins. Maintenance is primarily the responsibility of the municipality and most of the stormwater infrastructure is confined to road right-of-ways. This portion of the stormwater system typically lacks modern designs or upgrades and in many cases presents a layered approach where improvements or upgrades are made piecemeal.

- **Suburban Subdivision Systems** Spread throughout the watershed these systems are largely autonomous. These areas a typified by a residential roads and lot line swales which are drained by catch basins; that in turn feed a subsurface pipe network. These pipes discharge to one or more detention basin usually located in the lowest portion of the development. Subdivision systems tend to be planned extensively reviewed, and reflect the design standards at or near the time of construction.

- **Urban System** Found along the highways and in commercial areas these areas are characterized by the highest percentage of impervious surfaces. These high impervious cover areas generate more stormwater then do less developed parts of the watershed and therefore have a higher density of catch basins or other stormwater collectors. These areas have extensive subsurface pipe networks. Roof drains are commonly directly connected to the subsurface pipe system which is interconnected so that stormwater is passed across maintenance jurisdictions. Detention basins can be found in association with commercial structures until recently it was uncommon to see a basin constructed solely for a stretch of roadway.

One of the most useful results of locating and charactering the stormwater infrastructure of the Neshanic River Watershed is that it will allow informed decisions making. It has also generated data which highlights where opportunities exist for water quality improvement through retrofitting, and the employment of appropriate best management practices. Several retrofit opportunities are discussed for major types of stormwater infrastructure:

Swales and Ditches- Ideally a stormwater system should improve the quality of the water flowing through it. At the least, we should strive to have a conveyance system not degrade water quality by adding additional pollutants to the waters flowing through it. The ditch and swale system of the Neshanic River offers opportunities for improving both the design and maintenance of swales and ditches.

Table 2: Conditions of Swales and Ditches in Neshanic River Watershed

Condition Rating	Number of Mapped Segments	% of Mapped Segments	Length (Miles)	% of Total Length
Good	185	21.69	8.68	21.67
Needs Repair	515	60.37	25.81	64.42
Urgent	153	17.94	5.57	13.90
Total	853	100.00	40.06	100.00

Of 853 (40.06 miles) mapped swale segments 185 (8.68 miles) were rated as being in urgent need of repair- these swales were actively eroding, thus contributing sediment to stormwater which flows through them. Of the 515 of 853 (25.81 miles) were rated as needing repair. In these swale segments water was permitted to flow over exposed earth in at least portions of conveyance. Only 153 (5.57 miles) of swale segments were found to be in good condition -consistent with the soil erosion standards for a grassed waterway or rip-rap channel. Swales in good condition should be expected to offer some water quality improvement, (Schueler, 1995) or again, not further degrade water quality by contributing additional loadings. Properly vegetated swales, with good maintenance regimes have been shown to promote recharge while reducing the volume, velocity and peak flows. (The Center for Neighborhood Technology, 2009)

Points of Discharge -Made up of detention basin discharges, outfall pipes and detention basin inflows this group of infrastructure denotes locations where piped stormwater flows exited the covered (piped) system and re-enter the environment. The primary opportunities for retrofit involve correcting erosive conditions where flows and a lack of energy disapators (conduit outlet protection) create an erosive condition. Opportunities for retrofit also exist in depositional areas where upstream sediments and debris accumulate due to a change in the energy environment.

Of 747 mapped conduit outlets 39 were found to be erosive while 158 were depositional. Retrofitting these parts of the stormwater system will decrease bank erosion, reduce siltation, and help to decrease non-point source pollution (The Center for Neighborhood Technology, 2009).

Table 3 Conditions of Points of Discharges in Neshanic River Watershed

Type	Detention Basin Outfalls	Detention Basin Inflows	Outfall pipes
Total	118	220	409
Erosive	5	13	21
Depositional	34	*	124

* Deposition associated with detention basin inflows is noted in the detention basin data

Also of interest is the ratio of outfall pipes to detention basin outfalls: 409 / 118. At nearly 4:1 this demonstrates that a large portion of the stormwater in the watershed is discharged without the volume and velocity reductions associated with modern detention basin design.

Detention Basins There are a variety of different detention basin designs in the Neshanic River Watershed. These include wet ponds, infiltration basins, bio-retention basins, extended dry detention basins, and even bermed off stream corridors with flow control weirs. Adding further diversity to the data set, there are a variety of maintenance levels ranging from heavily landscaped and manicured to benign neglect and outright abandonment. Virtually all of detention basins in the watershed present an opportunity for upgrades or retrofits.

