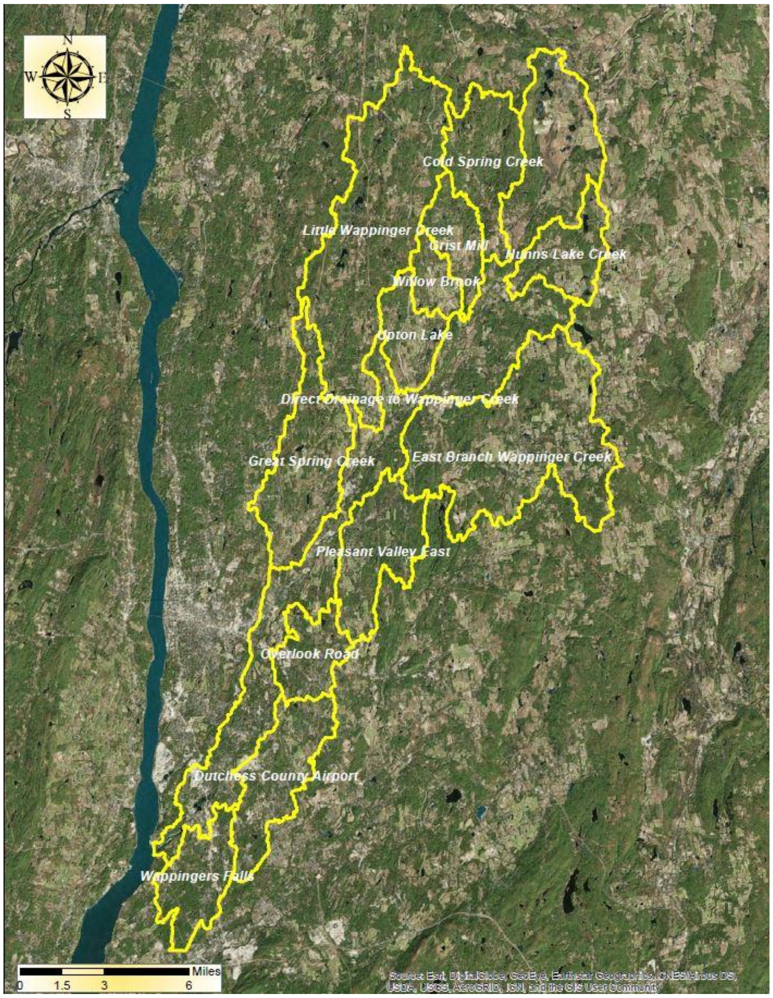
Watershed Characterization and Recommendations Report for the Wappinger Creek Watershed



Prepared for

THE VILLAGE OF WAPPINGERS FALLS

Dutchess County, NY

Prepared April 2019

Revised January 2020

Final Revision June 2022

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Acknowledgements

Thank you to the many individuals who have contributed to discussion, content, data, and review for this study.

Funding for this project was provided by the New York State Department of State's (NYSDOS) Local Waterfront Revitalization Program.

To improve the water quality of the Wappinger Creek and restore the watershed, the Village of Wappinger Falls, in partnership with the Wappinger Creek Watershed Intermunicipal Council (WIC) and Cornell Cooperative Extension Dutchess County (CCEDC) decided to complete a comprehensive study of the potential sources of pollution (phosphorus and silt/sediment) within the Wappinger Creek Watershed.

The Wappinger Creek Watershed encompasses large portions of the Towns of Pine Plains, Milan, Clinton Stanford, Washington, Pleasant Valley, LaGrange, Poughkeepsie, Wappinger, the Villages of Millbrook and Wappingers Falls, and small portions of the Towns of Hyde Park and Fishkill.

There have been many contributors involved within the life of this study including NYSDOS, NYSDEC, WIC, CCEDC, municipal officials, staff and consultants, and a dedicated project steering committee of many volunteers. Participation and input from each have been vital to the development of this study.

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1.0 Introduction

Contained entirely within Dutchess County, the Wappinger Creek watershed spans 211 square miles and is one of the five major tributaries that feed into the lower Hudson River (Findlay et al., 2010). The watershed encompasses large portions of the Towns of Pine Plains, Milan, Clinton Stanford, Washington, Pleasant Valley, LaGrange, Poughkeepsie, Wappinger, the Villages of Millbrook and Wappingers Falls, and small portions of the Towns of Hyde Park and Fishkill (Findlay et al., 2010). Historically, this watershed has been the lifeblood of these communities, supplying, water, recreation, electrical power, habitat, and flood storage. At present, the watershed needs revitalization. Recent observations of Wappinger Creek found the watershed to be overloaded with phosphorus and filled with silt (Cadmus Group, 2009). These pollutants are deteriorating water quality and have reduced the flood storage capacity of Wappinger Lake. Consequently, Wappinger Lake is becoming eutrophic, as it is being filled in with silt at an alarming rate, which is negatively impacting aquatic plant growth (Paggi, Martin, and Del Bene, LLP. 2009). Wappinger Lake is on the 2016 303(d) list of impaired waterbodies, which require development of a total maximum daily load (TMDL) and is a restoration target for pollutant reduction (NYSDEC, 2016. 2016 section 303(d) list of impaired waters requiring a TMDL/ other strategy). A bathymetric study of the lake was conducted in 2018, which found further evidence of increased sedimentation in the lake, as well as the presence of various pollutants and contaminants in the lake sediment (Appendix L: Bathymetric Study). Since Wappinger Lake outlets into the Hudson River, and acts as a sink for substances that travel downstream, it is an indicator of water quality issues in the greater watershed.

To improve the water quality of the Wappinger Creek and restore the watershed, the Village of Wappinger Falls, in partnership with the Wappinger Creek Watershed Intermunicipal Council (WIC) and Cornell Cooperative Extension Dutchess County, has decided to complete a comprehensive study of the potential sources of pollution (phosphorus and silt/sediment) within the Wappinger Creek Watershed. This plan will analyze the 41.7-mile-long Wappinger Creek from its headwaters to its confluence with the Hudson River to identify key contributors of pollutant-loading. The project will then identify where the pollutants of concern (phosphorus and silt/sediment) are entering the creek and will estimate their loads to develop a watershed management plan for the Wappinger Creek. Once the pollutant-loading locations have been prioritized, the Project Advisory Committee, with the assistance of KC Engineering, will identify pilot infrastructure implementation projects for design and construction, based on municipal and stakeholder engagement and feedback. Following implementation, progress measurements will be completed, and adjustments will be made to the Watershed Management Plan.

Based on the assessment of land use and other potential pollutant sources, a total of 15 sampling locations were identified along the length of the creek and its tributaries within the watershed for monitoring. The monitoring program gathered information about inputs from other pollutants including total phosphorus, total nitrogen, suspended solids (TSS), turbidity, dissolved oxygen (DO), biological oxygen demand (BOD) and fecal coliform bacteria. The sampling data were used to verify existing pollutant sources and to locate unknown sources as well. In addition to field sampling, pollutant discharge monitoring report data was also obtained from sewage treatment plants (STPs) within the watershed. This data was used to assess the potential amount of pollution from point sources.

2.0 Watershed and Subwatershed Delineations

The Wappinger Creek watershed is located entirely within Dutchess County and the watershed is approximately a quarter of the land area of the county. The Wappinger Creek has three major branches: the Little Wappinger Branch, the Main Branch, and the East Branch.

Table 2.1 Watershed and Subwatershed Areas

ID	Subwatershed	Total Area (Acres)	% of Total Area
1	Cold Spring Creek	6,992	5.2
2	Pleasant Valley East	7,389	5.5
3	Dutchess County Airport	7,520	5.6
4	East Branch Wappinger Creek	21,521	15.9
5	Great Spring Creek	10,012	7.4
6	Grist Mill	3,711	2.7
7	Hunns Lake Creek	4,903	3.6
8	Little Wappinger Creek	21,277	15.7
9	Overlook Road	4,209	3.1
10	Upton Lake	4,077	3.0
11	Direct Drainage to Wappinger Creek	35,703	26.4
12	Wappingers Falls	5,411	4.0
13	Willow Brook	2,427	1.8
Total		**135,152**	**100**

For the purpose of this report, the Wappinger Creek watershed was divided into 13 subwatersheds for a total acreage of approximately 135,000 acres (Figure 2.1). The subwatersheds were delineated by the Dutchess County Environmental Management Council (EMC) and digitized into CCEDC's Geographic Information System (GIS) based on the local topography.

The watershed delineations provide an essential framework in characterizing the upland areas that contribute flow and pollutants to Wappinger Creek. The subwatersheds are distinctive in terms of their topography, land use characteristics and contribution to the water quality of Wappinger Creek. Data for the entire watershed, including land use, impervious surface area, population characteristics, and potential pollution sources, are evaluated and summarized according to subwatershed boundaries. These subwatershed summaries will be utilized for determining the selection and timing of appropriate watershed management strategies.

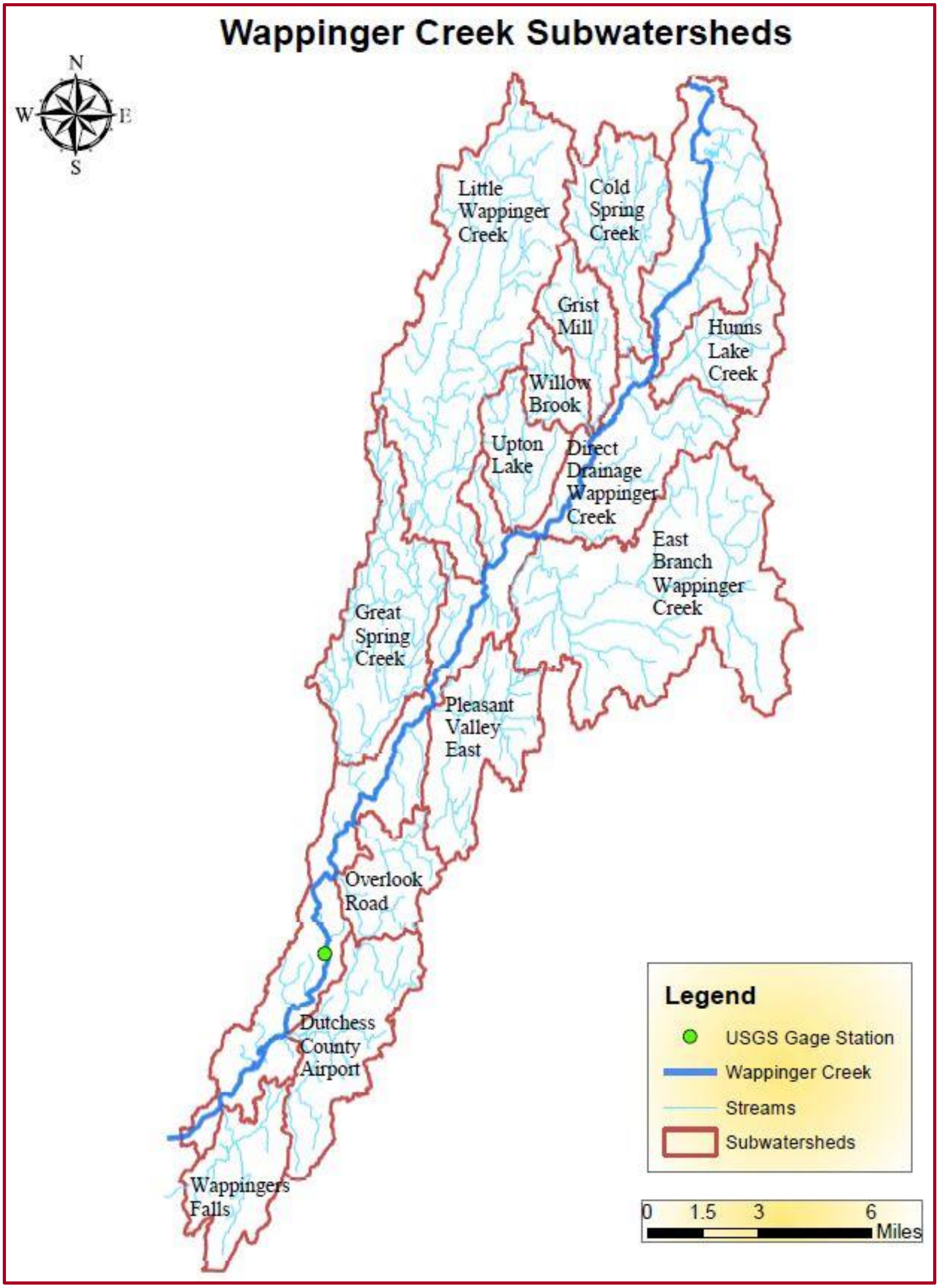

Figure 2.1 Wappinger Creek Subwatersheds

3.0 Watershed Characteristics

3.1 Geographic Setting

The Wappinger Creek Watershed is situated in the central portion of Dutchess County (Figure 3.1).

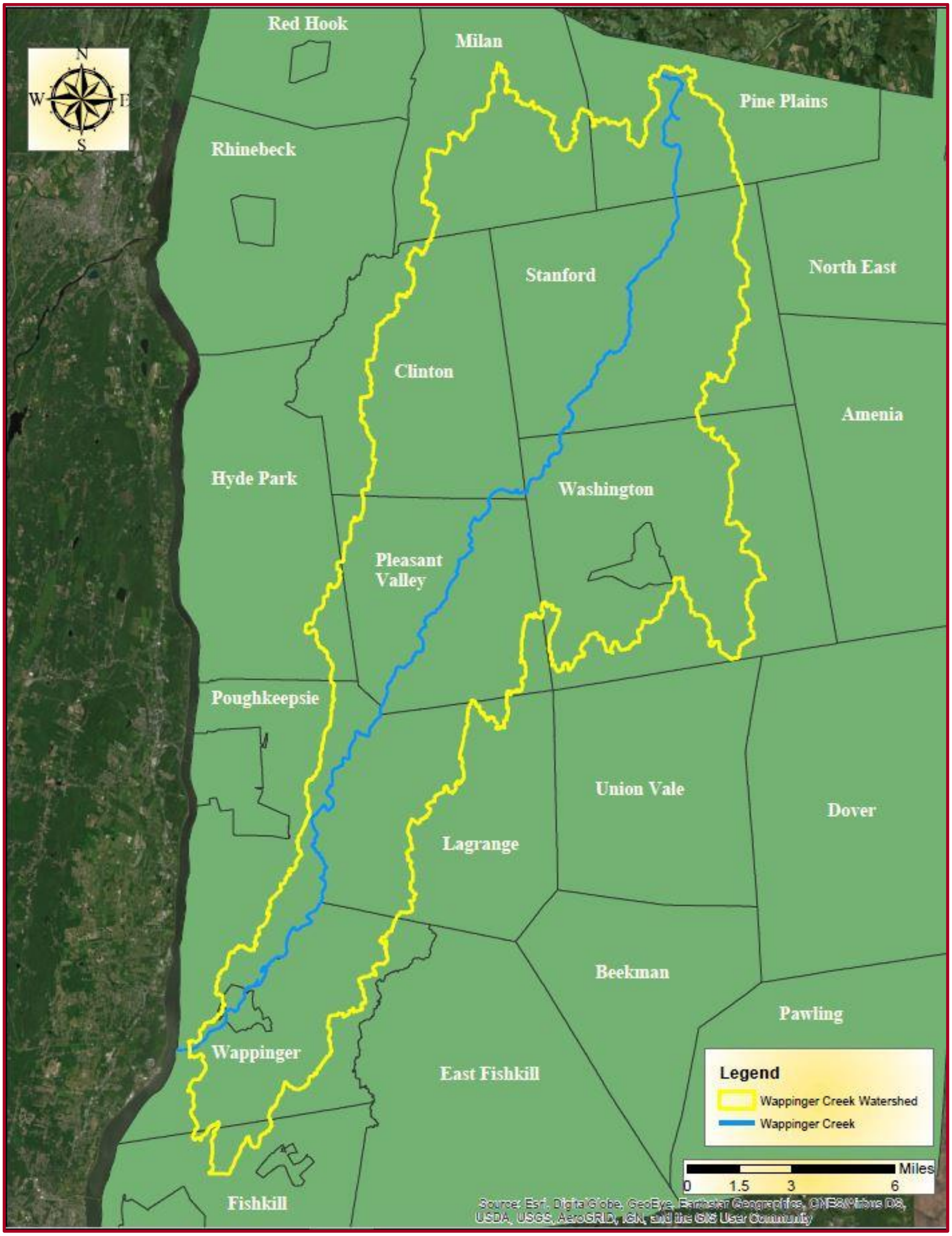

Figure 3.1 Location Map of Wappinger Creek Watershed

There are several State roads within the Wappinger Creek Watershed. The Taconic State Parkway runs longitudinally within the middle of the watershed. U.S. Route 9 runs longitudinally along the southwestern portion of the watershed and has notable concentration of commercial land uses. State Highway 44 is an important east-west corridor for local commerce; it passes through the population centers of Poughkeepsie, Pleasant Valley, and Millbrook. Other transportation features in the watershed include State Highway 82 and the Dutchess County Airport.

Most of the population within the watershed is in its southern portion, within the City of Poughkeepsie and the Towns of LaGrange, Wappinger, and Pleasant Valley (U.S. Census Bureau, 2010.). Except for a few small-to-medium density residential communities, population density within the upper reaches of the watershed is relatively low, and vacant/forest land area is significant (U.S. Census Bureau, 2010.).

3.2 Data Sources and Maps

Several data sources, including a variety of geographic, environmental, and socioeconomic data, were utilized to characterize the watershed. Data sources are primarily from government and academic institutions. Data developed, updated, and/or enhanced as a result of this study is denoted below as “consultant” (Table 3.1).

Table 3.1 Data Sources

Data Type	Source
Land Cover	National Land Cover Database, 2011, and consultant, 2019
Land Use	New York State Office of Information Technology Services (NYS ITS), 2019
Topography	United States Geological Survey (USGS), 2019
Municipal Boundaries	Dutchess County Office of Central and Information Services (OCIS), 2019
Precipitation	Natural Resources Conservation Services (NRCS), 1981-2010
Flood Zones	Federal Emergency Management Agency (FEMA), 2019
Population	Dutchess County Planning, 2010 Census
Hydrology	National Hydrography Dataset (NHD), 2019
SPDES Permits and DMRs	New York State Department of Environmental Conservation (NYSDEC) and EPA Echo Water Pollution Search, 2019
Septic Systems	Consultant, 2019
Bedrock Geology	United States Geological Survey (USGS), 2019
Stormwater Infrastructure	Dutchess County Office of Central and Information Services (OCIS), 2019
Roads and Transportation	Dutchess County Office of Central and Information Services (OCIS), 2019
Digital Elevation Model	United States Geological Survey (USGS), 2019
Waterbody Inventory and Priority Waterbodies List (WI/PWL)	New York State Department of Environmental Conservation (NYSDEC), 2008

3.3 Topography

A review of the digital elevation model reveals that topography of the Wappinger Creek Watershed varies significantly with elevations ranging approximately 1,400 feet at the highest point in the watershed in Pine Plains, to sea level at the creek's mouth at the Hudson River in New Hamburg (Figure 3.2). The major tributaries to the Wappinger Creek are permanent streams with elevations ranging from 400 to 600 feet.

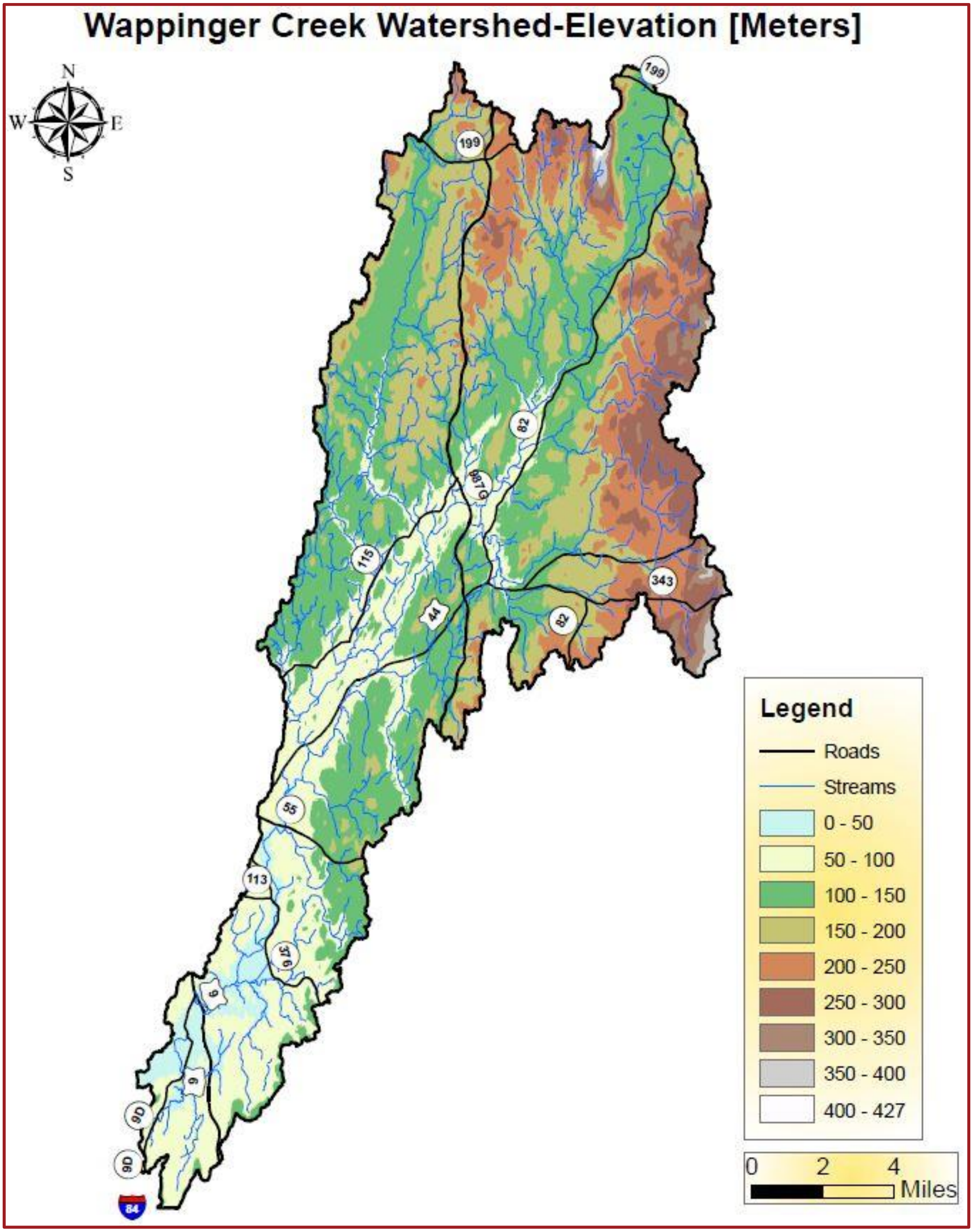

Figure 3.2 Digital Elevation Model of the Watershed

3.4 Flood Zones

Much of the area along the Wappinger Creek and its tributaries are subject to flooding with approximately 13,000 acres of the watershed within the 100-year flood hazard area (Figure 3.3). The Federal Emergency Management Administration (FEMA) has developed maps for the 100-year floodplains in Dutchess County to determine low-cost federal flood insurance rates, and to develop local land use controls to comply with FEMA's requirement (Findlay *et al.*, 2010). The lower portion of the watershed is prone to flooding. The majority of its residents are within the 100-year flood hazard zones.

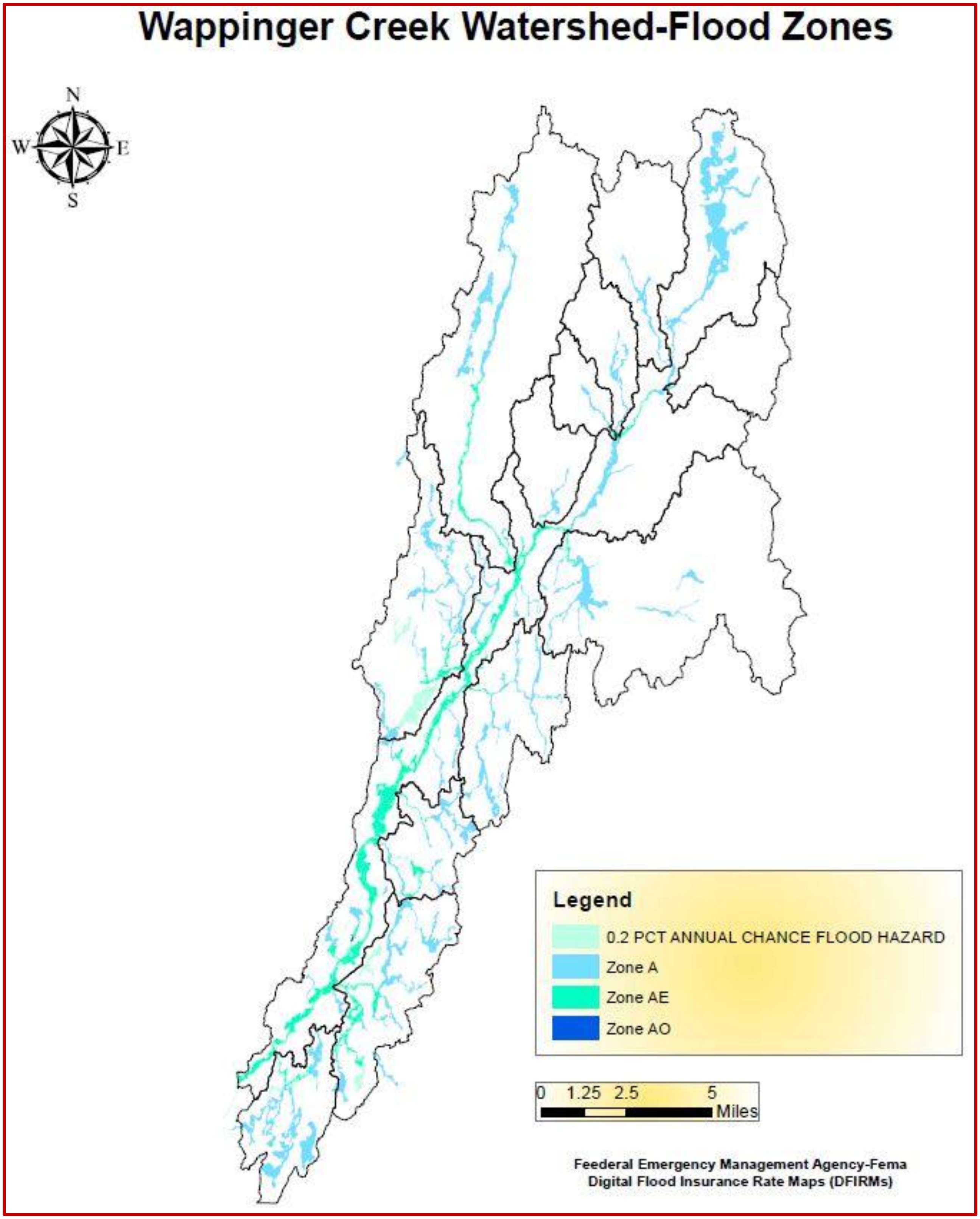

Figure 3.3 Flood Zones of the Wappinger Creek Watershed

3.5 Climate

The Wappinger Creek Watershed is located within a temperate climate zone. The weather is variable with heavy contrasts, due to large weather systems that move across both the continental U.S. and the Atlantic coast. Over the course of the year, the temperature typically varies from 18 to 84 degrees Fahrenheit. Annual precipitation in the watershed ranges from 42 to 47 inches (Figure 3.4). The ample year-round precipitation is supplemented in late summer by tropical maritime air masses.

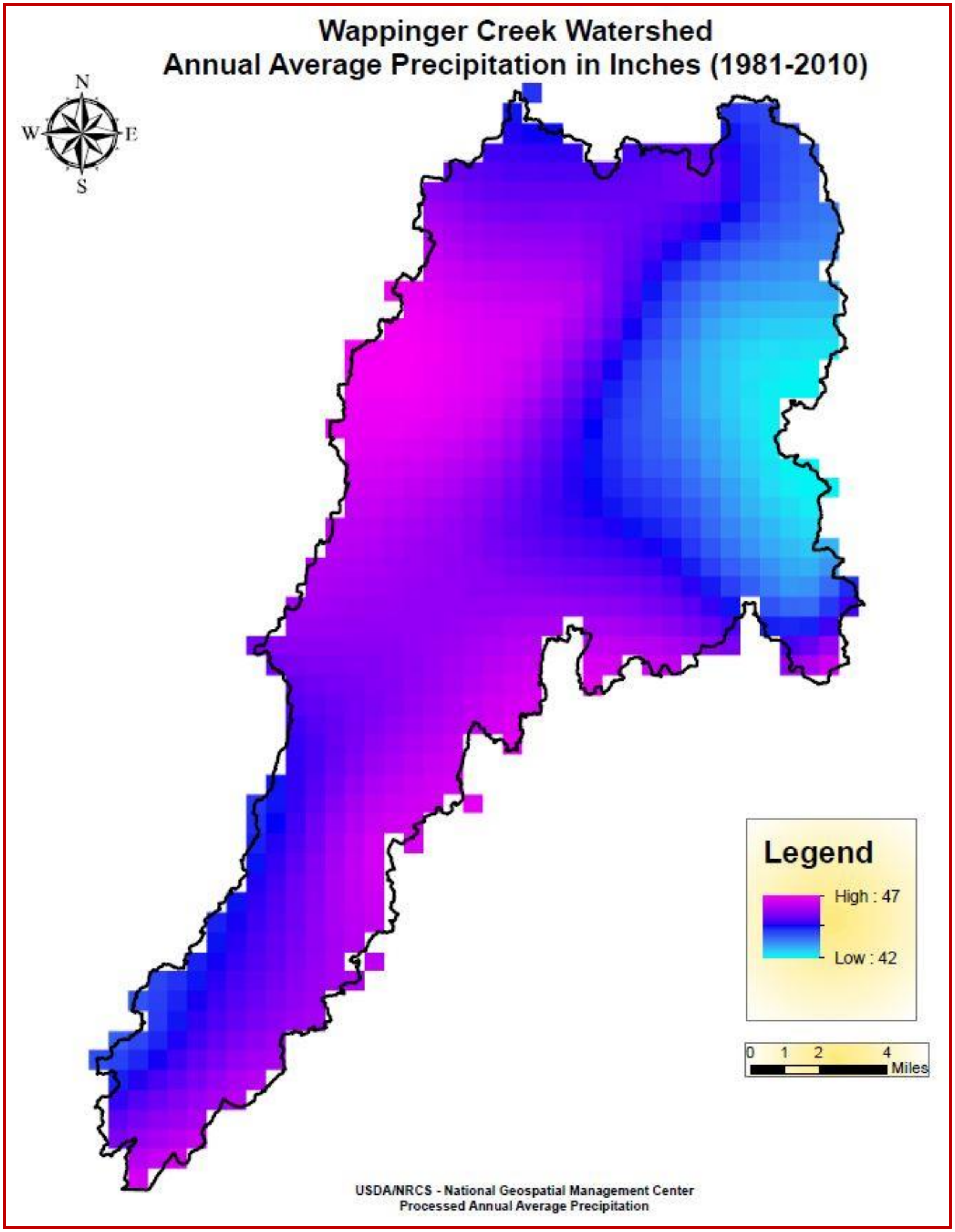

Figure 3.4 Average Annual Precipitation in Wappinger Creek Watershed

3.6 Drainage Infrastructure

The Wappinger Creek Watershed drains approximately 135,000 acres. Storm drainage infrastructure in the watershed consists of typical structures such as catch basins, manholes, and outfall structures. However, the presence of storm drainage infrastructure is limited mainly to the southern portion of the watershed, due to relatively sparse residential and commercial land developments compared to the northern portion. Most of the northern subwatersheds discharge to groundwater via infiltration and/or re-direct precipitation to downstream subwatersheds via overland and stream flow.

Dams

There are 86 dams in the Wappinger Creek watershed, most of which are smaller earthen and concrete dams for ponds (OCIS, 2019). Of these, only Wappingers Falls Dam is designated as Class C by NYSDEC, meaning "High Potential Hazard". The Wappingers Falls Dam is located on the Wappinger Creek in the Village of Wappingers Falls, and is about 215 feet long, of which 172 feet is an unregulated spillway. The dam was originally built in 1872 to produce water and power for the surrounding area. In 1988 the dam was converted into a hydroelectric power facility (U.S. Army Corps of Engineers New York Division, 1993).

Municipal Separate Storm Sewer Systems

In 1990, the United States Environmental Protection Agency (EPA) developed rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff or dumped directly into municipal separate storm sewer systems (MS4s) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a storm water management program to control polluted discharges from MS4s. Approved storm water management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, and hazardous waste treatment. There are no large or medium MS4s in the Wappinger Creek watershed (EPA, 2010 and OCIS, 2019).

In 2003, Phase II of the rule extended coverage of the NPDES storm water program to include additional sources of storm water pollution from construction sites and smaller municipalities – small MS4s. Municipalities affected by small MS4 regulations in the Wappinger Creek Watershed include: Town of Hyde Park, Town of LaGrange, Town of Pleasant Valley, Town of

Poughkeepsie, Town of Wappinger and Village of Wappingers Falls. As a condition of the MS4 permit, permittees are required to submit annual reports on permit activities to New York State Department of Conservation (NYSDEC) in June of each year, showing how the MS4 is complying with the requirements of the permit during that reporting period, and provide an assessment of the community's program. Mapped sewer discharge points within the watershed are shown in Figure 3.5, with the most located in the southern half.

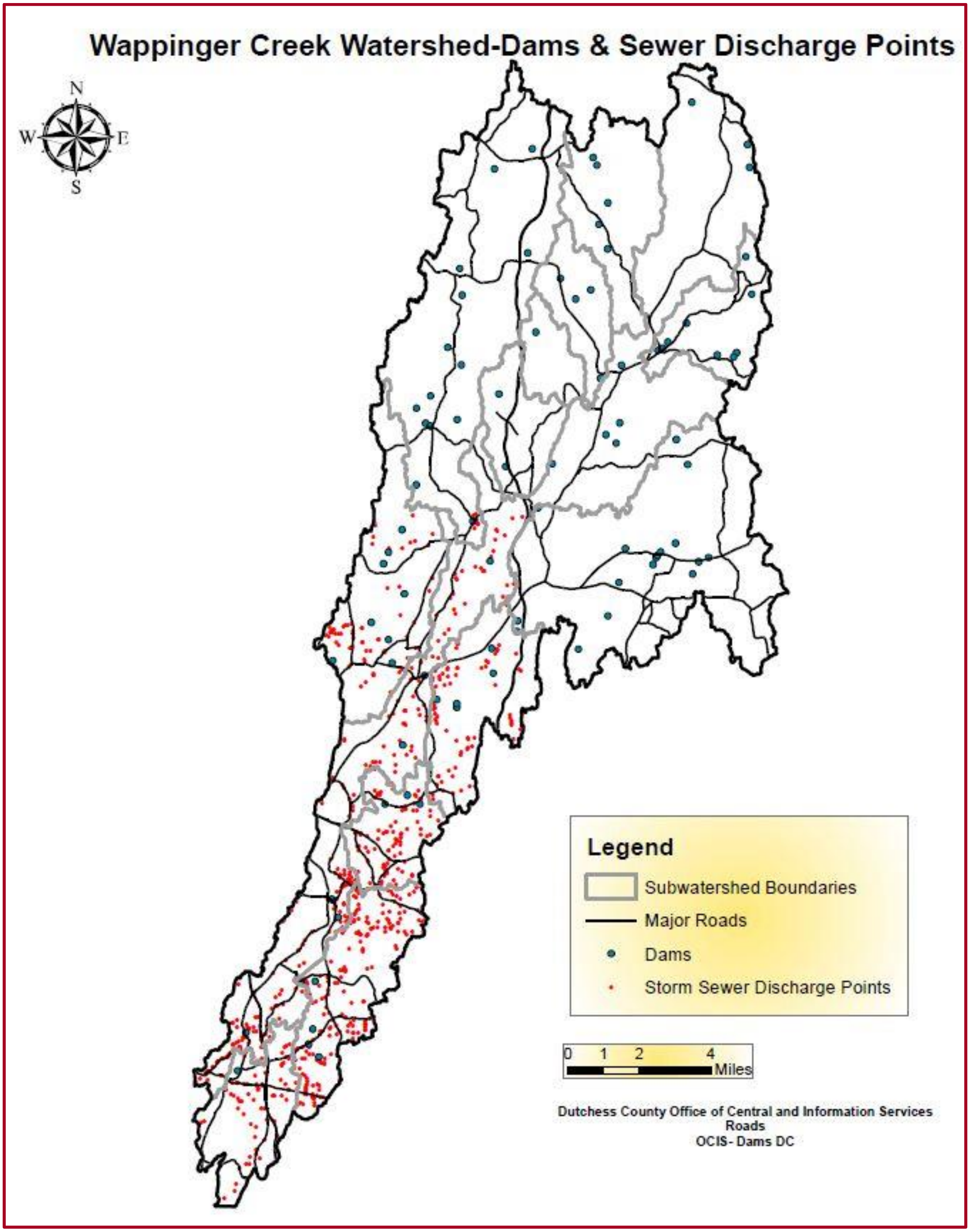

Figure 3.5 Drainage Infrastructure in Wappinger Creek Watershed

3.7 Geology and Groundwater

The bedrock geology of the Wappinger Creek Watershed is primarily made up of sedimentary rock with some metamorphic rock. The rock makeup varies from hard shales to softer sandstones and limestone. The Wappinger Group, found along the Wappinger Creek mainstem, consists of Cambrian- and Ordovician-age carbonate rocks composed of layered sediments (Figure 3.6). These rocks weather readily, and lead to formation of solution channels and voids, providing storage cavities for groundwater supplies (Cadwell and Gerhard, 1993). This stored water is easily susceptible to contamination sources such as septic systems. The carbonate rocks are softer and more susceptible to erosion than the surrounding metamorphic rocks.

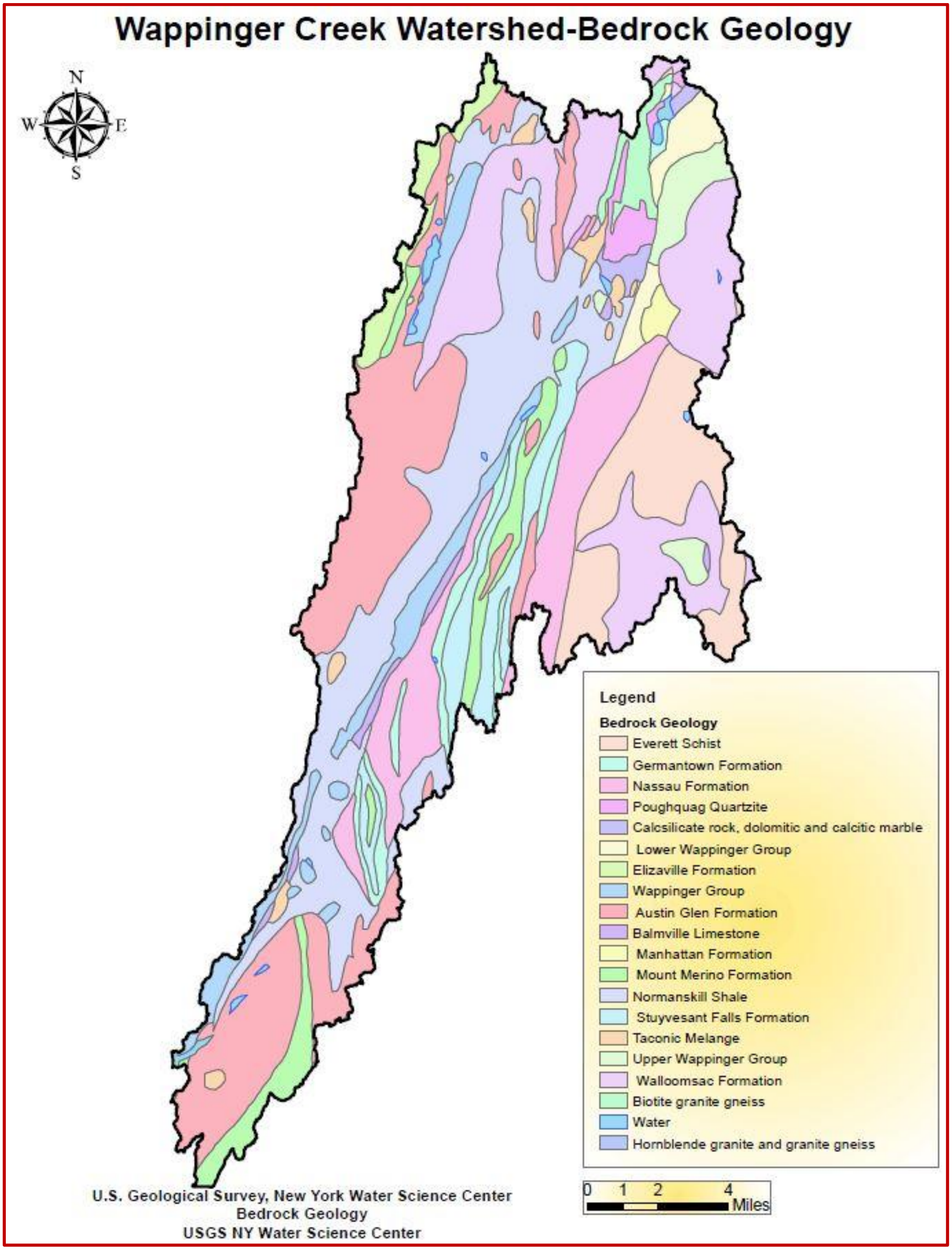

Figure 3.6 Bedrock Geology in Wappinger Creek Watershed

The chemical component of the Wappinger group is slightly alkaline in nature. The limestone component has economic value and is mined in the towns of Poughkeepsie and Pleasant Valley. Harder sedimentary rocks, including Taconic sequence, shale, and Austin Glen, are found in the towns of Wappinger, LaGrange, Pleasant Valley, and Washington (Cadwell and Gerhard, 1993).

The surficial geology of the Wappinger Creek Watershed is composed of sand and gravel, glacial till, and alluvial deposits (Figure 3.7). Extensive deposits of sand and gravel over limestone along the Wappinger Creek and its primary tributaries indicate the presence of aquifers (Chazen Companies, 2007). The aquifers in the Wappinger Creek Watershed are primarily classified as Zone I, with permeable deposits directly overlying the aquifer (Figure 3.8). These permeable deposits allow the contaminants to move directly downward to the underlying aquifer with little to no natural filtration by the soil, because the water moves too quickly. The aquifer recharge rates vary with different hydrologic soil groups in the watershed, with values ranging from 3.8 inches/yr for HSG D soils to 18.2 inches/yr for HSG A soils (Chazen Companies, 2006).