When examining the data recorded concerning the bottoms of detention basins there are a variety of conditions that would suggest opportunities for retrofits:

- 106 of 155 basins were found to have mowed turf bottoms.
- 8 basins had weeds or successional vegetation due to a lack of mowing.

- 3 basins were fully overgrown with trees and shrubs.
- 1 basin lacked any vegetation and was covered with deposited material.

Other components of detention basins

- Low flow channels were very common in the watershed's detention basins. Of these, 156 of 196 low flow channel segments were found to be concrete.
- Greater then 1/3 of the (63 /151) detention basin outlet structures were found to have a three-inch water quality orifice. This indicates that 88 of the watershed's detention basins either were not constructed to achieve water quality through extended detention, or they achieve this though other designs.

There are also several watershed wide concerns:

Drainage Density Drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream channels. It is equal to the reciprocal of the constant of channel maintenance and equal to the reciprocal of two times the length of overland flow. Drainage density depends upon both climate and physical characteristics of the drainage basin. Soil permeability and underlying rock type affect the runoff in a watershed; impermeable ground or exposed bedrock will lead to an increase in surface water runoff and therefore to more frequent streams. Rugged regions or those with high relief will also have a higher drainage density than drainage other drainage basins if the other characteristics of the basin are the same. Drainage density can affect the shape of a river's hydrograph during a rain storm. Rivers that have a high drainage density will often have a more 'flashy' hydrograph with a steep falling limb. High densities can also indicate greater flood risk (Delaware Riverkeeper Network, 2001). Analysis of the storm hydrographs recorded at the Neshanic River gauging station points clearly demonstrates the influence of the drainage system on the flow of the Neshanic River. Figure 17 presents the stream hydrograph observed at the USGS Neshanic River at Reaville Gage Station during May 5th 2010 through June 5th 2010. The distinct spikes on the hydrograph are noticed. Each of these spikes represents a rainfall event where stormwater rapidly reaches the river via the stormwater system. Such typical urban stream systems and flashy stream hydrograph often result in canalized streams, decreased baseflow, flooding and ultimately degraded water quality.

The calculated drainage density with in the Neshanic River increases from 2.02 miles (streams only) to 7.05 miles (both streams and roads). When the subsurface drainage system, and infrastructure not associated with the road network is factored drainage density will be even higher. The negative impacts of this condition are well documented (Delaware Riverkeeper Network, 2001, Reiser, 2004, NJDEP, 2000).

By creating an artificial system of connected impervious surfaces the Neshanic River watershed is far more efficient in moving water out of the watershed. The stormwater infrastructure system, at 3.5 to 4 times the size, of the geologic stream system, influences flow rates every stream channel in the watershed. The increases in volume and velocity reaching in the stream channel represents a massive energy transfer and allows stormwater to bypass beneficial natural systems such as forests and wetlands. (Delaware Riverkeeper Network, 2001)