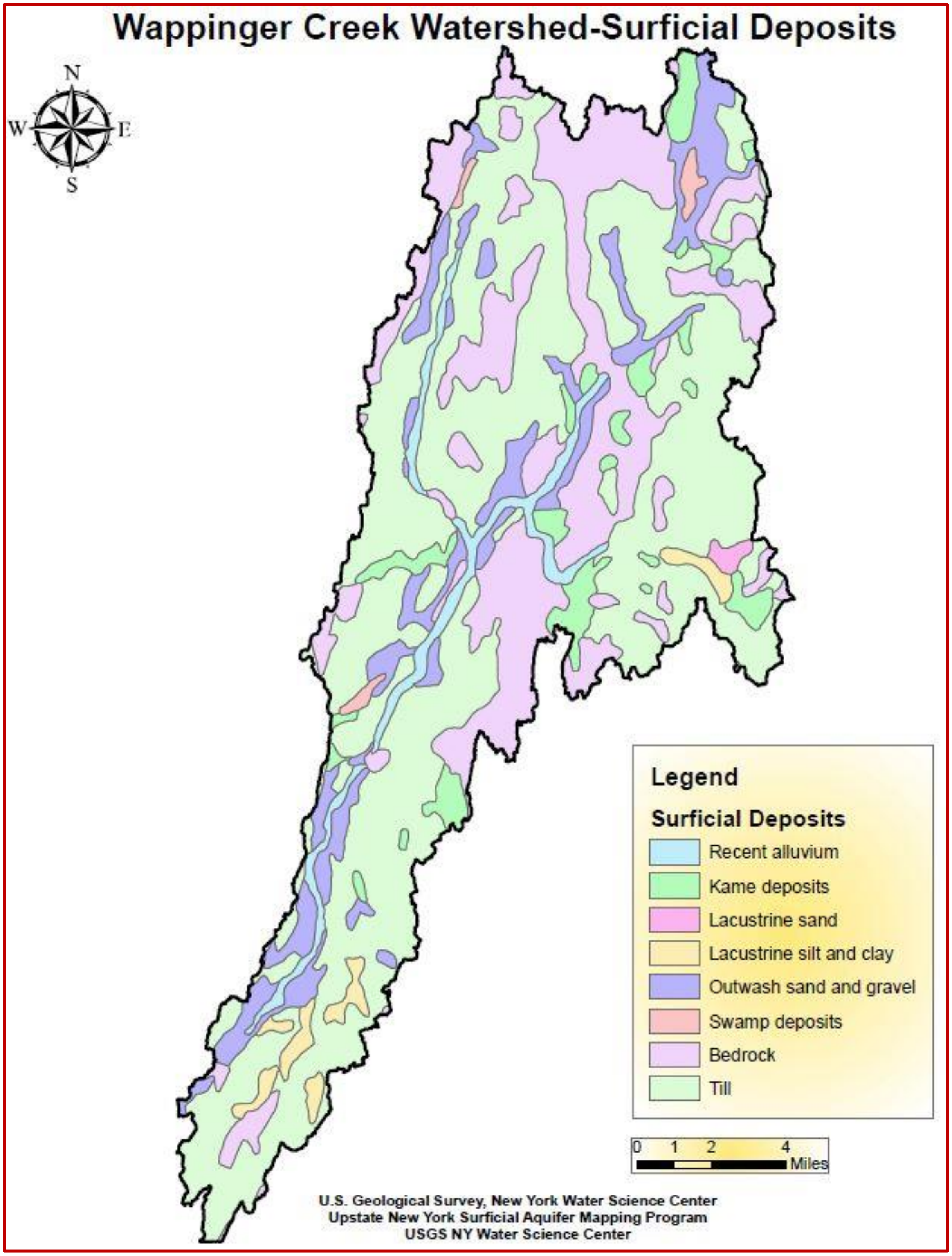

Figure 3.7 Surficial Deposits in Wappinger Creek Watershed

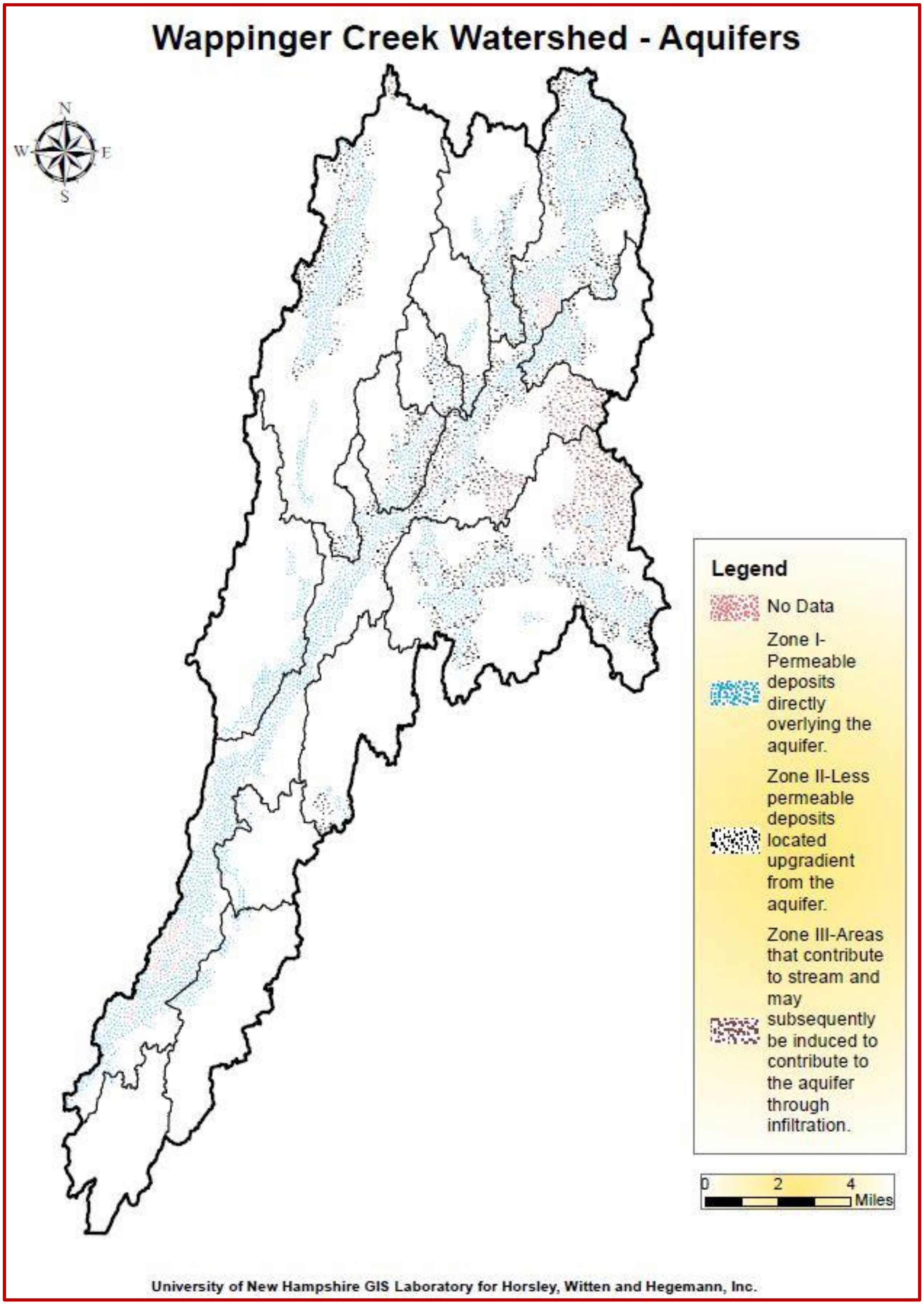

Figure 3.8 Aquifiers in Wappingers Creek Watershed

3.8 Watershed Habitat and Vegetation

The Wappinger Creek Watershed has a great diversity of habitats, both upland and wetland. The upland habitats of the watershed include hardwood forest, mixed forest, conifer forest, cedar woodland, upland shrubland, upland meadow, and orchard/plantation (Tabak & Stevens, 2008; Graham *et al.,* 2012). Dominant vegetation in these habitats is mostly deciduous canopy trees, such as maples, oaks, hickories, white ash, black birch, black locust, black cherry. Coniferous species such as red cedar, eastern hemlock and eastern white pine make up a smaller percentage of the forest cover (Tabak & Stevens, 2008; Graham *et al.,* 2012). Understory and shrub species are composed largely of witch-hazel, Japanese barberry, common buckthorn, shadbush, and a variety of wildflowers, sedges, ferns, and mosses (Tabak & Stevens, 2008; Graham *et al.,* 2012). Wetland habitats of the watershed range from hardwood, conifer and mixed forest swamps, acidic bogs, woodland pools, kettle shrub pools, buttonbush pools, marsh, calcareous wet meadow, fen, circumneutral bogs, streams, ponds and lakes (Tabak & Stevens, 2008; Graham *et al.,* 2012). These habitats incorporate a variety of vegetation, such as maple, ash, elm, oak, willow, buttonbush, sedges, ferns, wetland orchids, wildflowers and peat mosses (Tabak & Stevens, 2008; Graham *et al.,* 2012). Several habitats within the watershed may be threatened, including fens, calcareous wet meadows, kettle shrub pools, and cliffs. These habitats support rare plants, such as certain wetland orchids and sedges, that are more at risk of endangerment as these habitats remain threatened (NY Natural Heritage Program, 2010).

3.9 Wildlife and Endangered Species

The Wappinger Creek Watershed is home to a diverse array of wildlife, ranging from otters and black bears to woodpeckers, warblers, and some more common species including, deer, raccoon, red fox, robin, and painted turtle. Less common species observed include bobcat, mink, and otter (Riverkeeper and Scenic Hudson, 2016). Reservoirs and kettle lakes within the watershed are attractive to migrating birds, such as gulls, geese, ducks, and shorebirds. The tidal mouth of the Wappinger Creek serves as an important spawning area for anadromous fish. Wappinger Creek resident fish species include chain pickerel, bluegill, brook and brown trout, black crappie, pumpkinseed, redbreast sunfish, largemouth bass, and brown bullhead (NYDOS, 2012.). In addition, about 12,000 brown trout and 2,000 rainbow trout are stocked annually in Wappinger Creek for recreational fishing. The lakes in the watershed also support a wide variety of warmwater fish, including American eel, smallmouth bass, rock bass, carp, yellow perch, shiners, and white suckers (NYDOS, 2012). Animal populations act as sensitive indicators of environmental health, as population changes are sensitive to pollution, changes in land use, and other stresses. This is true of resident endangered species, such as Blanding's turtle and Indiana bat, which are becoming increasingly threatened as a result of a rapidly changing habitat (NY Natural Heritage Program, 2014.; Hartwig *et al.,* 2009).

3.10 Recreation

The Wappinger Creek Watershed is widely used for recreation. Activities include, but are not limited to fishing, hiking, picnicking, and boating. It is estimated that over $1 million is spent annually in direct and indirect expenses for recreational use of the watershed (Dutchess County Environmental Management Council *et al.,* 2000.). The Wappinger Creek Water Derby, a recreation event for canoeing and kayaking, also takes place on the creek annually.

3.11 Demographics

Local populations within the watershed's municipalities range from 2,370 in the Town of Milan, to 22,468 in the Town of Wappinger. The Dutchess County Department of Planning and Development has projected an average growth of 13.4% for the years 2010 to 2025, with large increases expected in Poughkeepsie (35%), Pine Plains (20%), Milan (17%), and Millbrook (16%) (U.S. Census Bureau, 2010). These projections indicate an impending increase in population and development throughout the watershed, thereby translating into impacts on open space, recreation, land development, and an increase in point and non-point source pollution into the Wappinger Creek.

Table 3.2 Wappinger Creek Watershed Population Projections

Municipality	Population 2010	Population Forecast 2025
Clinton	4,312	4,850
Hyde Park	21,571	25,217
La Grange	15,730	18,054
Milan	2,370	2,849
Pine Plains	2,473	3,107
Pleasant Valley	9,672	10,964
Poughkeepsie	32,736	50,552
Stanford	3,823	4,286
Wappinger	27,048	26,996
Washington	4,741	4,007
Fishkill	2,171	2,098
Millbrook	1,452	1,728
Wappinger Falls	5,522	5,961

Source: *United States Census Bureau (2013) 2010 decennial census Dutchess County municipal populations. Revised February 2013.*

3.12 Waterbody Inventory/Priority Waterbodies List

Wappinger Creek is the largest stream in the watershed at 41.7 miles long, with an additional 320 miles of tributaries. The major tributaries include: Cold Spring Creek, Hunns Lake Creek, Tamarack Creek, Grist Mill Creek, Willow Brook, East Branch Wappinger Creek, and Great Spring Creek. There are 602 acres of ponds and lakes, and 8,362 acres of wetlands within the watershed.

Table 3.3 Lakes and Ponds in Wappinger Creek Watershed Listed on WI/PWL

Lake/Pond Name	Municipality	Area (Acres)	NYSDEC Classification
Long Pond	Clinton	81.9	AA
Ryder Pond, Hunns Lake	Stanford	78.8	B
Silver Lake	Clinton	110.7	AA(T)
Thompson, Stissing, Mud/Twin Island Ponds	Pine Plains	204.4	B
Upton Lake	Stanford	45.5	B
Wappinger Lake	Wappingers Falls	80.2	B

Source: *NYSDEC (2008) WI/PWL Fact Sheets – Wappinger Creek/ Hudson River.*

The Waterbody Inventory/Priority Waterbodies List (WI/PWL) is a statewide inventory of the waters of New York State that NYSDEC uses to track support (or impairment) of water uses, overall assessment water quality, causes and sources of water quality impact/impairment, and the status of restoration, protection and other water quality activities and efforts. The PWL is included within the Watershed Inventory to identify those water quality issues and specific waterbodies where efforts will have the greatest impact and benefit, objectively evaluate needs for project funding, monitor water quality improvement, and record and report changes over time.

Table 3.4 Rivers and Creeks in Wappinger Creek Watershed Listed on WI/PWL

River/Creek	Municipality	Length (Miles)	NYSDEC Classification
Great Spring Brook and tributaries	Pleasant Valley	31.3	B
Little Wappinger Creek, Lower and tributaries	Pleasant Valley	28.2	B(T)
Wappinger Creek, Middle, and minor tributaries (Portion 3)	Pleasant Valley	42.7	B(T)
Wappinger Creek, Middle, and minor tributaries (Portion 4)	Millbrook	91.8	B(T)
Wappinger Creek, Upper, and tributaries (Portion 5)	Millbrook	81.5	C(TS)

Source: *NYSDEC (2008) WI/PWL Fact Sheets – Wappinger Creek/ Hudson River.*

Within the watershed, there are 6 lakes and ponds and 5 rivers and streams that are listed as priority waterbodies (Table 3.3, Table 3.4, Figure 3.9). Refer to Appendix C for stream and tributary classifications for the streams listed in Table 3.4. Most of the waterbodies in Lower Hudson Basin were not assessed, according to the 2008 Final Draft Lower Hudson River Basin WI/PWL Report. For the waterbodies assessed, impairment was documented in Wappinger Lake (NYSDEC, 2008.).

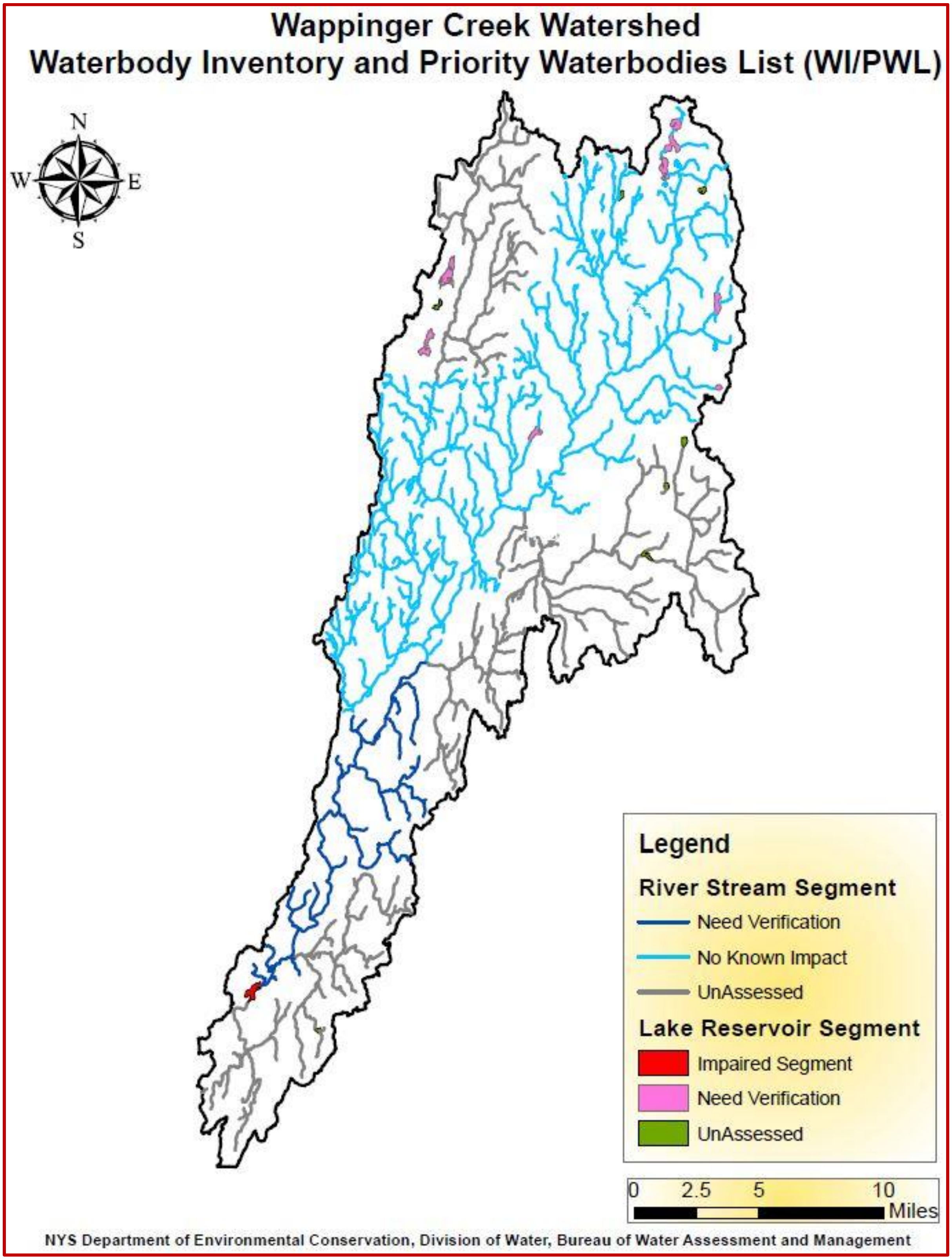

Figure 3.9 Wappinger Creek Watershed WI/PWL

3.13 Land Cover

3.13.1 Classification Methodology

Figure 3.10 provides an overview of the most recently available land use in the Wappinger Creek Watershed, as classified using Multi-Resolution Land Characteristics Consortium (MLRC) National Land Cover Data (NLCD).

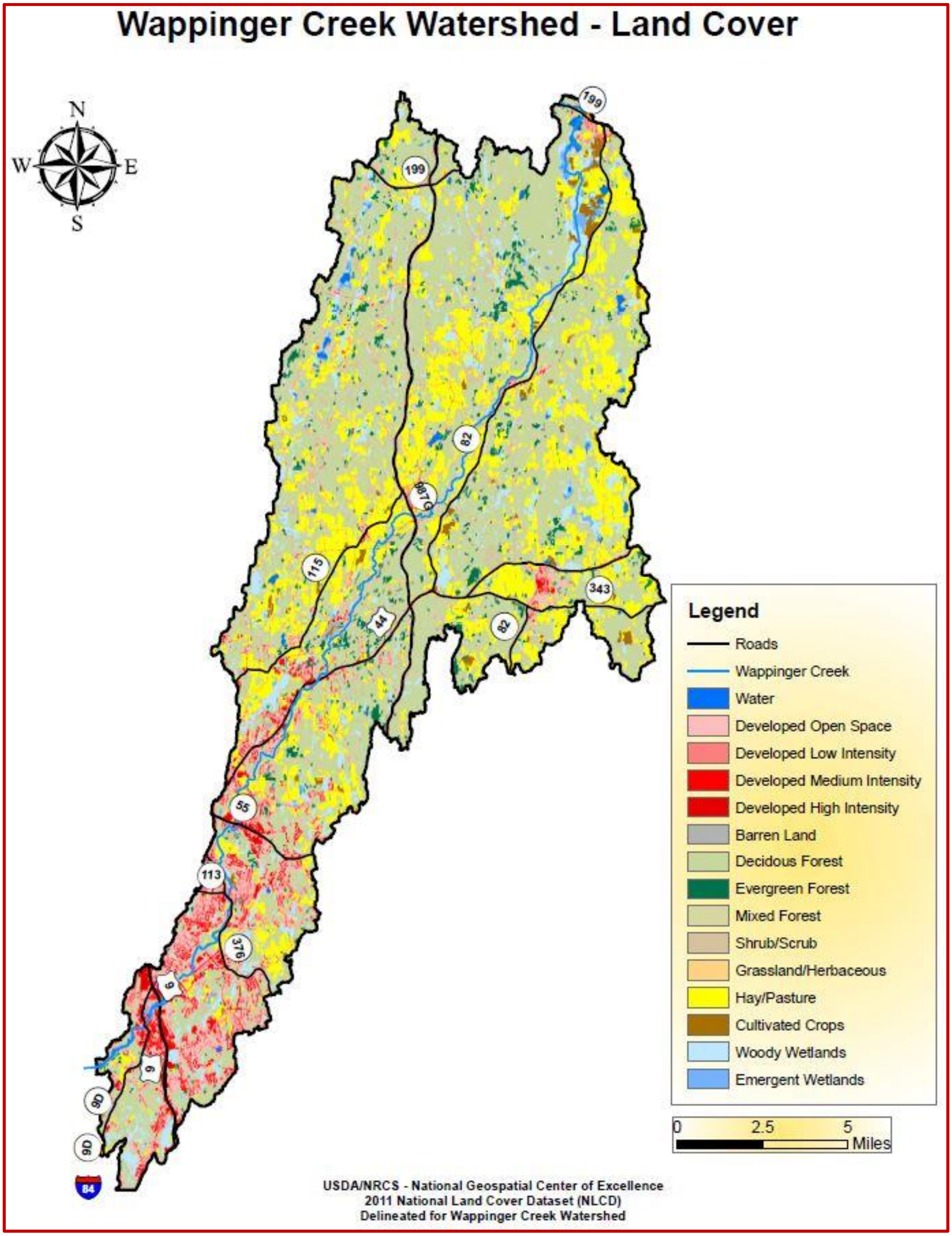

Figure 3.10 Wappinger Creek Watershed Land Cover

Land Cover has been mapped for all the 13 subwatersheds of the Study Area. Land cover is comprised of 15 categories (https://www.mrlc.gov/data/legends/national-land-cover-database-2011-nlcd2011-legend) as follows:

Water. Fresh waterbodies.

Developed Open Space. Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. These areas most commonly include parks, golf courses, large-lot-single-family housing units, and developed settings for recreation and erosion control.

Developed Low Intensity. Areas with a mixture of constructed materials and vegetation with impervious cover accounting for 20% to 49% of total cover. These commonly include single-family housing units.

Developed Medium Intensity. Areas with a mixture of constructed materials and vegetation with imperious cover accounting for 50% to 79% of total cover. These commonly include single-family housing units.

Developed High Intensity. Highly developed areas with impervious cover accounting for 80% to 100% of the total land cover. These areas include apartment complexes, row houses and commercial/industrial units.

Barren Land. Areas of bedrock, desert pavement, slides, volcanic materials, sand dunes, gravel pits, and other accumulations of earth material with vegetation accounting to less than 15% of total cover.

Deciduous Forest. Areas dominated by trees greater than 5 meters tall. This category includes small patches to large contiguous areas of trees that shed foliage at end of growing season. Common examples include oaks and maples.

Evergreen Forest. Areas dominated by trees greater than 5 meters tall. This category includes small patches to large contiguous areas of needle-leaved, evergreen, and/or cone-bearing trees. Common examples include pines, spruces, and firs.

Mixed Forest. Areas dominated by trees greater than 5 meters tall. Where neither deciduous nor evergreen species are greater than 75% of total cover.

Shrub/Scrub. Areas dominated by shrubs less than 5 meters tall, with shrub canopy greater than 20% of total vegetation cover. Common examples include true shrubs and young trees in early successional stages.

Grassland/Herbaceous. Areas dominated by graminoid and herbaceous vegetation. This category includes native grasses and lawns that are not subjected to intensive management but can be utilized for grazing.

Hay Pasture. Areas of grasses, legumes or mixtures planned for livestock grazing or production of seed or hay crops, typically on a perennial cycle.

Cultivated Crops. Areas used for production of annual crops such as corn, soybeans, vegetables, cotton, and perennial woody crops such as orchards and vineyards. This category also includes land that is being actively tilled.

Woody Wetlands. Areas where forest and shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated or covered with water.

Emergent Herbaceous Wetlands. Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated or covered with water.

Impervious cover was used to estimate the stormwater runoff volumes from areas with developed stormwater infrastructure. This detailed land cover classification contributed essential data for the development of hydrologic and water quality model for the Wappinger Creek Watershed.

3.13.2 Land Cover Characteristics and Distribution

Land cover varies significantly throughout the watershed. The land cover classification is summarized in Appendix A, at the watershed and subwatershed levels. The Wappinger Creek Watershed is largely forested, with agriculture being more prevalent in the upper portion of the watershed, and increasing residential, urban, and industrial areas moving downstream (Figure 3.10). At the broad watershed level, deciduous forests constitute the largest amount of the land cover at approximately 61,467 acres (45.5%) while hay pastures account for approximately 23,457 acres (17.4%). In effect, these two land cover types cover a majority (63%) of the watershed. Developed areas (e.g., open space, low intensity, medium intensity, and high intensity) together comprise the next largest land cover class, occupying 21,020 acres (15.6%). Shrub and herbaceous grassland areas account for about 3,682 acres (4.4%) which primarily consist of shrubs, native grasses, and lawns. Cultivated crops account for 3,158 acres (2.3%), while barren land accounts for 375 acres (0.3%). Wetlands and fresh waterbodies comprise 10,355 acres (8.7%) and 4,816 acres (3.6%), respectively (NLCD 2011).

In terms of its relative distribution, land cover varies widely from north to south across the watershed. It is evident that forested areas and agriculture (hay pasture and crops) dominate the northernmost areas of the watershed, whereas impervious surfaces are less densely concentrated within this portion. The northern and central portions of the watershed contain 73% of the wetlands (NLCD 2011).

The land cover in the southern portion of the watershed differs significantly from its northern counterpart. A substantial amount of the southern portion of the watershed is developed, especially the southwestern portion, focused around Poughkeepsie and Wappinger Falls. Impervious surfaces, including structures, roadways, parking areas, and high density developed areas, comprise a large share of the southern portion of the watershed. This is most prominent around the towns of Wappinger, Poughkeepsie, and Pleasant Valley. Within the Overlook Road, Dutchess County Airport, and Wappingers Falls subwatersheds, developed areas account for 33.4%, 39.9%, and 39.1% of the land cover, respectively.

3.14 Land Use

Land use varies significantly across the Wappinger Creek Watershed. A substantial amount of the southern portion of the watershed, particularly in the southwestern portion, is heavily developed (Figure 3.11). Residences are more densely concentrated along the shorelines of Wappinger Creek, located in the towns of Poughkeepsie and Wappinger. Most land uses defined as community and public services by NYS Tax Parcels are also located in the southern portion of the watershed, though they occupy significantly less space than residential spaces (Figure 3.11). Most of the vacant land in the southern portion of the watershed is located within the Wappingers Falls and Dutchess County Airport subwatersheds (Figure 3.11).

Commercial uses are notably concentrated along U.S. Route 9, which runs longitudinally, and State Highway 55 and U.S. Route 44. Transportation comprises a fair share of the watershed's land use, especially in the central and southern portions of the watershed, where a significant amount of land is dedicated to the Dutchess County Airport and right-of-way for State Highway 55, U.S. Route 9 and U.S. Route 44. Residential streets also constitute a substantial amount of land devoted to transportation (Figure 3.11).

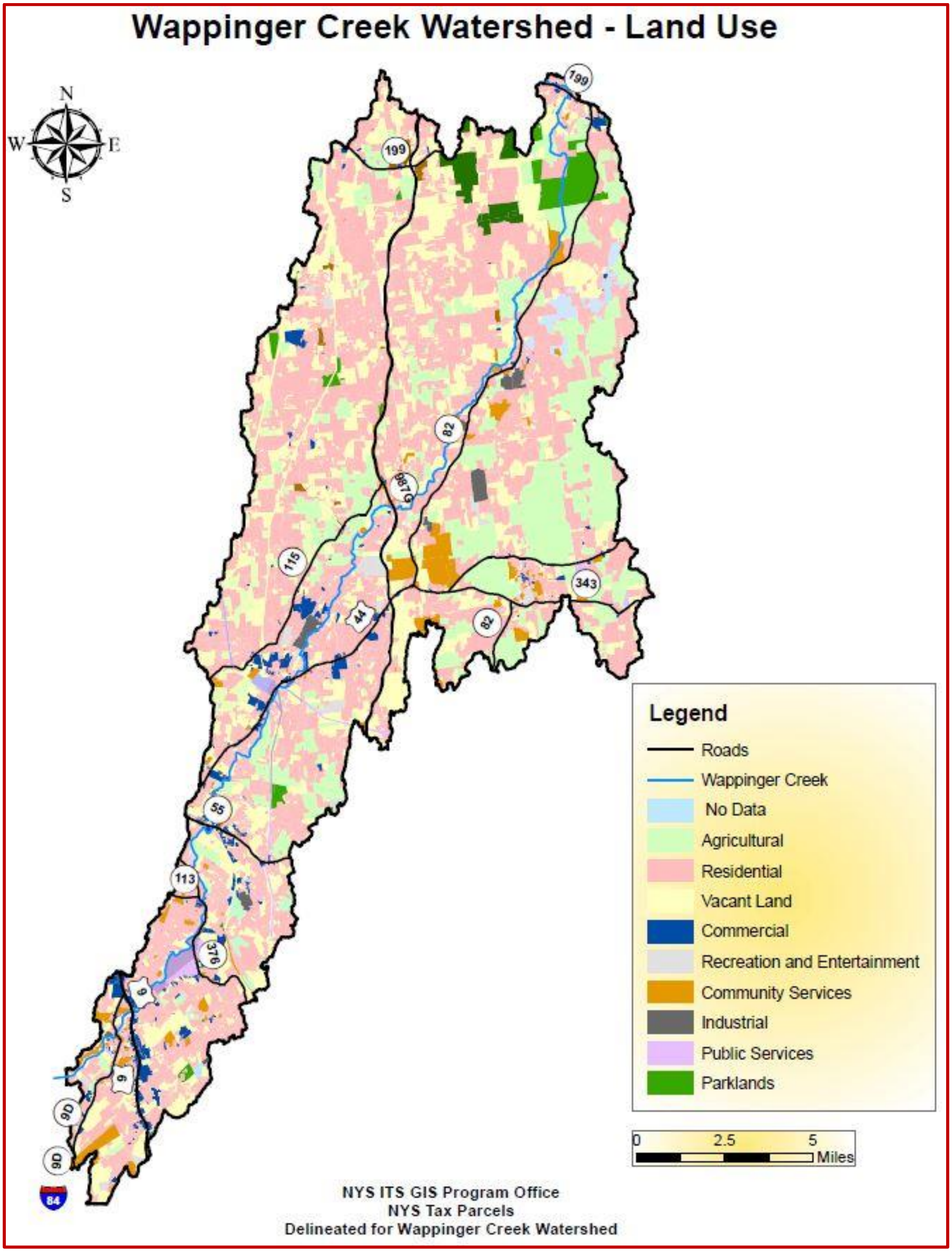

Figure 3.11 Wappinger Creek Watershed Land Use

The northern portion of the watershed differs in character from its southern counterpart because of its generally lower development density. Whereas moderate to high density and commercial land uses tend to dominate the southern portion of the watershed, vacant land, agriculture, parklands, and low-density residential uses are more prevalent throughout the northern portion.

Residential land use accounts for the highest single land use in the watershed with an approximate area of 66,663 acres (49.3%). Industrial, commercial, and public service uses, which are relatively intense uses, account for 953, 3,275, and 1,595 acres, respectively, for a total area of 5,823 acres (4.3%). Collectively, residential, industrial, commercial, and public service uses account for 53.6% of the total land in the watershed. Vacant land accounts for 29,484 acres (21.8%), while agricultural land accounts for 23,177 acres (17.2%). Recreation and entertainment; and community services, which are relatively less intensive land uses, account for 6,172 acres (4.6%) of the total. There are approximately 3,425 acres (2.5%) of preserved parklands, mostly located at the extreme northern portion of the watershed (Appendix B: Summary of Land Use by Subwatershed).

Residential and vacant land (property that is not in use, is in temporary use, or lacks permanent improvement) comprise most of the land use in several subwatersheds. In the northern portion, residential and vacant land uses account for 78.3% (Cold Spring Creek), 85.3% (Little Wappinger Creek), 92.4% (Grist Mill), 77.2% (Willow Brook), 62.7% (Hunns Lake Creek), and 83.7% (Upton Lake), for a total of 35,399 acres. On the eastern side, residential, agricultural, and vacant land uses account for 89.1% and 91.4% of the land use in East Branch Wappinger Creek and Pleasant Valley East subwatersheds. Collectively, residential, vacant land, and agricultural land uses account for 88.3% of the total land in the watershed (Figure 3.11).

3.15 Point Sources

There are 16 State Pollutant Discharge Elimination System (SPDES) permitted facilities in the watershed that discharge directly into the Wappinger Creek or its tributaries. Six of these 16 facilities are publicly owned treatment works (POTW) and the remaining are non-public owned treatment works (Non-POTW). Seven of these 16 facilities are in direct drainage to the Wappinger Creek, the rest being located in Dutchess County Airport (2), East Branch Wappinger Creek (1), Great Spring Creek (1), Overlook Road (2), Pleasant Valley East (1), and Wappingers Falls (2) subwatersheds (Appendix F: Summary of Point Sources in Wappinger Creek Watershed).

4.0 Water Quality

Information from historical monitoring efforts and studies indicate that water quality is presently impaired in Wappinger Creek (Burns, 2006 and DC EMC et al., 2000). This section presents an evaluation of monitoring observations, and a discussion of potential sources for impairment for each subwatershed and the entire watershed.

4.1 Water Quality Monitoring and Assessment

Water quality for the Wappinger Creek was monitored at 15 stations over the period of September 2017 to October 2018. Sampling sites were distributed along approximately 40 miles of the Wappinger Creek from its headwaters through Wappinger Lake and Wappingers Falls. Sites were selected based on the information gathered from historical monitoring and available literature (Burns, 2006, DC EMC et al., 2000, Cadmus Group, 2009, and Smith, 2017). Monitoring stations included main branch Wappinger Creek and tributaries (Figure 4.1; Table 4.1). The watershed study included analysis of nitrogen, phosphorus, suspended sediment, and fecal coliform. It also included an analysis of baseline chemistry, consisting of measurements of dissolved oxygen, pH, turbidity, and biochemical oxygen demand (BOD). Grab samples were collected monthly using sterile polypropylene bottles which included two 250 mL, two 1000 mL and one 125 mL bottles at each site. The samples were capped and sealed immediately and placed on ice in a dark container and transported to Envirotest Laboratories (ELAP-certified) in Newburgh, NY for analysis. Stream temperature and pH were measured during each sample collection by a hand-held meter. Refer to Appendix I for the approved Quality Assurance Project Plan (QAPP) for the water quality monitoring program.

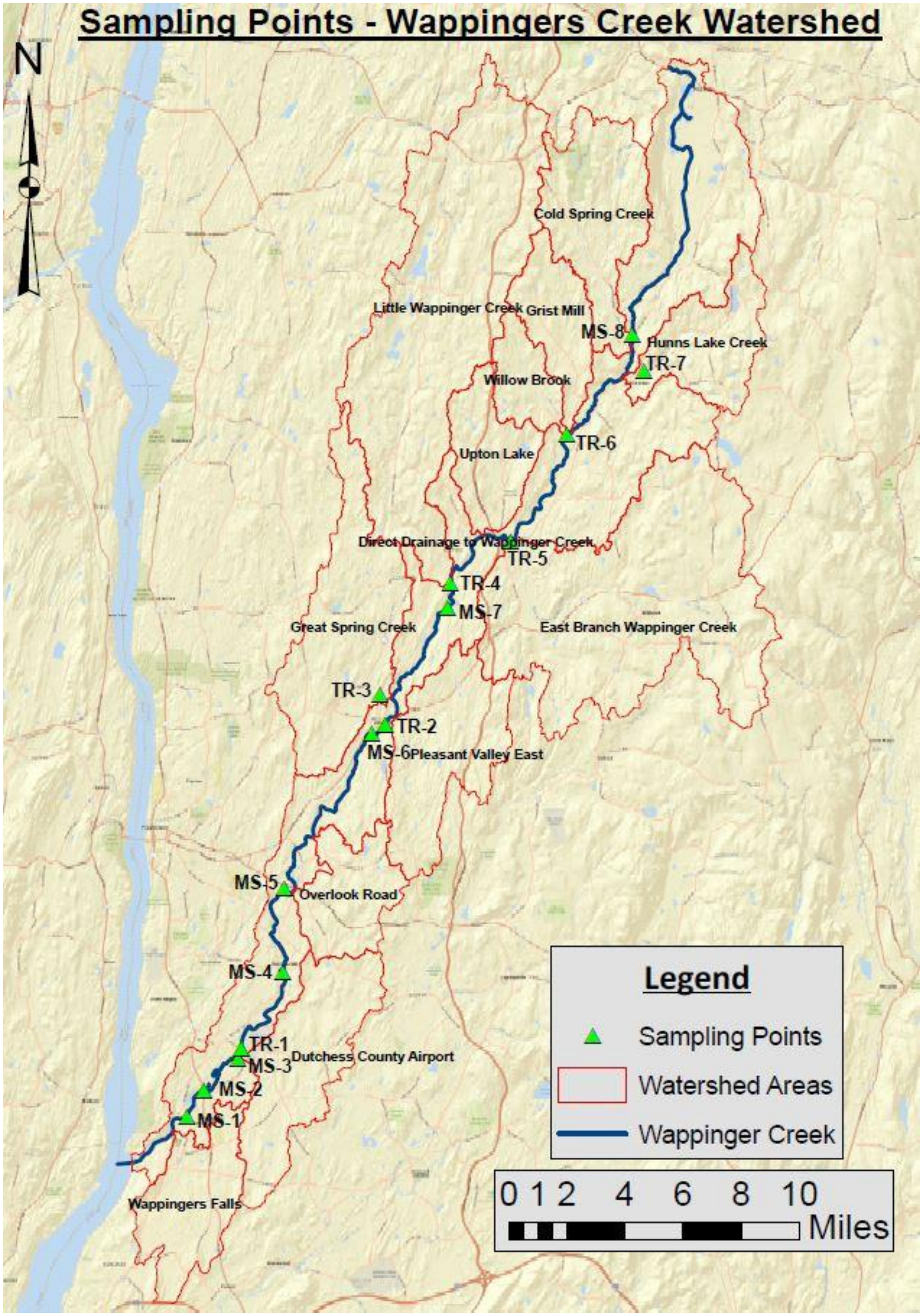

Figure 4.1 Wappinger Creek Watershed Water Quality Monitoring Points (2017-2018)

4.1.1 Streamflow Measurements

Streamflows were measured based on a velocity-area approach during each sampling event at all the sampling sites. The widths of the streams were measured along a stream cross-section, water depths were measured at four to five locations across the width and average depths were obtained at each sampling site. The average cross-sectional area (ft^2) was determined by multiplying the average depth by the width of the stream section. Velocity was measured by tracking the time it took a floating tennis ball to move along a 20-foot length of stream.

Table 4.1 Monitoring Sites in Wappinger Creek Watershed (2017-2018)

Site ID	Site Name	Approx. Latitude	Approx. Longitude	Type of Site
MS-1	West Main Street Bridge	41.5992	-73.9202	Mainstream
MS-2	Albany Post Road bridge	41.6091	-73.9118	Mainstream
MS-3	Dutchess County Airport	41.6209	-73.8947	Mainstream
TR-1	Dutchess County Airport Tributary at New Hackensack Road	41.6248	-73.8931	Tributary
MS-4	USGS Gauging Station (01372500)	41.5031	-73.8725	Mainstream
MS-5	State Route 55	41.5842	-73.8718	Mainstream
MS-6	Dutchess Turnpike	41.7416	-73.8280	Mainstream
TR-2	Pleasant Valley East Tributary at Highway 44	41.7451	-73.8214	Tributary
TR-3	Great Spring Creek Tributary at Wigsten Road	41.7562	-73.8241	Tributary
MS-7	Creek Road at Camp Nooteeming	41.7886	-73.7904	Mainstream

TR-4	Little Wappinger Creek Tributary at Salt Point	41.7975	-73.7890	Tributary
TR-5	East Branch of Wappinger Creek Tributary at Hibernia Road	41.8139	-73.7581	Tributary
TR-6	Willow Brook Tributary at Point Turnpike	42.7267	-73.7072	Tributary
TR-7	Hunns Lake Creek Tributary at Route 82A	41.8757	-73.6927	Tributary
MS-8	Cold Spring Road at Community of McIntyre	41.8899	-73.6983	Mainstream

4.2 Results

The results from the water quality sampling for the analyzed constituents of interest for each subwatershed are shown in Tables 4.2 through 4.16., whereas the overall results for all the parameters are presented in Appendix H. The sampling sites in the following tables and figures represent the Wappinger Creek and its tributaries from downstream (MS-1: most downstream mainstream station and TR-1: most downstream tributary) to upstream (MS-8: most upstream mainstream station and TR-7: most upstream tributary station).