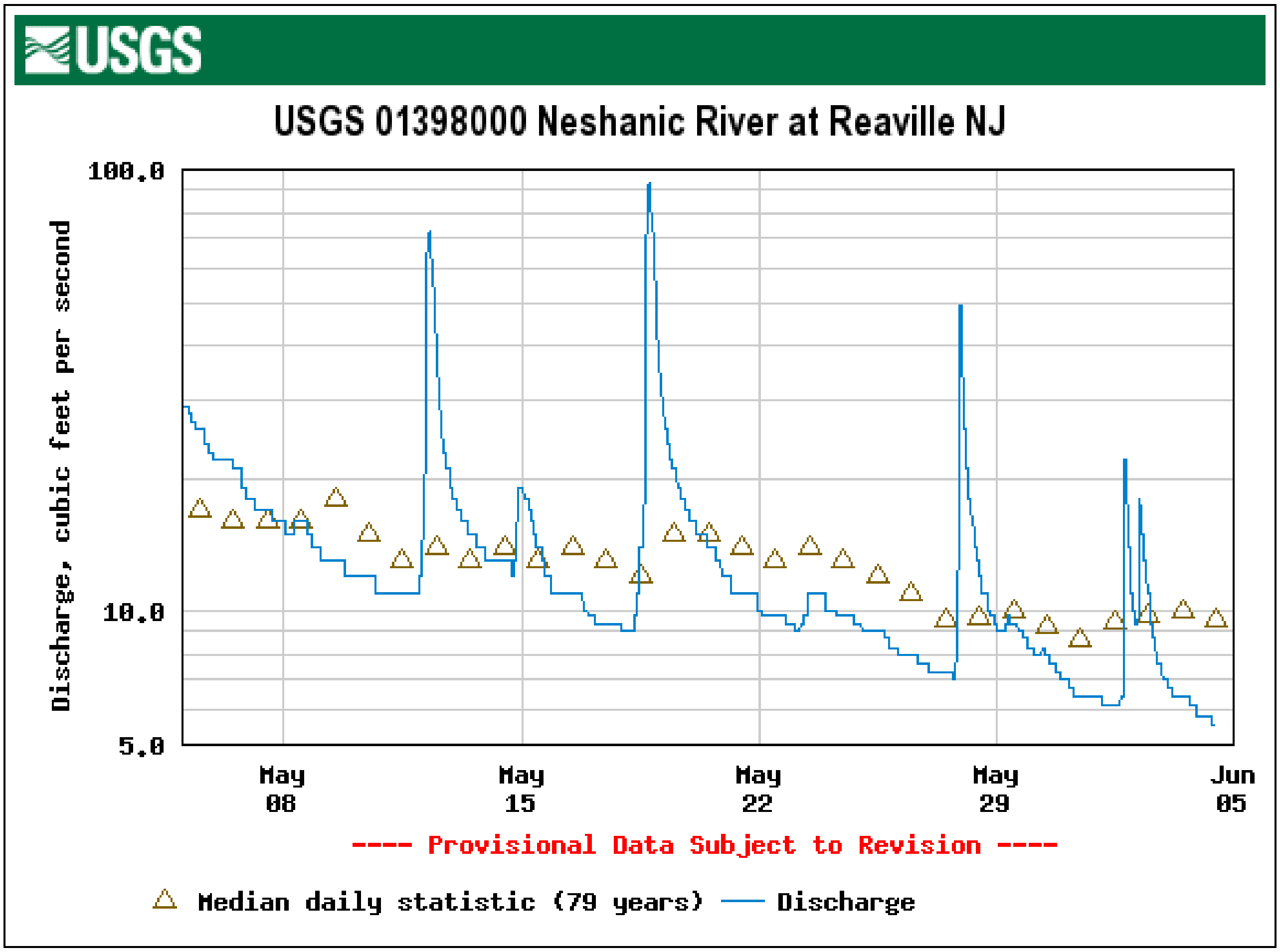

Figure 17: The Hydrograph in the Selected Dates at the Neshanic River

Hydromodification Both the road crossing survey and the stream visual assessment have documented the degraded condition of the stream corridor. Where localized land use is in part responsible for some of these conditions, the hydrology of the river is also a critical factor in determining the condition and health of streams. (Delaware Riverkeeper Network, 2001) Like many urbanizing watersheds the Neshanic River is evolving to accommodate the hydraulic changes brought on by urbanization, and a regime of elevated storm flows.

Land use and the stormwater system One somewhat unusual aspect of the Neshanic River watershed is that the affluence of the area has allowed for the extension of the stormwater system into rural/ agricultural areas of the watershed. Every road in the watershed has stormwater infrastructure, and it is not uncommon for overland flow from agricultural areas to be directly directed to the roadside stormwater system. Thus the shrinking average farm sizes and suburban infill development allow for greater interconnections to the stormwater system. Many of the areas remaining agricultural tracts are completely encircled by networks of stormwater infrastructure. This condition allows runoff to bypass buffer and treatment areas via the road network. Whereas the agricultural operations within the Neshanic Watershed are not exceptionally intense (sources) the infrastructure (pathways) which drains those potential sources is robust and growing. Future management decision should carefully consider both of these factors when crafting solutions.

Conclusion

The mapping and characterizing of stormwater infrastructure has proven to be an important undertaking in answering question as to how to best protect and improve the water quality of the Neshanic River Watershed. The GIS shapefiles created for this project represent the most up-to-date representation of this data, and are the only place where all of this information is centrally located.

The extent and complexity of the system underscores the importance of including it in any remedial strategies presented in the future. The data collected in this study offers opportunities to improve future additions to the system and should be consulted when making maintenance decisions. By looking at the role of stormwater infrastructure as interconnected system acting in concert with the natural system, we can gain a more complete understanding of how to manage the Neshanic River Watershed more sustainably and in a manner that result in a fishable and swimmable waterway.

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