Table 4.2 Constituent of Interest Data for Station MS-1 for All Sampling Events

MS -1 (West Main Street Bridge) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
9/12/2017	0.39	0.2	1.7	50	51
11/20/2017	0.41	0.1	7	10	70
3/6/2018	0.69	0.027	3.2	20	1008
4/3/2018	0.41	0.010	1.9	10	775
5/1/2018	0.34	0.01	3.4	30	611
6/5/2018 (S)	0.4	0.051	4.8	390	262
7/24/2018 (S)	0.34	0.054	3.7	120	148
8/15/2018 (S)	0.38	0.075	9.4	1000	414
9/27/2018 (S)	0.3	0.07	21	1600	1574

10/31/2018	0.44	0.028	7.2	550	480
11/28/2018 (S)	0.49	0.020	6.0	270	1278
Mean	**0.42**	**0.06**	**6.3**	**368**	
Median	**0.40**	**0.05**	**4.8**	**120**	
Geometric Mean	**0.41**	**0.04**	**4.9**	**112**	
Variance	**0.01**	**0.003**	**26.8**	**237706**	
Standard Deviation	**0.10**	**0.06**	**5.4**	**511**	
Dates marked with (S) denote storm events					

Table 4.3 Constituent of Interest Data for Station MS-2 for All Sampling Events

MS -2 (Albany Post Road bridge) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
9/12/2017	0.49	0.29	9.6	60	48
11/20/2017	0.39	0.22	16	80	54
3/6/2018	0.69	0.054	2.4	30	955
4/3/2018	0.41	0.010	1.1	40	679
5/1/2018	0.34	0.01	3.3	190	567
6/5/2018 (S)	0.42	0.081	3.6	490	235
7/24/2018 (S)	0.46	0.081	7.2	440	114
8/15/2018 (S)	0.43	0.085	5	890	357
9/27/2018 (S)	0.29	0.096	33	2419	1511
10/31/2018	0.45	0.025	1.6	41	412
11/28/2018 (S)	0.51	0.025	6.4	210	1196
Mean	**0.44**	**0.09**	**8.1**	**445**	
Median	**0.43**	**0.08**	**5.0**	**190**	
Geometric Mean	**0.43**	**0.05**	**5.1**	**174**	
Variance	**0.01**	**0.008**	**86.5**	**499791**	
Standard Deviation	**0.10**	**0.09**	**9.3**	**707**	
Dates marked with (S) denote storm events					

Table 4.4 Constituent of Interest Data for Station MS-3 for All Sampling Events

MS -3 (Dutchess County Airport) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
9/12/2017	0.49	0.28	4	60	34
11/20/2017	0.35	0.1	3.9	80	46
3/6/2018	0.66	0.029	2.8	20	911
4/3/2018	0.41	0.010	3.8	4	564
5/1/2018	0.32	0.01	5.4	N/A	478
6/5/2018 (S)	0.41	0.05	5.2	370	182

7/24/2018 (S)	0.44	0.05	3.6	240	89
8/15/2018 (S)	0.41	0.089	28	370	311
9/27/2018 (S)	0.27	0.17	40	1300	1450
10/31/2018	0.4	0.021	1.7	43	357
11/28/2018 (S)	0.47	0.022	5.8	160	1145
Mean	**0.42**	**0.08**	**9.5**	**265**	
Median	**0.41**	**0.05**	**4.0**	**120**	
Geometric Mean	**0.41**	**0.04**	**5.6**	**101**	
Variance	**0.01**	**0.007**	**155.6**	**150956**	
Standard Deviation	**0.10**	**0.08**	**12.5**	**389**	
Dates marked with (S) denote storm events					

Table 4.5 Constituent of Interest Data for Station MS-4 for All Sampling Events

MS -4 (USGS Gauging Station (01372500)) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
9/12/2017	0.48	0.1	1.3	130	33
11/20/2017	0.3	0.1	1	40	49
3/6/2018	0.62	0.043	4	10	807
4/3/2018	0.39	0.010	2.8	80	527
5/1/2018	0.29	0.01	5	10	456
6/5/2018 (S)	0.4	0.049	8	370	176
7/24/2018 (S)	0.38	0.044	2.6	350	74
8/15/2018 (S)	0.37	0.085	11	200	248
9/27/2018 (S)	0.25	0.21	41	2419	1370
10/31/2018	0.38	0.017	1.7	67	330
11/28/2018 (S)	0.46	0.031	5.8	74	1080
Mean	**0.39**	**0.06**	**7.7**	**341**	
Median	**0.38**	**0.04**	**4.0**	**80**	
Geometric Mean	**0.38**	**0.04**	**4.2**	**102**	
Variance	**0.01**	**0.003**	**131.6**	**490762**	
Standard Deviation	**0.10**	**0.06**	**11.5**	**701**	
Dates marked with (S) denote storm events					

Table 4.6 Constituent of Interest Data for Station MS-5 for All Sampling Events

MS -5 (State Route 55) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
9/12/2017	N/A	N/A	N/A	N/A	29
11/20/2017	N/A	N/A	N/A	N/A	42
3/6/2018	0.55	0.024	1.9	40	601

4/3/2018	0.41	0.010	2.4	10	443
5/1/2018	0.33	0.01	3.3	40	412
6/5/2018 (S)	0.39	0.047	4.3	410	154
7/24/2018 (S)	0.34	0.054	2.8	300	78
8/15/2018 (S)	0.39	0.085	13	490	220
9/27/2018 (S)	0.25	0.16	38	2419	1180
10/31/2018	0.37	0.023	1.7	42	285
11/28/2018 (S)	0.48	0.01	5.2	260	1044
Mean	**0.39**	**0.05**	**8.1**	**446**	
Median	**0.39**	**0.02**	**3.3**	**260**	
Geometric Mean	**0.38**	**0.03**	**4.5**	**143**	
Variance	**0.01**	**0.002**	**138.0**	**579357**	
Standard Deviation	**0.09**	**0.05**	**11.7**	**761**	
Dates marked with (S) denote storm events					

Table 4.7 Constituent of Interest Data for Station MS-6 for All Sampling Events

MS -6 (Dutchess Turnpike) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
10/20/2017	0.31	0.1	2.2	50	27
11/20/2017	0.35	0.1	1.6	10	40
3/6/2018	0.55	0.024	1.7	10	498
4/3/2018	0.35	0.010	1.7	10	363
5/1/2018	0.27	0.01	3.0	30	320
6/5/2018 (S)	0.32	0.048	4.6	490	129
7/24/2018 (S)	0.32	0.061	5.6	240	55
8/15/2018 (S)	0.28	0.083	8.4	330	185
9/27/2018 (S)	0.19	0.16	31.0	2400	1112
10/31/2018	0.33	0.018	2.1	54	260
11/28/2018 (S)	0.39	0.029	4.4	110	887
Mean	**0.33**	**0.06**	**6.0**	**339**	
Median	**0.32**	**0.05**	**3.0**	**54**	
Geometric Mean	**0.32**	**0.04**	**3.7**	**80**	
Variance	**0.01**	**0.002**	**73.0**	**491779**	
Standard Deviation	**0.09**	**0.05**	**8.5**	**701**	
Dates marked with (S) denote storm events					

Table 4.8 Constituent of Interest Data for Station MS-7 for All Sampling Events

MS -7 (Creek Road at Camp Nooteeming) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
10/20/2017	0.36	0.1	2	50	25
11/21/2017	0.33	0.1	1.3	130	35
3/6/2018	0.51	0.020	2.3	10	343
4/3/2018	0.36	0.010	2.3	40	211
5/1/2018	0.28	0.01	2.6	30	185
6/5/2018 (S)	0.34	0.046	4.4	310	118
7/24/2018 (S)	0.32	0.042	4	320	49
8/15/2018 (S)	0.24	0.076	19	2420	159
9/27/2018 (S)	0.17	0.16	29	2419	820
10/31/2018	0.35	0.018	1.7	49	175
11/28/2018 (S)	0.38	0.01	4.2	61	792
Mean	**0.33**	**0.05**	**6.6**	**531**	
Median	**0.34**	**0.04**	**2.6**	**61**	
Geometric Mean	**0.32**	**0.03**	**3.8**	**127**	
Variance	**0.01**	**0.002**	**79.9**	**883514**	
Standard Deviation	**0.09**	**0.05**	**8.9**	**940**	
Dates marked with (S) denote storm events					

Table 4.9 Constituent of Interest Data for Station MS-8 for All Sampling Events

MS -8 (Cold Spring Road at Community of McIntyre) - Mainstream Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
10/31/2017	0.12	0.1	2.2	280	17
11/21/2017	0.24	0.1	14	150	22
3/6/2018	0.36	0.027	4.4	10	61
4/3/2018	0.27	0.066	3.2	30	54
5/1/2018	0.17	0.021	4.6	70	42
6/5/2018 (S)	0.19	0.078	6.3	180	51
7/24/2018 (S)	0.2	0.078	4.3	410	31
8/15/2018 (S)	0.2	0.098	5.6	1200	57
9/27/2018 (S)	0.16	0.086	13	820	134
10/31/2018	0.28	0.017	1.6	21	39
11/28/2018 (S)	0.34	0.01	2.0	83	116
Mean	**0.23**	**0.06**	**5.6**	**296**	
Median	**0.20**	**0.08**	**4.4**	**150**	
Geometric Mean	**0.22**	**0.05**	**4.4**	**125**	
Variance	**0.01**	**0.001**	**17.6**	**146444**	
Standard Deviation	**0.08**	**0.04**	**4.2**	**383**	
Dates marked with (S) denote storm events					

Table 4.10 Constituent of Interest Data for Station TR-1 for All Sampling Events

TR-1 (Dutchess County Airport Tributary at New Hackensack Road) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
9/12/2017	0.41	0.3	2.2	110	6
11/20/2017	0.51	0.1	1.9	90	5
3/6/2018	0.85	0.031	5.2	30	20
4/3/2018	0.48	0.010	2.3	70	17
5/1/2018	0.28	0.01	2.2	100	15
6/5/2018 (S)	0.3	0.081	3.6	550	11
7/24/2018 (S)	0.24	0.1	8.3	480	10
8/15/2018 (S)	0.34	0.39	14	650	7
9/27/2018 (S)	0.42	0.15	11	2419	38
10/31/2018	0.45	0.054	1.6	84	9
11/28/2018 (S)	0.60	0.018	4.3	130	33
Mean	**0.44**	**0.11**	**5.1**	**428**	
Median	**0.42**	**0.08**	**3.6**	**110**	
Geometric Mean	**0.42**	**0.06**	**3.9**	**186**	
Variance	**0.03**	**0.015**	**17.4**	**484761**	
Standard Deviation	**0.17**	**0.12**	**4.2**	**696**	
Dates marked with (S) denote storm events					

Table 4.11 Constituent of Interest Data for Station TR-2 for All Sampling Events

TR-2 (Pleasant Valley East Tributary at Highway 44) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
11/3/2017	0.2	0.1	14	40	21
11/21/2017	0.29	2.5	140	50	28
3/6/2018	0.70	0.029	1.6	10	138
4/3/2018	0.27	0.010	1.3	30	106
5/1/2018	0.24	0.01	3.0	40	95
6/5/2018 (S)	0.26	0.096	4.3	230	55
7/24/2018 (S)	0.22	0.11	5.0	310	38
8/15/2018 (S)	0.34	0.14	4.6	490	60
9/27/2018 (S)	0.33	0.14	4.4	2419	214
10/31/2018	0.28	0.044	1.8	57	82
11/28/2018 (S)	0.55	0.028	3.3	120	200
Mean	**0.33**	**0.29**	**16.7**	**345**	
Median	**0.28**	**0.10**	**4.3**	**57**	
Geometric Mean	**0.31**	**0.07**	**4.8**	**103**	
Variance	**0.02**	**0.54**	**1685.3**	**495504**	
Standard Deviation	**0.15**	**0.73**	**41.1**	**704**	
Dates marked with (S) denote storm events					

Table 4.12 Constituent of Interest Data for Station TR-3 for All Sampling Events

TR-3 (Great Spring Creek Tributary at Wigsten Road) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
10/31/2017	0.54	0.14	2.2	440	3
11/21/2017	0.85	0.23	5.2	90	4
3/6/2018	0.40	0.027	1.3	10	20
4/3/2018	0.29	0.010	1.1	20	12
5/1/2018	0.15	0.01	2.7	10	11
6/5/2018 (S)	0.41	0.09	5	270	7
7/24/2018 (S)	0.72	0.15	7.3	430	6
8/15/2018 (S)	0.40	0.13	7.2	690	10
9/27/2018 (S)	0.21	0.11	2.8	410	42
10/31/2018	0.23	0.046	1.7	93	10
11/28/2018 (S)	0.37	0.011	16	290	37
Mean	**0.42**	**0.09**	**4.8**	**250**	
Median	**0.40**	**0.09**	**2.8**	**270**	
Geometric Mean	**0.37**	**0.05**	**3.5**	**119**	
Variance	**0.05**	**0.005**	**18.8**	**50805**	
Standard Deviation	**0.22**	**0.07**	**4.3**	**225**	
Dates marked with (S) denote storm events					

Table 4.13 Constituent of Interest Data for Station TR-4 for All Sampling Events

TR-4 (Little Wappinger Creek Tributary at Salt Point) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
10/31/2017	0.082	0.1	2	480	22
11/21/2017	0.05	0.1	9.2	80	28
3/6/2018	0.26	0.015	1.6	10	166
4/3/2018	0.16	0.010	1.0	10	119
5/1/2018	0.11	0.01	2.2	40	118
6/5/2018 (S)	0.1	0.036	3.2	100	55
7/24/2018 (S)	0.13	0.044	4	100	34
8/15/2018 (S)	0.085	0.049	2	390	60
9/27/2018 (S)	0.13	0.09	32	2419	214
10/31/2018	0.14	0.028	4.6	44	71
11/28/2018 (S)	0.19	0.01	2.5	72	171
Mean	**0.13**	**0.04**	**5.8**	**340**	
Median	**0.13**	**0.04**	**2.5**	**80**	
Geometric Mean	**0.12**	**0.03**	**3.4**	**93**	
Variance	**0.003**	**0.001**	**80.3**	**499438**	
Standard Deviation	**0.06**	**0.04**	**9.0**	**707**	
Dates marked with (S) denote storm events					

Table 4.14 Constituent of Interest Data for Station TR-5 for All Sampling Events

TR-5 (East Branch of Wappinger Creek Tributary at Hibernia Road) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
11/3/2017	0.32	0.1	3	170	12
11/21/2017	N/A	N/A	N/A	N/A	N/A
3/6/2018	0.61	0.024	1.3	40	85
4/3/2018	0.43	0.010	2.7	150	58
5/1/2018	0.39	0.01	4.2	90	60
6/5/2018 (S)	0.28	0.054	2.4	690	32
7/24/2018 (S)	0.33	0.075	7.4	400	18
8/15/2018 (S)	0.27	0.07	10	250	68
9/27/2018 (S)	0.33	0.056	8.8	340	127
10/31/2018	0.43	0.034	1.7	48	45
11/28/2018 (S)	0.54	0.012	5.6	230	120
Mean	**0.39**	**0.04**	**4.7**	**241**	
Median	**0.36**	**0.04**	**3.6**	**200**	
Geometric Mean	**0.38**	**0.03**	**3.8**	**173**	
Variance	**0.01**	**0.001**	**9.6**	**38962**	
Standard Deviation	**0.11**	**0.03**	**3.1**	**197**	
Dates marked with (S) denote storm events					

Table 4.15 Constituent of Interest Data for Station TR-6 for All Sampling Events

TR-6 (Willow Brook Tributary at Point Turnpike) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
11/3/2017	0.21	0.1	2.3	20	5
11/21/2017	0.21	0.1	2.1	10	7
3/6/2018	0.65	0.023	1.5	10	37
4/3/2018	0.30	0.010	10	10	35
5/1/2018	0.22	0.051	2.6	30	22
6/5/2018 (S)	0.39	0.05	2.4	260	18
7/24/2018 (S)	0.33	0.047	16	470	9
8/15/2018 (S)	0.22	0.063	8	1100	17
9/27/2018 (S)	0.25	0.079	8	870	58
10/31/2018	0.47	0.035	1.6	19	21
11/28/2018 (S)	0.44	0.01	2.0	100	55
Mean	**0.34**	**0.05**	**5.1**	**264**	
Median	**0.30**	**0.05**	**2.4**	**30**	
Geometric Mean	**0.31**	**0.04**	**3.6**	**68**	
Variance	**0.02**	**0.001**	**22.5**	**150334**	
Standard Deviation	**0.14**	**0.03**	**4.7**	**388**	
Dates marked with (S) denote storm events					

Table 4.16 Constituent of Interest Data for Station TR-7 for All Sampling Events

TR-7 (Hunns Lake Creek Tributary at Route 82A) - Tributary Sample					
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**
11/3/2017	0.4	0.1	2.4	27	3
11/21/2017	0.54	0.1	12	30	4
3/6/2018	1.00	0.015	1.6	30	30
4/3/2018	0.85	0.010	7.1	50	29
5/1/2018	0.75	0.01	3.0	60	19
6/5/2018 (S)	0.65	0.023	2.9	240	15
7/24/2018 (S)	0.63	0.01	3.8	130	11
8/15/2018 (S)	0.50	0.045	6.4	110	19
9/27/2018 (S)	0.61	0.038	7.6	410	52
10/31/2018	0.69	0.01	1.7	31	19
11/28/2018 (S)	0.70	0.01	2.2	190	48
Mean	**0.67**	**0.03**	**4.6**	**119**	
Median	**0.65**	**0.02**	**3.0**	**60**	
Geometric Mean	**0.65**	**0.02**	**3.7**	**77**	
Variance	**0.03**	**0.001**	**10.7**	**14486**	
Standard Deviation	**0.17**	**0.03**	**3.3**	**120**	
Dates marked with (S) denote storm events					

Dissolved Oxygen

Oxygen is a necessary element for most forms of life and adequate dissolved oxygen (DO) is necessary for acceptable water quality. The NYSDEC State criteria for DO concentrations in surface waters in 5.0 mg/L or greater for a healthy and diverse aquatic system (NYSDEC, 1986). During all the monitored events the DO concentration values were above 5.0 mg/L for all subwatersheds.

pH

The optimal range of pH for most of the freshwater organisms is between 6.0 and 9.0. For all the sampling events across all subwatersheds, the pH levels were found be between 7.0 and 8.2 and is within the optimal range.

Fecal Coliform

Fecal coliform bacteria are used as an indicator of possible sewage contamination because they are commonly found in human and animal feces. The NYSDEC State Criteria for fecal coliform in surface waters is 200 colonies per 100 mL, based on a monthly geometric mean, from a minimum of five samples collected in a period of 30 days.

Geometrical mean levels of fecal coliform for the watershed varied from 77 to 186 CFU/100 mL for the overall sampling period (Figure 4.3), while the levels varied from 117 to 392 CFU/100 mL during the summer period of May 2018 to October 2018 (Figure 4.4). During the summer period, fecal coliform levels as high as >2,419 CFU/100 mL were observed at several sampling stations throughout the watershed.

In general, the overall high levels of fecal coliforms (>200 CFU/100 ml) through the watershed could possibly be attributed to improper agricultural activities (manure application, animal grazing closer to the streams), residential pet waste, and failing septic systems.

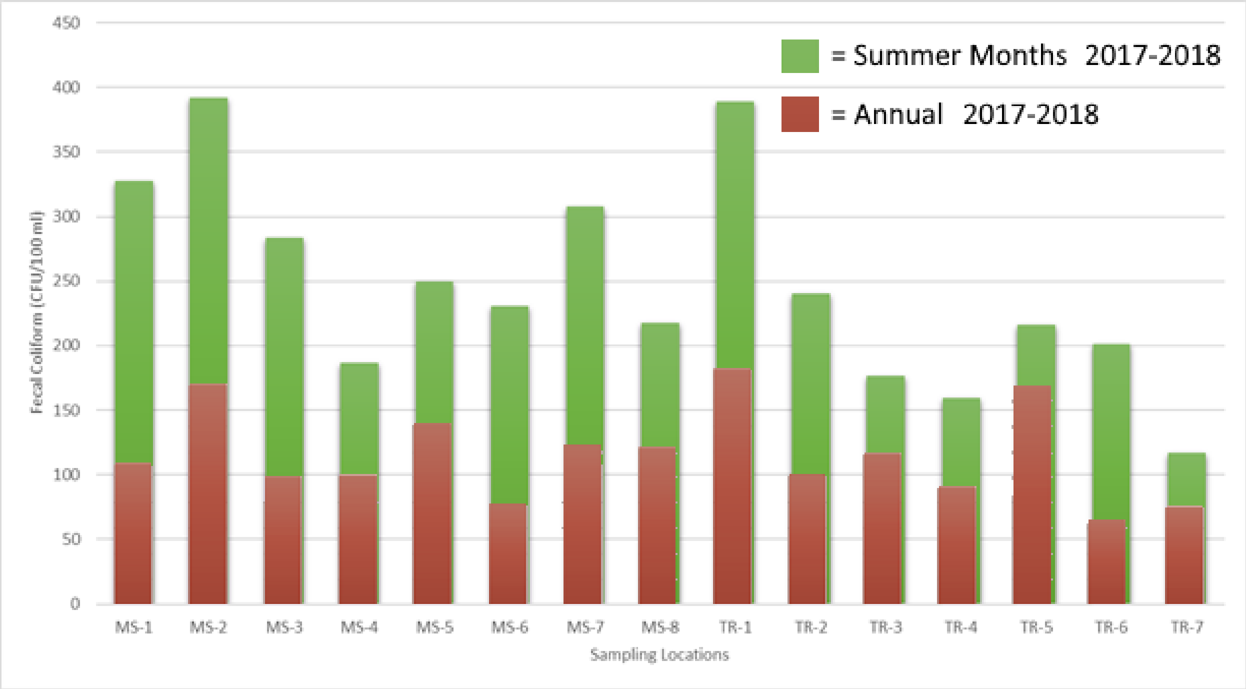

Figure 4.2 Geometric Mean Fecal Coliform Levels for Wappinger Creek Watershed (2017-2018, Summer Months: May-October)

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Nitrogen as Nitrate-Nitrite

Median concentrations of nitrate-nitrite for the watershed varied from 0.2 to 0.65 mg/L, the highest being observed for TR-7 (Hunns Lake Creek) (Figure 4.5). The observed concentrations were well below the NYSDEC State criteria for Nitrate-Nitrite concentrations for Class A surface waters of 10 mg/L.

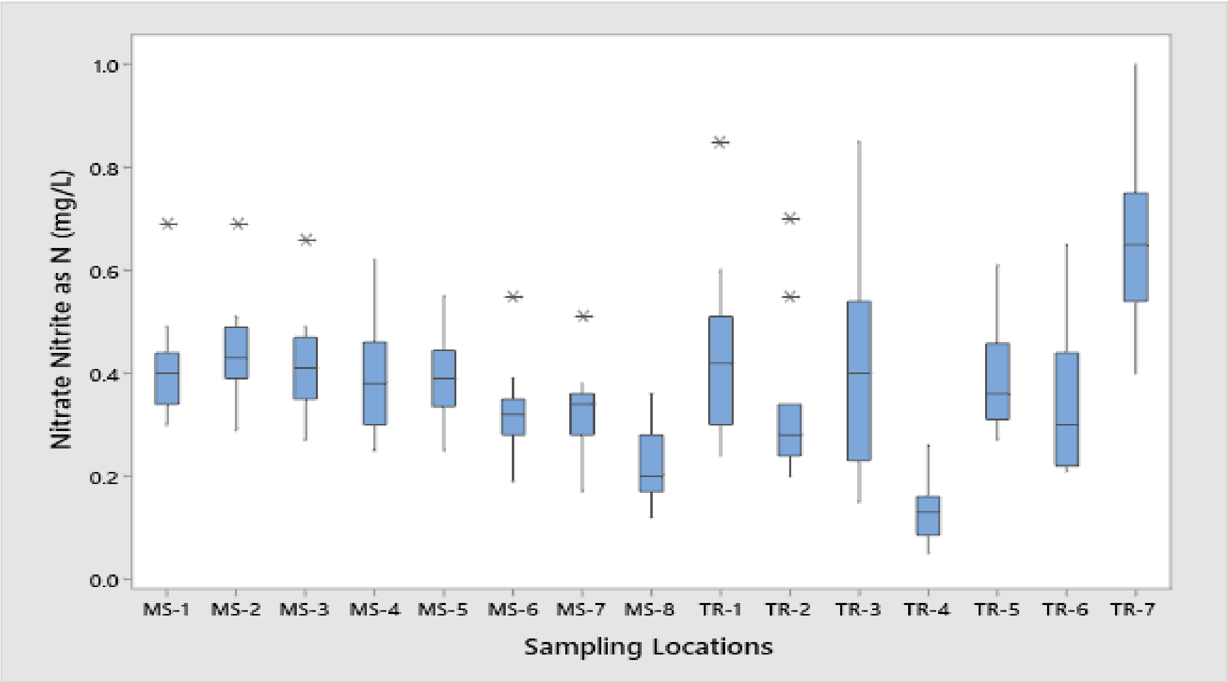

Figure 4.3 Nitrogen as Nitrate-Nitrite Concentration for Wappinger Creek Watershed (2017-2018)

Suspended Sediment

Median total suspended sediment (TSS) concentrations for the watershed varied from 2.4 mg/L to 5 mg/L (Figure 4.4). The intermittent stream limits that are applied to discharges from SPDES-permitted facilities typically include a suspended solids limit of 10 mg/L. The Wappinger Creek Direct Drainage subwatershed demonstrated the highest concentration of TSS to the Wappinger Creek. Other demonstrated areas of high TSS include Pleasant Valley East, Dutchess County Airport and East Branch Wappinger Creek.

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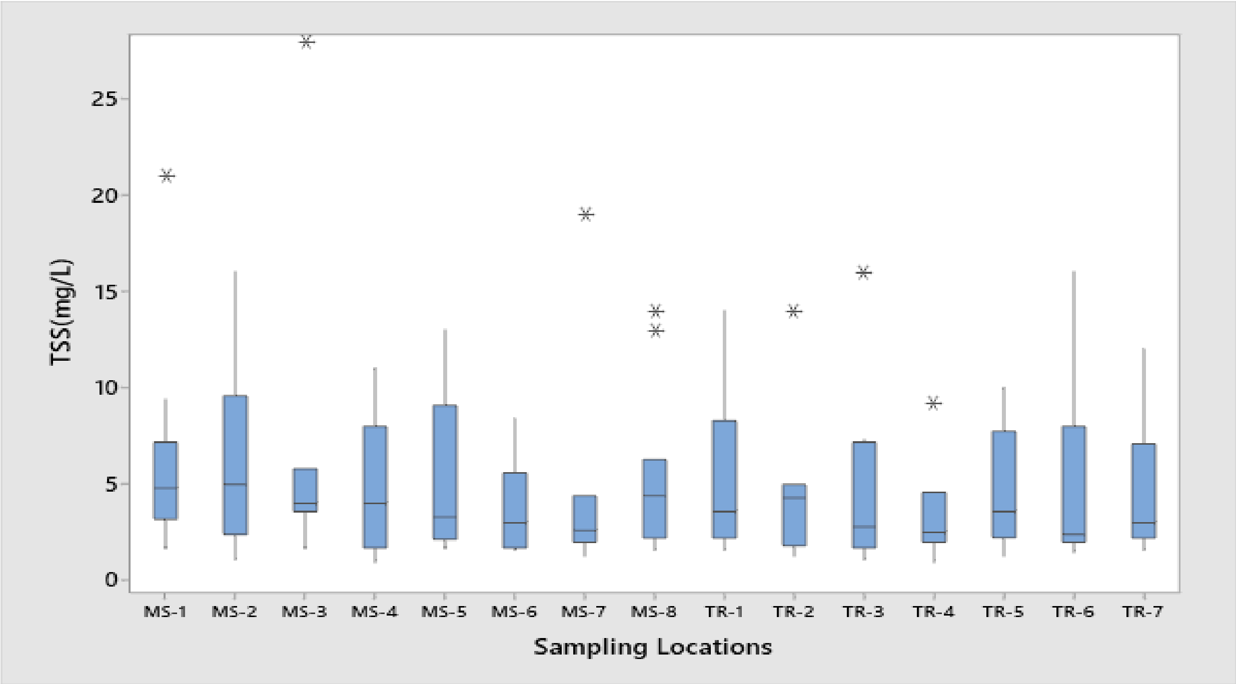

Figure 4.4 TSS Concentrations for Wappinger Creek Watershed (2017-2018)

Total Phosphorus

Phosphorus is often the nutrient limiting primary production (plant growth) in freshwater temperate lakes and ponds and is a primary food for aquatic plants, including algae. High phosphorus levels often contribute to algae blooms and can contribute to the overgrowth of rooted aquatic plants. As these algae and aquatic plants are decomposed by microorganisms, dissolved oxygen levels become depressed, creating conditions that are unsuitable for fish and other wildlife. Excess algae and aquatic plant growth also reduce the recreational and aesthetic value of a lake, and some forms of harmful algal blooms (cyanobacteria) can produce toxins. New York has narrative ambient water quality standards for phosphorus and nitrogen, promulgated in regulation in 6NYCRR 703.2. This standard sets forth limits for these two nutrients as "*None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.*" (NYCRR, 2018).

New York has an ambient water quality guidance value of 20 μg/L for phosphorus, established as a translation of the above-referenced narrative standard to protect recreational use that applies to Classes A, AA, A-S, AA-S, and B waters for which the letter "P" (ponds, lakes, and reservoirs) appears in the Water Index Number (NYSDEC, 2008). The observed median phosphorus concentrations were above the NYSDEC ambient recreation water quality

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guidance value for all the sampled sites except for TR-7 (Hunns Lake Creek) (Figure 4.5). Median phosphorus concentrations varied throughout the watershed, with the highest contribution from the Pleasant Valley East subwatershed, followed by Great Spring Creek, Dutchess County Airport, Direct Drainage to Wappinger Creek (headwaters and upstream of Wappinger Lake). All these subwatersheds have either a substantial amount of agricultural, developed lands or a combination of both, along with a high number of septic systems and 16 permitted wastewater discharge sites. The Wappinger Creek Direct Drainage and Great Spring Creek subwatersheds together account for 40% of the total farm animal count in the watershed (Appendix G: Summary of Farm Animals in Wappinger Creek Watershed).

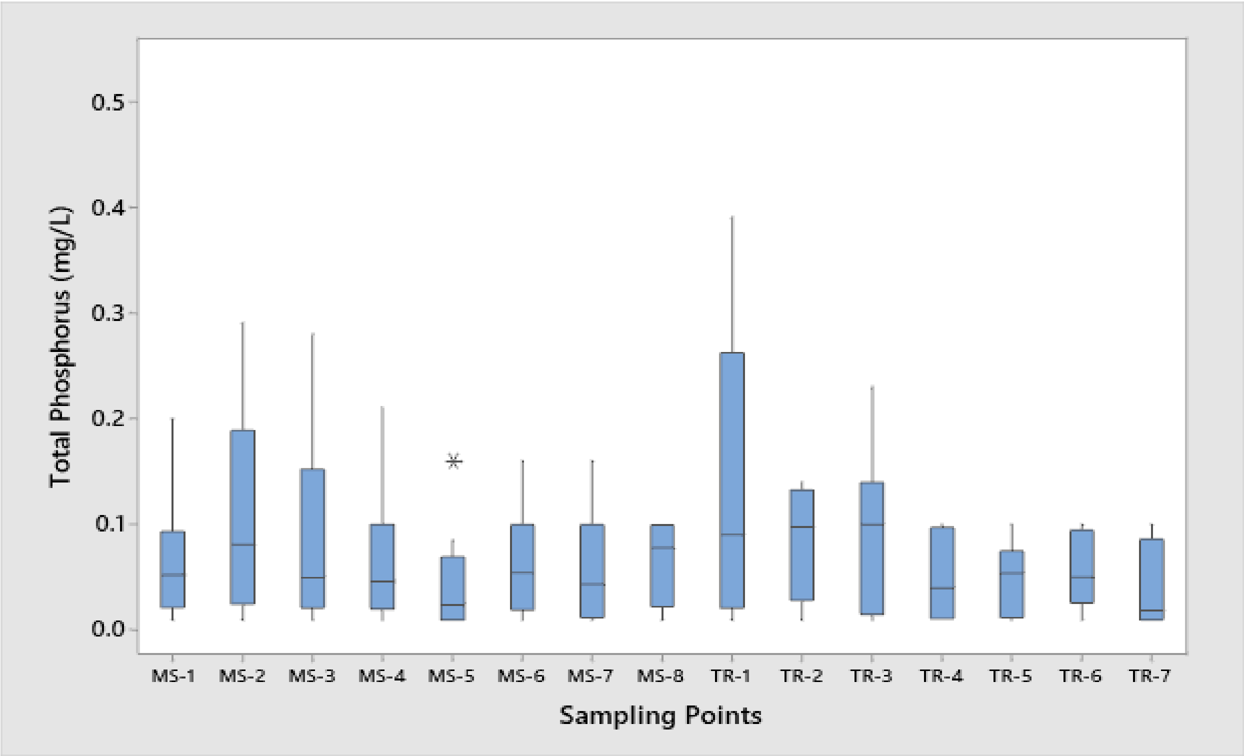

Figure 4.5 Box Plot for Total Phosphorus Concentration for Wappinger Creek Watershed (2017-2018)

4.3 Relationships between Water Quality Components

Correlation techniques are used to investigate linear relationships between two variables. Pearson correlations are one of the most common measures of correlation when examining many constituents. The strength of associations between two variables (stronger or weaker) is measured by Pearson's correlation coefficients. Values of Pearson's correlation coefficients range between –1 (negative correlation) and +1 (positive correlation). A value of 0 indicates no correlation. The linear relationships between variables were analyzed by drawing scatterplots to check for linearity. The strength of association between the variables was assessed by the distance of the scatter of points to a straight line; the nearer the scatter points are to the straight line, the higher the strength of association between variables. Parameters examined were discharge, nitrate-nitrite, total phosphorus, total suspended solids (TSS) and fecal coliform. Two sets of analysis were performed to investigate the relationships between the parameters of interest: 1) all sampling events and 2) wet weather sampling events.

Relationships between Water Quality Components for All Sampling Events

Positive correlations were observed between discharge and TSS for all the sampling sites except TR-2, TR-6 and TR-7. Correlation coefficients < 0.7 are considered not statistically significant. (Table 4.17; Figure 4.8). TSS showed moderate to very high positive correlations with fecal coliform for all the mainstream sites (correlation coefficients ranging from 0.35 to 0.99) indicating the sediment bound nature of fecal indicator bacteria (Table 4.17; Figure 4.8). Fecal coliform showed positive correlations with discharge although the correlations were not statistically significant (correlation coefficients < 0.7), while nitrate-nitrite did not show any positive correlations with other parameters of interest (Table 4.17; Figure 4.8). Total phosphorus showed statistically significant positive correlations with TSS for all the sampling sites except TR-6, indicating the affinity of association of phosphorus with particulates (Table 4.17; Figure 4.8).

Table 4.17 Pearson Correlation Matrix for Station MS-6 for All Sampling Events

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliform
Total P	-0.536			
TSS	-0.601	0.728		
Fecal Coliform	-0.583	0.722	0.986	
Discharge	-0.083	0.189	0.677	0.651

Relationships between Water Quality Components for Wet Weather Sampling Events

Pearson analysis was also conducted on the water quality parameters of interest to study the relationships under wet weather conditions. Positive correlations were observed between discharge and TSS for all the sampling sites except TR-1, TR-2 and TR-6, indicating some statistically significant correlations (correlation coefficients > 0.7) under wet weather conditions, which could be related to soil erosion in the watershed. TSS showed statistically significant positive correlations with total phosphorus and fecal coliform indicating a strong affinity of these components to sediment, thereby indicating the possibility of higher sediment associated load deliveries of these components into the streams during wet weather conditions. Nitrogen as Nitrate-Nitrite did not show any positive correlations with other parameters of interest under wet weather conditions (Table 4.18).

Table 4.18 indicates significantly very stronger relationships between Total P, TSS, and Fecal Coliforms for Station MS-4.

Table 4.18 Pearson Correlation Matrix for Station MS-4 for Wet Weather Sampling Events

	N as Nitrate-Nitrite	Total P	TSS	Fecal Coliforms
Total P	-0.949			
TSS	-0.894	0.985		
Fecal Coliforms	-0.920	0.958	0.968	
Discharge	-0.370	0.616	0.716	0.657

Results of the Pearson correlation analysis for all the sampling stations are presented in Appendix J.

4.4 Summary of Water Quality Sampling

Based on the sampling results, DO, pH and nitrate-nitrate levels were found to be well within the optimal ranges. The observed median total suspended sediment (TSS) concentrations for the watershed were found to be well under the intermittent stream limits that are applied to discharges from SPDES-permitted facilities (10 mg/L). Fecal coliform was observed at levels higher than the NYSDEC State Criteria for fecal coliform in surface waters during the summer months across the watershed. The observed median concentrations of phosphorus were above the NYSDEC ambient recreation water quality guidance value for all the sampled sites except the Hunns Lake Creek tributary site. Multivariate analyses indicated significantly strong relationships between TSS, total phosphorus and fecal coliform under wet weather conditions.

5.0 Watershed Pollutant Load Assessment

The MapShed watershed runoff model was used to assess the pollutant loading in the watershed originating from different contributing sources. MapShed incorporates an enhanced version of the Generalized Watershed Loading Function (GWLF-E) model developed by Haith and Shoemaker (1987) and the RUNQUAL model also developed by Haith (1993). The model simulates runoff and streamflow by a water balance method based on the daily precipitation and average temperatures. MapShed was developed to facilitate the use of GWLF-E and RUNQUAL models via a MapWindow interface (Evans, 2009).

5.1 Sources of Pollutant Loading in Wappinger Creek Watershed

MapShed was used to estimate mean annual pollutant loading into the Wappinger Creek Watershed for the period of 2009-2018. For the majority of the WWTPs (14 out of 16), phosphorus loading was estimated based on a discharge phosphorus concentration of 3mg/L. The estimated mean annual load of sediment and total phosphorus for the watershed from different sources are as shown in Tables 5.1 and 5.2 and Figures 5.1 and 5.2. Appendix D provides the additional model data along with the sources of these data for MapShed.

Table 5.1 Wappinger Creek Watershed Sediment Loading by Source

Source	Sediment (tons/yr)
Hay/Pasture	1,233
Cropland	957
Forest	453
Wetland	12
Disturbed	5
Low Density Mixed Use	237
Medium Density Mixed Use	168
High Density Mixed Use	48
Stream Banks	1,529

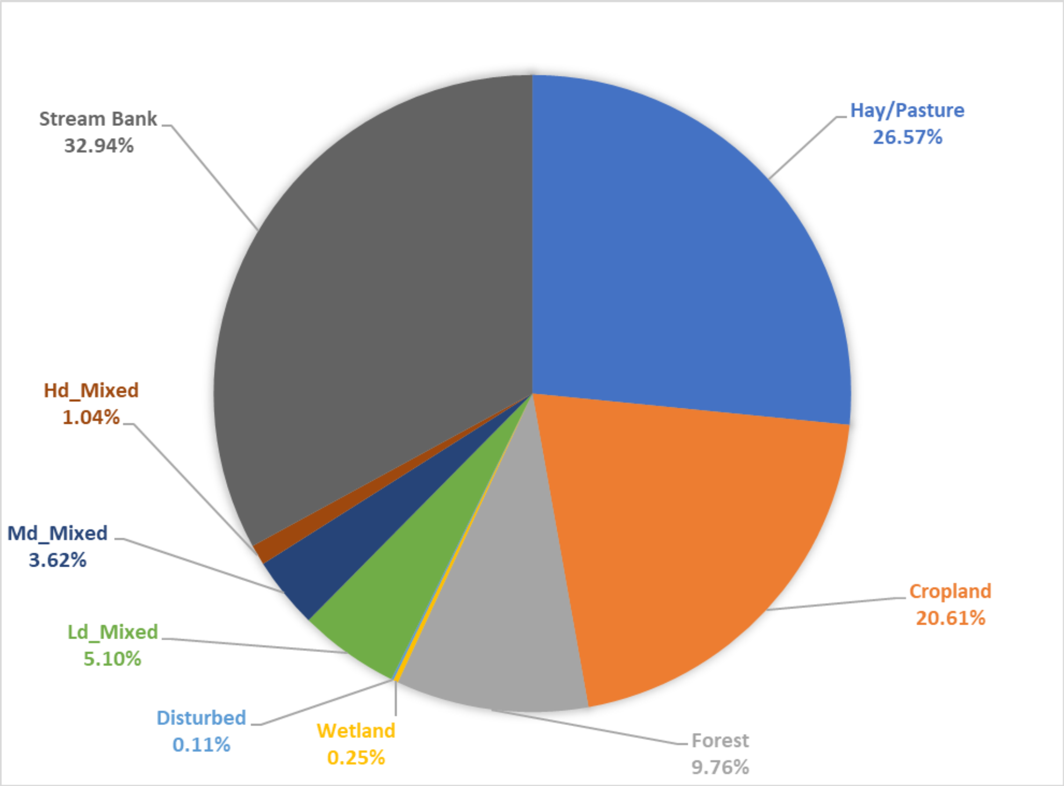

Figure 5.1 Wappinger Creek Watershed Sediment Load Distribution

Table 5.2 Wappinger Creek Watershed Phosphorus Loading by Source

Source	Total Phosphorus (lbs/yr)
Hay/Pasture	2,557
Cropland	1,531
Forest	618
Wetland	70
Disturbed	6
Low Density Mixed Use (Ld Mixed)	909
Medium Density Mixed Use (Md Mixed)	996
High Density Mixed Use (Hd Mixed)	285
Livestock (cattle, horses and sheep/goat)	8,172

Stream Banks	461
Groundwater	13,372
Point Sources	6,472
Septic Systems	2,975
Total	**38,423**

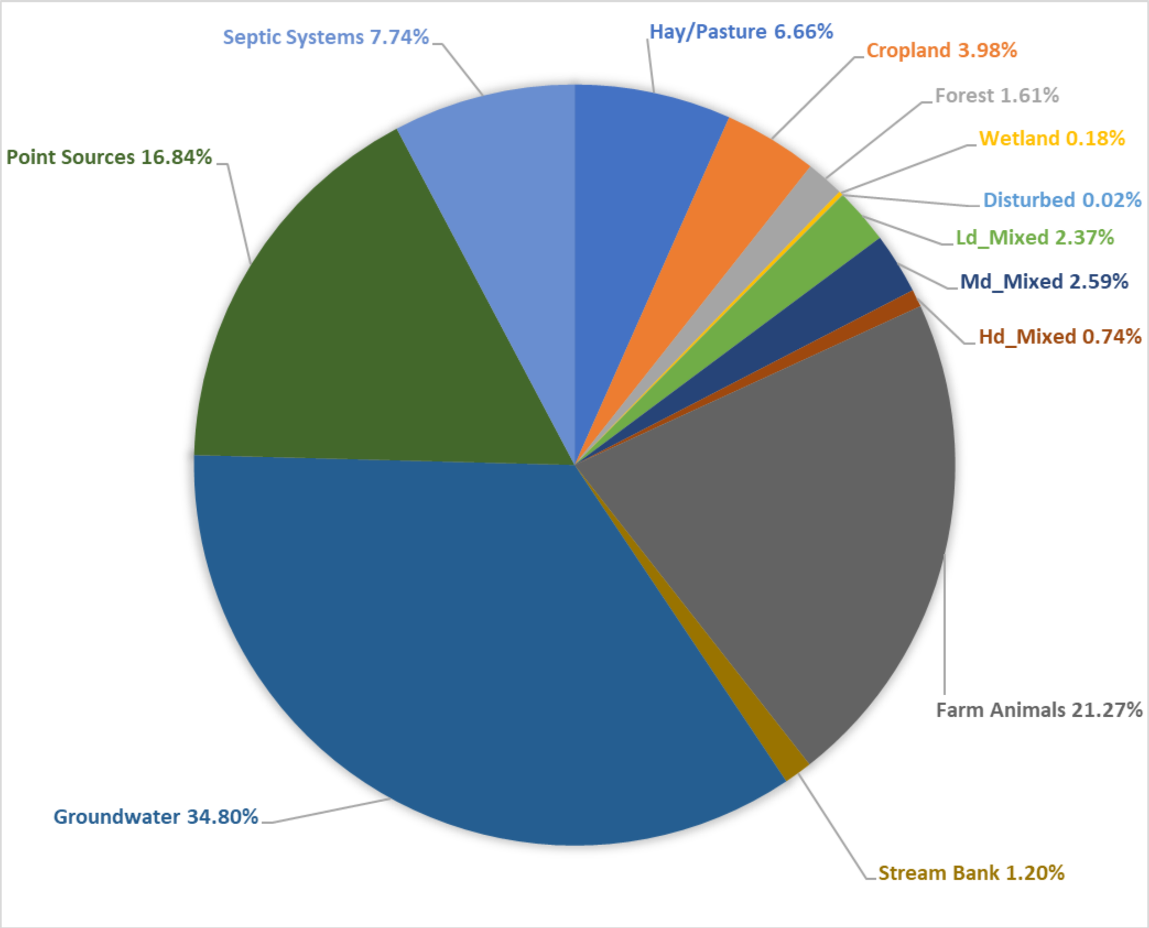

Figure 5.2 Wappinger Creek Watershed Phosphorus Load Distribution

Livestock and Other Agriculture

Livestock-related activities contribute 8,172 lbs/yr of phosphorus to the Wappinger Creek Watershed which is 21.27% of the total phosphorus loading (Table 5.1; Figure 5.2). Phosphorus produced by livestock can be transported to nearby waterbodies via three primary mechanisms: 1) runoff from barnyards, feedlots, chicken coops and similar confined areas, 2) runoff from crop and pasture land where livestock and poultry wastes have been applied for fertilizing and/or waste management purposes, and 3) losses that occur as a result of animal grazing which includes runoff from grazing land as well as direct deposits to streams where unimpeded access is available. The animal population estimates for the watershed are provided in Appendix G.

Non-livestock agricultural land encompasses 26,615 acres (19.69%) of the watershed and includes hay/pasture land (17.36%) and row crops (2.34%). Overland runoff from pasture/hay lands is estimated to contribute 2,557.2 lbs/yr of total phosphorus accounting for 6.66% of the total load (Table 5.1; Figure 5.2) and row cropland is estimated to contribute 1,530.8 lbs/yr of total phosphorus accounting for 3.98% of the total load in the Wappinger Creek Watershed (Table 5.1; Figure 5.2). Phosphorus loading from agricultural land originates primary from soil erosion and application of manure and fertilizers. In addition to the contribution of phosphorus from overland runoff, additional phosphorus originating from agricultural lands is leached in dissolved form from the surface and transported through subsurface movement via groundwater.

Point Source Facilities

There are 16 permitted wastewater treatment plant discharges within the Wappinger Creek Watershed. Estimated total phosphorus concentration data was obtained from Discharge Monitoring Reports (DMRs) for two of these facilities (Millbrook STP and Titusville WWTP). Titusville WWTP has a permit limit of 0.5 mg/L (monthly average) for phosphorus. Millbrook requires monitoring for phosphorus. For the remaining facilities with no phosphorus monitoring, NYSDEC recommended an assumed total phosphorus concentration of 3 mg/L to be used for modeling purposes (NYSDEC, 1986). Based on the assumed (3 mg/L) phosphorus concentrations for the unmonitored WWTPs and on DMR concentrations from monitored facilities, model-estimated total phosphorus loading from these point sources is 6472 lbs/yr, which is 16.84% of the total watershed loading. The flow and phosphorus concentration estimates for these facilities are provided in Appendix F.

Table 5.3 Estimated Phosphorus Loads from Point Sources

SPDES Facility	Total Phosphorus Load (lb/yr)- (Assumed 3 mg/L concentration)
Fleetwood Manor SD WWTP (NY0021601)	378
Midpoint Park - Royal Ridge (NY0035637)	763
Millbrook STP (NY0025429)	1,875
Noxon Knolls STP (NY0026085)	146
Poughkeepsie Corp Center (NY0218723)	24
Stratford Farms (NY0218944)	126
Titusville WWTP (NY0264989)	151
Valley Dale STP (NY0077593)	224
Wildwood SD (NY0037117)	798
Brookside Meadows (NY0268119)	380
Ennis Mobile Home Park (NY0218952)	310
Montclair Townhouses (NY0086550)	302
United Parcel Distribution Center (NY0149489)	5
Village Crest WW (NY1303232)	309
Woodhill Green Condos (NY0034240)	210
Titusville Corporate Park (NY0149420)	471
Totals	6,472

Residential On-site Septic Systems

Based on the model, residential on-site septic systems contribute an estimated 2,974.6 lbs/yr of phosphorus to the Wappinger Creek Watershed which is 7.74% of the total phosphorus loading (Table 5.1; Figure 5.2). Residential septic systems contribute dissolved phosphorus to the nearby waterbodies due to failures (Day, 2001). Septic systems treat human waste by digesting the organic matter and discharging the liquid waste into soil through a series of perforated pipes that comprise the leach field. Normally functioning systems contribute very little phosphorus loads to nearby waterbodies as phosphates are adsorbed and retained by the soil as the effluent moves through the soil to the shallow saturated zone (Day, 2001). In ponding septic systems, failure occurs when there is a discharge of waste to the soil surface. As a result, ponding systems can contribute high phosphorus loads to nearby waterbodies. Short-circuit systems (systems near the waterbodies) also contribute significant phosphorus loads to nearby waterbodies as there is limited opportunity for phosphorus adsorption to take place. Septic systems within 250 feet of the waterbodies are subject to potential short-circuiting (Day, 2001). Additional details about the population served by normal and failing septic systems within the watershed are provided in Appendix E.

Analysis of the orthoimagery of the watershed shows approximately 347 houses within 50 feet of the stream shorelines and 1,785 houses between 50 and 250 feet of the stream shorelines that rely on septic systems. Within 50 feet of the stream shorelines, 100% of the septic systems were categorized as short-circuiting. Between 50 and 250 feet, 10% of the septic systems were categorized as short-circuiting, and 5% were categorized as ponding systems, and 85% were categorized as normal systems (Evans, 2009, Haith and Shoemaker, 1987, and Haith, 1993). To convert the estimated number of septic systems to population served, an average household size of 2.57 people per dwelling was used based on the circa 2018 USCB census estimate for the number of persons per household in New York State. The estimated population in the Wappinger Creek Watershed served by normal and malfunctioning systems in summarized in Table 5.4.

Table 5.4 Estimated Population in the Watershed Served by Septic Systems

	Normally Functioning	Ponding	Short Circuiting	Total
Population	41,144	232	1,352	42,728

Urban and Residential Development Runoff

Developed land comprises 21,020 acres (15.55%) of the watershed. Stormwater runoff from developed land contributes 2189.8 lbs/yr of phosphorus to the Wappinger Creek Watershed which is 5.7% of the total phosphorus loading (Table 5.1; Figure 5.2). This load does not account for contributions from failing septic systems. In addition to the loading to the watershed from overland urban runoff, additional phosphorus originating from developed lands is leached in dissolved form from the surface and transported through subsurface movement via groundwater. Shoreline development can have a large phosphorus loading impact to nearby waterbodies in comparison to its relatively small percentage of the total land area in the watershed (Haith, 1993 and Haith and Shoemaker, 1987).

Forest Land Runoff

Forest land includes 68,289 acres (50.53%) of the watershed. Loading from forested land is estimated to contribute 618.3 lbs/yr of total phosphorus accounting for 1.6% of total load in the Wappinger Creek Watershed (Table 5.1; Figure 5.2).

Wetlands

Wetlands include 10,355 acres (7.66%) of the watershed. Loading from forested land is estimated to contribute 69.9 lbs/yr of total phosphorus accounting for 0.18% of total load in the Wappinger Creek Watershed (Table 5.1; Figure 5.2).

Groundwater Seepage

In addition to nonpoint sources of phosphorus delivered by surface runoff, a portion of phosphorus loading in the watershed from nonpoint sources seeps into the ground and is transported into waterbodies via groundwater. Groundwater is estimated to transport 13,371.95 lbs/yr which is 35.23% of the total phosphorus loading in the watershed (Table 5.1; Figure 5.2). With respect to groundwater, there is typically a small "background" concentration owing to various natural sources (Evans et al., 2002). In the Wappinger Creek Watershed, the model-estimated groundwater phosphorus concentration is 0.019 mg/L. The GWLF manual provides estimated background groundwater phosphorus concentration of 0.006 mg/L for >90% forested land in the eastern United States, or 32% of the groundwater load (4,279 lbs/yr). The remaining 68% of the groundwater load (9,093 lbs/yr) originates from developed and agricultural sources.

5.2 Pollutant Load Assessment by Subwatershed

The loads from different subwatersheds based on the MapShed-incorporated GWLF-E modeled loads are shown in Tables 5.5 through 5.7. Non-point loads derived from the modeled output were subdivided into loads based on different land cover categories and are used to calculate the loading from individual subwatersheds, whereas point source, septic systems and farm animal loads were subdivided based on the model generated output for these categories.

Table 5.5 Estimated Pollutant Loads by Subwatershed Based on Land Cover

Subwatershed	Sediment Load		Total N Load		Total P Load	
	Lbs/yr	Lb/acre	Lbs/yr	Lb/acre	Lbs/yr	Lb/acre
Direct Drainage to Wappinger Creek	1,757,206	50	17,213	0.488	2,141	0.061
Overlook Road	159,693	38	2,339	0.557	257	0.061
Dutchess County Airport	275,893	37	4,007	0.535	447	0.060
Wappingers Falls	160,627	30	3,149	0.583	320	0.059
Willow Brook	133,714	55	964	0.398	137	0.056
Great Spring Creek	478,140	48	3,883	0.391	516	0.052
East Branch Wappinger Creek	1,050,281	49	7,769	0.363	1,076	0.050
Upton Lake Creek	180,246	45	1,432	0.356	196	0.049
Hunns Lake Creek	208,699	43	1,518	0.310	215	0.044
Grist Mill Creek	133,022	36	993	0.269	135	0.036
Pleasant Valley East	236,947	32	1,918	0.260	254	0.034
Little Wappinger Creek	648,720	31	4,890	0.232	660	0.031
Cold Spring Creek	152,059	22	1,054	0.152	141	0.020

Table 5.6 Estimated Total Phosphorus Loads by Subwatershed From Point Sources, Septic Systems, and Farm Animals

Subwatershed	Total Phosphorus Load (Lbs/yr)			
	Point Sources	Septic Systems	Farm Animals	Streambanks
Direct Drainage to Wappinger Creek	1,927	879	1,974	111
East Branch Wappinger Creek	1,875	211	2,257	60
Dutchess County Airport	909	141	99	25
Little Wappinger Creek	0	306	1,002	78
Great Spring Creek	380	242	907	51
Pleasant Valley East	224	369	327	24
Wappingers Falls	680	83	16	15
Overlook Road	476	112	82	13
Willow Brook	0	42	505	10
Hunns Lake Creek	0	176	469	15
Upton Lake Creek	0	249	209	15
Grist Mill Creek	0	66	262	14
Cold Spring Creek	0	105	65	32

Table 5.7 Estimated Total Phosphorus Loads by Subwatershed From All Sources Excluding Groundwater

Subwatershed	Total Phosphorus Load (Lbs/yr) excluding groundwater
Cold Spring Creek	343
Direct Drainage to Wappinger Creek	7,032
Dutchess County Airport	1,621
East Branch Wappinger Creek	5,479
Great Spring Creek	2,096
Grist Mill Creek	477
Hunns Lake Creek	875
Little Wappinger Creek	2,047
Overlook Road	469
Pleasant Valley East	1,198
Upton Lake Creek	1,140
Wappingers Falls	1,114
Willow Brook	694

From the model-generated output, the following subwatersheds could be targeted as higher in priority in comparison to the others to implement water quality Best Management Practices for phosphorus load reduction based on load factors and individual source loads:

- Direct Drainage to Wappinger Creek
- Dutchess County Airport
- East Branch Wappinger Creek
- Great Spring Creek
- Little Wappinger Creek
- Overlook Road
- Pleasant Valley East

- Wappingers Falls
- Willow Brook

5.3 Summary of Watershed Pollutant Load Assessment

The model-generated average yearly phosphorus load from the watershed was found to be 38,423 pounds. Groundwater seepage was estimated to transport 35% of the total phosphorus load in the watershed followed by farm animals (21%), point sources (17%), non-livestock agriculture (11%), septic systems (8%), and developed lands (6%). The subwatersheds that are major contributors of phosphorus loading (excluding the groundwater load) in the watershed were found to be Direct Drainage to Wappinger Creek followed by East Branch Wappinger Creek, Great Spring Creek and Little Wappinger Creek.

6.0 Pollutant Load Reductions

Pollutant load reductions were estimated using the Generalized Watershed Loading Functions-Enhanced (GWLF-E) model. The model within this study focuses on reducing the non-point source load. For study purposes, the overall goal is an estimated 50% reduction in phosphorus loading, to be achieved at the rate of approximately 5% per year over the course of 10 years (or more), provided enough funds and community willingness.

Point-source pollutants are qualitatively discussed within this study. Site specific point-source reductions are not part of the model because the level of achievable reductions is facility-specific and would require NYSDEC analysis and determination along with the permittee. Some of the treatment works facilities may be able to achieve reductions with simple chemical addition, where other facilities could require SPDES Permit modifications and expensive capital improvement upgrades to achieve beneficial phosphorus reductions.

Non-point Source Pollution Reductions

Varying levels of agricultural best management practices (BMPs) and stormwater retrofit implementation across the watershed were modeled (Tables 6.1, 6.2). The estimated load reductions represent implementation of the management practices at the whole watershed level. It is not realistic for any one management practice to be implemented across the entire watershed, but a combination of several different management practices could be implemented in strategic locations across the watershed.

The pollutant load evaluation suggests that significant pollutant load reductions could be achieved by implementing the plan recommendations to address the water quality impairments in the Wappinger Creek watershed sufficiently to restore the recreation and habitat uses that have been lost due to degraded water quality. Significantly higher reductions (up to 50%) could potentially be achieved by retrofitting a much greater percentage of the watershed.

Table 6.1 Estimated Pollutant Load Reductions From Agricultural Sources

Management Practice	Sediment Reduction		Phosphorus Reduction		Nitrogen Reduction	
	Load (lbs/yr)	%	Load (lbs/yr)	%	Load (lbs/yr)	%
Cover Crops	203,800	2.20	232	0.60	712	0.08
Conservation Tillage	174,800	1.88	102	0.27	196	0.02
Strip Cropping	99,000	1.07	46	0.12	172	0.02
Conservation Plan	93,200	1.00	46	0.12	123	0.01
Nutrient Management - Row Crops (model estimated 50% of the locations)	0	0.00	375	0.99	17,689	2.07
Nutrient Management - Hay/Pasture (model estimated 60% of the locations)	0	0.00	1,123	2.96	2,645	0.31
Grazing Land Management (model estimated 90% of the locations)	552,600	5.95	436	1.15	3,020	0.35
Animal Waste Management System (model estimated 50% of the locations)	0	0.00	453	1.19	1,910	0.22
Animal Waste Management System (model estimated 75% of the locations)	0	0.00	905	2.39	3,820	0.45

Animal Waste Management System (model estimated 100% of the locations)	0	0.00	1,358	3.58	5,730	0.67
Vegetated Buffer Strips - Agricultural Streams (model estimated 25% of the locations)	160,800	1.73	399	1.05	2,882	0.34
Vegetated Buffer Strips - Agricultural Streams (model estimated 50% of the locations)	428,000	4.61	1,062	2.80	7,675	0.90
Vegetated Buffer Strips - Agricultural Streams (model estimated 75% of the locations)	696,200	7.50	1,727	4.55	12,483	1.46
Vegetated Buffer Strips - Agricultural Streams (model estimated 100% of the locations)	963,400	10.38	2,390	6.30	17,276	2.02
Fencing - Agricultural Streams (model estimated 25% of the locations)	54,200	0.58	162	0.43	485	0.06
Fencing - Agricultural Streams (model estimated 50% of the locations)	158,400	1.71	471	1.24	1,412	0.17
Fencing - Agricultural Streams (model estimated 75% of the locations)	263,000	2.83	781	2.06	2,341	0.27
Fencing - Agricultural Streams (model estimated 100% of the locations)	367,200	3.96	1,092	2.88	3,270	0.38
Bank Stabilization - Agricultural Streams (model estimated 25% of the locations)	130,600	1.41	20	0.05	66	0.01

Bank Stabilization - Agricultural Streams (model estimated 50% of the locations)	260,800	2.81	40	0.10	132	0.02
Bank Stabilization - Agricultural Streams (model estimated 75% of the locations)	391,400	4.22	60	0.16	196	0.02
Bank Stabilization - Agricultural Streams (model estimated 100% of the locations)	521,800	5.62	79	0.21	262	0.03

Table 6.2 Estimated Pollutant Load Reductions From Urban Sources

Management Practice	**Sediment Reduction**		**Phosphorus Reduction**		**Nitrogen Reduction**	
	Load (lbs/yr)	%	Load (lbs/yr)	%	Load (lbs/yr)	%
Vegetated Buffer Strips – Non-Agricultural Streams (model estimated 25% of the locations)	151,000	1.63	365	0.96	3,552	0.42
Vegetated Buffer Strips – Non-Agricultural Streams (model estimated 50% of the locations)	302,000	3.25	730	1.92	7,103	0.83
Vegetated Buffer Strips – Non-Agricultural Streams (model estimated 75% of the locations)	453,200	4.88	1,095	2.88	10,655	1.25
Vegetated Buffer Strips – Non-Agricultural Streams (model estimated 100% of the locations)	604,200	6.51	1,460	3.85	14,206	1.66

Bank Stabilization – Non-Agricultural Streams (model estimated 25% of the locations)	607,600	6.55	93	0.24	304	0.04
Bank Stabilization – Non-Agricultural Streams (model estimated 50% of the locations)	1,215,400	13.09	183	0.48	608	0.07
Bank Stabilization – Non-Agricultural Streams (model estimated 75% of the locations)	1,823,200	19.64	276	0.73	913	0.11
Bank Stabilization – Non-Agricultural Streams (model estimated 100% of the locations)	2,430,800	26.19	366	0.96	1,217	0.14
Constructed Wetlands, Wet Ponds (Treat 1% Developed Area)	17,600	0.19	14	0.04	81	0.01
Constructed Wetlands, Wet Ponds (Treat 5% Developed Area)	88,000	0.95	69	0.18	402	0.05
Constructed Wetlands, Wet Ponds (Treat 10% Developed Area)	176,800	1.90	138	0.36	803	0.09
Infiltration Practices, Impervious Disconnection Practices, Buffers (Treat 1% Developed Area)	18,000	0.19	18	0.05	135	0.02
Infiltration Practices, Impervious Disconnection Practices, Buffers (Treat 5% Developed Area)	90,200	0.97	86	0.23	668	0.08
Infiltration Practices, Impervious Disconnection Practices, Buffers (Treat 10% Developed Area)	181,400	1.95	171	0.45	1,336	0.16
Street Sweeping – Vacuum (Treat 5% Developed Area)	2,000	0.02	5	0.01	54	0.01

7.0 General Recommendations for Watershed Health

This section provides the recommendation for improving and protecting water quality in the Wappinger Creek Watershed. The continued health and effective management of the Wappinger Creek Watershed can be achieved through the careful implementation of the general strategies, recommendations, and best management practices as identified in the following sections. Each community and subwatershed within the overall Wappinger Creek Watershed are unique and has its own set of factors that influence water quality and opportunities for effectively addressing those factors. The strategies and best management practices identified herein are not appropriate in every location of the watershed but provide an overarching framework of actions that should be undertaken to improve and maintain good water quality.

The Wappinger Creek Watershed management recommendations were built around the framework provided by the comprehensive vision and goals of the Watershed Advisory Committee. Therefore, they follow the main categories of agriculture, development, natural resources, education and outreach, and interjurisdictional coordination.

Partnerships, Collaboration and Education/Outreach

The success of a watershed plan will depend on effective leadership, active participation by the watershed stakeholders, and local buy-in of the plan recommendations by the watershed municipalities, in addition to funding and technical assistance. Within the 132,000-acre Wappinger Creek Watershed are 11 towns, 2 villages, and 1 county. In addition to these government units, the watershed is also home to approximately 65,000 people. Given the diverse nature of different subwatersheds, any efforts designed to improve water quality in the watershed will require the cooperation between its many stakeholders. Improving watershed water quality will not be possible without such collaboration.

An important component of building partnerships in the Wappinger Creek Watershed is that of Watershed education. By educating stakeholders on general functions and issues in the watershed, support can be built for various initiatives designed to improve water quality in the basin. Education can also help in development of decision-making tools to modify existing policies, regulations that are detrimental to water quality and to develop new policies and regulations for long-term watershed health.

Goals

The following goals have been identified for the Partnerships, Collaboration and Education category:

- Build a foundation for successful implementation of the watershed management plan by the watershed municipalities, non-governmental organizations (environmental groups and non-profits), residents, local businesses, and other stakeholders.
- Network with regional jurisdictions to address common goals of water quality protection and environmental stewardship.
- Promote stewardship of the watershed through education and outreach, improved access to the Wappinger Creek and its tributaries, and citizen involvement in science, conservation, and restoration activities.

Strategies & Recommendations

To maintain and improve water quality in the Wappinger Creek Watershed, a collective effort by all the stakeholders is required. Many of the watershed issues cross jurisdictional boundaries and often require a multi-disciplinary approach to implement effective solutions. This partnerships, collaboration and education are crucial for effective watershed management.

Partnerships and Collaboration Recommendations

1. Promote the networking of stakeholders by providing an avenue for participants through Watershed Intermunicipal Council (WIC) meetings to input, share and compare information gathered on the watershed to increase environmental knowledge, stewardship and community service in the watershed.
2. The Watershed Intermunicipal Council should direct resources to the highest priority projects through the Wappinger Creek Watershed. The WIC should also work to identify funding sources and opportunities, including in-kind services, for cost sharing of watershed management implementation between municipalities.
3. Secure funding for and hire a long-term Watershed Coordinator. Potential funding source could include an intermunicipal agreement and voluntary "dues" contributed by each watershed municipality. The Watershed Coordinator would be responsible for: Identifying funding sources, as well as pursuing grant funding for projects identified in the watershed plan, periodically reviewing and updating action items in the plan, developing annual work plans (i.e., specific "to-do" lists), coordinating and leading

public outreach activities, hosting public meetings to celebrate accomplishments, recognize participants, review lessons learned, and solicit feedback on plan updates and next steps.

4. Identify opportunities for sharing the cost burden of watershed management implementation between municipalities.
5. Develop an information and data clearinghouse that provides access to watershed-specific resources, information on BMPs, funding sources, etc.
6. Establish an Implementation Committee to oversee and promote implementation progress of Management Strategies.
7. Form watershed plan implementation sub-committees around the watershed plan goals – water quality, habitat restoration, land use/open space, and education/outreach. The sub-committees would ideally consist of volunteers with a particular interest or area of expertise in each topic.
8. Organize a periodic meeting series with representatives from other watershed groups and agencies within New York such as Hudson River Watershed Alliance's round tables, to share information on ongoing activities, new advances in science and technology, and discuss lessons learned.
9. Share outreach materials with other watershed managers and participate in coordinated events to gain experience in other methods and approaches.

Education/Outreach Recommendations

1. Develop a watershed education program that provides specific areas of focus for various watershed stakeholders. The efforts should focus on addressing sources of sediment and nutrients and other nonpoint source pollution in the watershed and providing solutions that citizens can apply to reduce the pollutant loading. Target groups should include but not limited to watershed residents, pet owners, farmers, businesses, municipal staff and land use boards and schools.
2. Develop and/or offer workshops for elected and appointed officials on erosion control, stormwater management, agricultural BMPs, proper streambank and shoreline management, floodplain management, any other watershed-specific issues of interest.

3. Launch an outreach campaign, which should target, at a minimum, watershed residents, businesses, and municipalities, including incentive programs for residential "green" practices.
4. Expand existing relationships and educational programs with schools. Consider implementing a watershed-based component to the curriculum in school districts where such programs are not already in place.
5. Continue to recruit student volunteers to participate in water quality and benthic monitoring and stream walks.

Planning and Land Use

Municipal land use plans and regulations help shape the development patterns within a watershed and can play a significant role in protecting water quality and other natural resources at the watershed scale. These commonly include municipal plans of conservation and development, zoning regulations, subdivision regulations, inland wetland and watercourses regulations, and stormwater regulations, all of which influence the type and density of development that can occur within a watershed. Local land use regulations often vary by municipality within a watershed, and regulations are periodically revised in response to development pressure, shifts in attitude toward natural resource protection, and political and socioeconomic factors.

As the primary responsibility for ensuring the protection of water quality supplies and other important water resources falls on local municipalities, the strategies and recommendations provided in this section address how communities throughout the Wappinger Creek Watershed can incorporate water quality objectives into their local planning and land use projects.

Goals

The following goals have been identified for Planning and Land Use category:

- Align local planning and land use practices to minimize the water quality impacts of existing and future developments in the Wappinger Creek Watershed.
- Incorporate BMPs for improved water quality into local land use ordinances and decision making.
- Promote sustainable growth and appropriate development in the watershed while preserving and improving the watershed's natural resources.

Strategies & Recommendations

1. Add language to the Purpose and Objectives section of local zoning ordinances to address environmental objectives, especially concerning the restoration and protection of surface and groundwater resources.
2. Municipalities should amend their zoning ordinances to include a detailed list of those design elements that should be included as part of an acceptable plan submittal. In addition to standard elements, design elements addressing the proposed development's impact on water resources and quality (e.g., stormwater management plans, soil erosion/sediment control plans, impervious surfaces coverage) should also be included.
3. Watershed municipalities should provide training to plan review staff on local, state and federal stormwater and other environmental regulatory requirements.
4. Where not currently permitted, watershed municipalities should amend the zoning ordinance to allow cluster development and Planned Unit Developments. Cluster developments and planned unit developments should be designed to support environmental objectives such as natural area preservation and stormwater absorption.
5. Watershed municipalities should adopt green infrastructure and LID stormwater requirements, including runoff reduction standards, particularly for new development and redevelopment of sites with large amounts of existing or proposed impervious surfaces. Protocols and recommendations should be developed for green infrastructure practices such as rain gardens, green roofs, pervious pavement, bio-retention, rain barrels/cisterns, downspout diversions, and urban tree canopy expansion.
6. Work with local landowners to increase the amount of naturally vegetated riparian areas throughout the watershed.
7. Work with local landowners and watershed municipalities to develop a program for acquiring conservation easements on environmentally important lands such as Special Areas.

8. Consider incentives to promote the use of LID for private development such as increased development densities, reduced review time or expedited review, reduced application fees, and reduced property taxes.
9. Develop an illicit discharge ordinance that prohibits improper water discharges to the regulated municipal storm drainage systems (MS4s).
10. Encourage the use of pervious paving materials to the maximum extent practicable and minimize impervious surfaces in recreation and open space areas.
11. Within subdivisions, design open areas to serve as filters, buffers, swales, wet and dry ponds, and detention and retention areas.
12. Within public open areas such as parks and playgrounds, design for filtering polluted runoff from adjacent impervious areas.
13. Encourage infill development and development of brownfield sites (contaminated sites) and greyfield sites (underutilized or abandoned sites) through such tools as density bonuses, tax incentives, and streamlined permitting. Consider allowing offsite treatment of stormwater and wastewater at brownfield and greyfield sites to reduce overall development costs.
14. Maintain comprehensive on-line mapping of critical water resources including, but not limited to, watercourses, wetlands, and flood hazard zones. Promote preservation and restoration of wetlands and watercourses in municipal plans and policies.
15. Adopt local riparian buffer regulations, with the goal of establishing a contiguous vegetated riparian area on either side of the Wappinger Creek and its tributaries.
16. Establish maximum disturbance and include vegetation replacement and mitigation for various activities. Limit the area of vegetation that can be disturbed for various regulated activities.

Agricultural Practices and Management

Along with the historic, economic, and cultural place that farming occupies in the Wappinger Creek watershed, agricultural land also maintains a strong physical presence. With more than 26,000 acres of land under agricultural production in the Wappinger Creek Watershed, agricultural land use practices are a significant contributor to nutrient and sediment loadings in the watershed. Additionally, agricultural uses in the watershed are directly related to livestock and its associated products. Typical agricultural practices that negatively impact watershed quality include:

- Nutrient and sediment inputs from agricultural runoff.
- Direct access of livestock to streams, resulting in bank erosion and vegetative buffer destruction.
- Excessive manure application and manure application during the wrong time of the year.

Goals

The following goals have been identified for the Agricultural Practices and Management category:

- Promote the recognition of the value of farming, awareness of best management practices, preservation of farmland and financial resources necessary for their implementation.
- Minimize the negative impacts that some agricultural practices have on water quality, particularly the movement of sediments and nutrients from agricultural lands to surface waters.

Strategies & Recommendations

The strategies and recommendations to reduce negative impacts from agricultural practices on water quality are grouped into three categories

- Agricultural Environmental and Waste Management Plans
- Educational Materials for Agricultural Operations
- Best Management Practices

Agricultural Environmental and Waste Management Plans

1. New York State Soil and Water Conservation Committee has been promoting the Agricultural Environmental Management (AEM) program as an essential watershed management tool to reduce pollutant inputs. Continue to use and promote the AEM program as an initial review tool for which additional needs can be determined.

2. Promote local, state and federal agriculturally based cost-share and incentive programs, including but not limited to nutrient management plans and environmental quality incentive programs. These programs provide opportunities for implementing BMPs for improving water quality and wildlife habitat.
3. Develop up-to-date nutrient management plans for agricultural livestock operations of all sizes. Measures may include waste storage facilities, fencing along streams to restrict livestock access, establishment of streamside buffers to trap sediment and waste runoff, installation of stock watering systems which are located away from wetlands and waterbodies, and pasture management.
4. Target lands within high priority subwatersheds for preservation through easement programs to preserve productive agriculture and environmentally sensitive land.

Educational Materials for Agricultural Operations

1. Providing educational materials for agricultural operations that enhance the producer's understanding of the relationship between their practices and farm management plan and water quality. Information would describe practices that could be implemented to improve control of stormwater runoff, protection of watercourses, pasture management, and waste management. Education material could include flyers, brochures, booklets and workshops.
2. Ensure the availability of technical and financial resources information to facilitate efforts on the part of the producer to implement conservation practices on their land.

Best Management Practices

Many of the watershed's farmers are working with or have worked with County Soil & Water Conservation Districts to implement conservation practices on their farms in order to minimize the potential impacts on water quality in the watershed. These practices include but not limited to

- Cover Crops
- Conservation Tillage
- Contour Farming
- Nutrient Management

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- Conservation Planning
- Grazing Land Management
- Fence and Access Roads
- Riparian Buffers

An extensive list of BMPs is presented in Section 9 of this report.

Development and Stormwater Management

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Wappinger Creek Watershed. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. Development often results in a significant change to the natural conditions (NYSDEC, https://www.dec.ny.gov/chemical/69422.html), resulting in increased rates and volumes of runoff, and associated pollutants from roads, parking areas, roofs, lawns and other developed surfaces.

Goals

The following goals have been identified for Development category:

- Utilize sustainable development and implementation approaches to manage impervious surfaces and protect water quality
- Reduce loading of sediment, nutrients and bacteria into the creeks and lakes from stormwater runoff

Strategies & Recommendations

1. Develop a model stormwater ordinance in consistence with New York State Stormwater Management Design Manual and Specifications for Erosion and Sediment Control, that municipalities in the watershed can modify and adopt.
2. Develop protocols and recommendations for green infrastructure practices such as rain gardens, down spout disconnects, permeable pavement, infiltration planters, rain barrels and cisterns, trees and tree boxes, and urban tree canopy expansion. This should also include pursuing funding for implementation of retrofit and development projects. Simultaneously, pursue partnerships with businesses and homeowner associations to implement site specific green infrastructure concepts

for privately owned sites. An extensive list of BMPs is presented in section 9 of this report.

3. Educate residential and property owners about impacts of fertilizer and pesticide/herbicide use in the watershed.
4. Work with NYSDOT and local highway departments to establish guidelines for minimizing erosion from existing roadways and construction of new roadways. Protocols could include requiring that roadside ditches remain vegetated, steep roadside ditches are rock-lines, and check-dams are installed in roadside ditches.
5. Evaluate and identify stormwater management projects on public properties. Typically, signage can be provided at sites to describe project benefits.

Wastewater Management

The two predominant methods for wastewater management in the watershed include municipal treatment facilities and on-site treatment facilities (septic systems). Most of the northern and central portions of the Wappinger Creek Watershed rely on on-site treatment systems. Although on-site systems are cost-effective, failure of these systems potentially contributes to pollutant loading. Many factors will directly influence the degree to which a failing system may add to pollutant loading: proximity to a waterbody, type of soils, and the degree to which the system is failing.

There are 16 permitted municipal wastewater treatment systems in the Wappinger Creek Watershed. 7 of these facilities discharge, directly into Wappinger Creek, 7 discharge to tributaries to Wappinger Creek, 1 discharges to Great Spring Creek, and 1 discharges to East Branch Wappinger Creek. On average, these facilities discharge a total of approximately 1 million gallons of treated wastewater into the watershed each day.

Goals

The following goals have been identified for Wastewater Management category:

- Reduce nutrient and bacteria loads into surface waters.

Strategies & Recommendations

1. Strengthen local regulations to require regular septic system inspection and maintenance and upgrades to sub-standard systems, such as requiring systems to pass an inspection. Regulations should also include minimum distance to

waterbody requirements, regularly scheduled maintenance, and provisions to allow alternative wastewater disposal methods.

2. Encourage regular maintenance of septic systems by providing homeowners with educational materials on how to identify improperly functioning systems and procedures to have systems inspected, cleaned, and repaired or upgraded.
3. Encourage the use of alternative/innovative treatment systems such as cluster/community-based septic systems, constructed wetlands, or composting toilets where lot sized do not meet minimum on-site septic system requirements.
4. Where density allows, increase the number of residences served by the existing municipal treatment systems.

Stream Walk Assessments

Visual stream assessments are a simplified assessment protocol to evaluate the condition of aquatic ecosystems associated with streams. They help to evaluate the overall condition of the stream, riparian buffer, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation and habitat and floodplain encroachment. Stream walks provide an idea opportunity to involve public and volunteers as a form of outreach.

Goals

The following goals have been identified for Stream Walk Assessments category:

- Identify problem areas and provide a basis for further detailed field investigation and potential stream restoration opportunities.

Strategies & Recommendations

1. Conduct Stream Walk assessment surveys in the watershed using state and federal (NRCS New York) protocols and field data collection sheets; compile and analyze the collected data. Following the assessments, plan and conduct subwatershed visual “track down” surveys of identify pollution sources and conditions responsible for water quality impairments in streams. Develop and implement a plan to address the identified sources of concern.
2. Update Stream Walk assessments and track down surveys every five to ten years to monitor changing watershed conditions and the progress of plan implementation.

Engineering and Land Surveying, P.C.

Forests and Wetlands

The Wappinger Creek watershed comprises a substantial amount of forest (50% of total area) and wetlands (7.7 % of total area). Forest and wetland cover represent the best uses in terms of water quality in a watershed as they support runoff reduction, water storage, groundwater recharge, pollutant reduction and habitat. Lands devoted to forestry industry are usually owned and managed by logging farms, sawmills, wood energy industry, and some private individuals. Responsibly managed working forests encompass treed lands that provide many benefits to communities, including sustainable supply of wood products, wildlife habitat, as well as clean water and air.

Wetlands improve water quality supplied to downstream environments in several ways. By spreading out and slowing down flows they reduce erosion and prevent sediment being transported downstream where it might affect the ecology and productivity of other environments. When healthy, wetlands have a rich natural diversity of plants and wetlands. These can act as filtering systems, removing sediment, nutrients and pathogens from water.

Goals

The following goals have been identified for Forest and Wetlands category:

- Protect and restore forest and wetland resources.
- Minimize the negative impacts that some forestry practices can have on water quality

Strategies & Recommendations

- Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation, for managed forests. Water quality principles include the development of forest management plans, low impact riparian buffers, stream crossings that minimize erosion, properly located haul roads, skid trails and log landings, and steep slope practices.
- Encourage the use of conservation easements on working forest lands.
- Research grant funding to assist woodland owners to develop Forest Management Plans to effectively manage their forestland for water quality and habitat benefits.
- Promote and implement wetlands restoration/ enhancement projects.

- Seek conservation easements for current and potential future wetlands of concern that are not in public ownership. Information of wetland conservation can be found at the following page. https://www.dec.ny.gov/lands/5133.html.

Floodplain Management

Although water quality is the primary focus of Wappinger Creek Watershed management, usually water quality issues and quantity (flooding) issues are closely related in terms of watershed resource management. Implementation of floodplain management programs provide corrective and preventive measures for reducing flood damage. While these programs may take a variety of forms, typical measures include requirements from zoning, subdivision or building permits, and special-purpose floodplain or stream buffer ordinances. By adopting and enforcing these measures, communities make federally subsidized insurance available to local property owners.

Goals

The following goals have been identified for Floodplain Management category:

- Implement an integrated, watershed-based approach to addressing flooding, water quality, and habitat restoration.
- Plan and restore riverine corridors (insurance claims, adaptation-avoidance by elevating structures, discouraging future development activities within flood prone areas, and floodplain easements), while reducing damage to private property and public infrastructure from flooding.

Strategies & Recommendations

1. The watershed communities should adopt a policy of no-net-loss of flood storage capacity or flood conveyance within the Wappinger Creek watershed.
2. Municipalities should adopt or update their floodplain ordinance by adopting the most current NYSDEC Model Law for Flood Damage Reduction.
3. Encourage flood proofing of structures in areas prone to repetitive floods. Identify and seek pre-disaster mitigation funding and other sources of funding available at the state and federal level to implement flood proofing measures within each municipality.

4. Delineate Base Flood Elevations (BFEs) at the parcel level, as designated by FEMA, on official City/Town/Village maps and publish them on City/Town/Village webpages so that they can be used by residents and potential developers.
5. Ensure that flood mitigation projects and designs include provisions for water quality and riparian/aquatic habitat restoration. Provide or maintain vegetated buffers around all watercourses and wetlands where feasible.
6. Emphasize infiltration using green infrastructure techniques, which provides water quality and other benefits in addition to reducing water volumes and decreasing peak flows to mitigate flooding.
7. Provide training to local floodplain administrators and code enforcement officers to increase the capability of local municipalities to effectively manage floodplains and reduce the impacts associated with floodplain management and so that they can adequately enforce their floodplain laws and educate planners and local officials about them.
8. Ensure that all new construction and substantial improvements meet the NFIP floodplain requirements.

Habitat Protection and Restoration

Habitat Protection and Restoration is essential for the function and maintenance of overall social and environmental sustainability of watersheds. Forest cover, including natural forest soils with irregular topography, provides numerous benefits at both the site and watershed scales. In addition to providing habitat for terrestrial and aquatic wildlife, watershed forest cover also reduces stormwater runoff and flooding, improves regional air quality, reduces stream and channel erosion, improves soil and water quality, and reduces summer air and water temperatures (USDA Forest Service, 2005).

Goals

The following goals have been identified for Habitat Protection and Restoration category:

- Protect and improve terrestrial, riparian, and aquatic habitat in the watershed to maintain and increase the watershed's diversity of plant and animal species.

Strategies & Recommendations

1. Protect and Restore In-Stream and Riparian Habitat: Implement priority stream restoration projects identified during stream walks and track down surveys. Address areas of streambank erosion using appropriate bioengineering and habitat-sensitive measures. Research options for and encourage the use of riparian buffers on streams and wetlands within new and existing conservation easement. Implement stream daylighting projects for priority culverted segments in the watershed.
2. Protect and Restore Forested Areas, Wetlands and Tree Canopy: Protect existing forests through land acquisition and conservation easements. Amend site development regulations and zoning to encourage tree retention and maintenance, restrict tree removal, and require landscaping and parking lot shading. Encourage reforestation of private land by developing education, stewardship and incentive programs. Consider developing a tree ordinance, especially for canopy protection along the river corridor. Research grant funding to assist woodland owners to develop Forest Management Plans to effectively manage their forestland for water quality and habitat benefits. Promote and implement wetlands restoration/ enhancement projects
3. Protect Sensitive Species Habitat: Restore or enhance trout supportive streams and their buffers by planting riparian buffers. Restore and enhance sensitive species habitat on private land (such as Blanding turtle habitat). Improve connectivity of the instream habitats to enhance trout spawning migrations and movement of cold-water species into thermal refuges during the warmer months of the year, by placing a priority placed on the identification and replacement of all hanging culverts and the breaching and/or removal of all dams that no longer serve any useful purpose.
4. Manage Invasive Plant Species: Implement priority invasive species management projects identified during stream walks and watershed field inventories. Develop an invasive species management plan for targeted and accessible areas of the watershed, including prevention and education efforts to preempt arrivals, early detection and citizen monitoring efforts, rapid response measures for successful eradication, and when a species cannot be eradicated, continued control efforts that are necessary to minimize ecological and economic impacts. Involve

volunteers and neighborhood groups in invasive species removal and stream corridor improvements.

Protection and Preservation of Open Spaces

Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious coverage, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space is also important as habitat for native and migratory species and protection of public water supply. Open space includes preserved natural areas as well as lightly developed parks and playgrounds. Approximately 1500 acres of the Wappinger Creek Watershed consists of open space including municipally owned parks, cemeteries, golf courses, and schools.

Goals

The following goals have been identified for Protection and Preservation of Open Spaces category:

- Manage, maintain, and promote existing open space and continue to protect and acquire open space that meets resource protection and recreational goals in concert with development and redevelopment efforts within the watershed.

Strategies & Recommendations

1. The watershed municipalities should develop or update existing municipal open space conservation plans.
2. The watershed municipalities should work closely with landowners to protect and/or acquire unprotected open space.
3. Plan and provide for public access to open space areas and connect existing open spaces to avoid open space fragmentation. Obtain public access easements from property owners to link open space areas.
4. Ensure that open spaces remain available for passive recreation. Promote awareness and appropriate use of existing open space by publicizing parks, trails, community gardens, and historic landscapes as well as educational events on open space parcels.

5. Assess, improve, and restore parcels already acquired. Develop management plans for the use of acquired parcels.
6. Work with property owners to permanently protect more sensitive portions of their properties with conservation easements and/or the purchase/donation of development rights.
7. Perform an evaluation of undeveloped and underdeveloped parcels in the watershed based upon environmental criteria such as size of parcels, water resources, wetlands and wildlife habitat, floodplain protection, streamflow protection and recreation. Consider two types of open space protection – acquisition or protection through a conservation easement or restriction. Parcels that are currently undeveloped should be assigned higher priority for acquisition, while those parcels that are partially developed but have potential for future development should be assigned higher priority for a conservation restriction.

Illicit Connections and Discharges

Illicit discharges are non-stormwater flows that discharge into the stormwater drainage system or directly into surface waters. Wastewater connections to the storm drain system, sanitary sewer overflows, and illegal dumping are among the types of illicit discharges that may exist in sewered residential and commercial areas within the watershed. Identifying and eliminating these discharges is an important means of pollution source control for the watershed. The MS4 Permit regulates the quality of discharges from municipal storm drainage systems. The permit requires municipalities to implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the municipal storm drainage system, as well as sanctions to ensure compliance. This includes developing and implementing an Illicit Discharge Detection and Elimination (IDDE) program to systematically find and eliminate sources of non-stormwater discharges to its municipal separate storm sewer system and implement procedures to prevent such discharges.

Goals

The following goals have been identified for Illicit Connections and Discharges category:

- Eliminate illicit connections and discharges to waterbodies in the watershed.

Strategies & Recommendations

1. Implement IDDE programs as required by the MS4 Permit, including an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the regulated municipal separate storm sewer system and an IDDE program to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.
2. Educate municipal staff and the public about illicit discharges and the importance of eliminating or avoiding such discharges.

Homeowner Education and Outreach

Watershed residents play a major role in improving and maintaining water quality in the watershed. With more than 60,000 people residing in the watershed, there are several key actions that residents can take to improve the water quality in the watershed.

Goals

The following goals have been identified for Homeowner Education and Outreach category:

- Reduce the impact that watershed households have on water quality.

Strategies & Recommendations

1. Encourage the use of Residential LID practices: Homeowners should be encouraged to implement green infrastructure or Low Impact Development (LID) practices on their properties. Encourage disconnection of rooftop runoff from the storm drainage system and impervious areas to reduce the quantity of runoff by redirecting the runoff to pervious lawn areas, using dry wells, rain barrels or rain gardens. Provide education and outreach to homeowners, neighborhood groups, and roofing contractors on disconnecting roof downspouts and installing and maintaining residential rain gardens and rain barrels.
2. Promote Sustainable Lawn Care Practices: Homeowners should be encouraged to use environmentally friendly lawn care practices such as reducing or eliminating fertilizer and pesticide usage through the use of slow release fertilizers and fertilizer application timing; utilizing alternative landscaping that decreases maintenance; soil testing and non-chemical lawn care measures. Although sustainable lawn care practices will not significantly reduce bacteria loadings, they will reduce nutrient loadings, the use of toxic chemicals, and promote water conservation. Develop a

sustainable lawn care and gardening recognition and incentive program, with landscapers and homeowners.

3. Promote Backyard Habitat: Encourage the creation of backyard buffers in residential areas near stream corridors, including the importance of maintaining healthy vegetated buffers to streams, ponds, and wetlands, and recognize the efforts of the public. Educate homeowners about the value and importance of stream buffers through outreach and educational programming.
4. Provide Homeowner Outreach on Septic Systems: Watershed residents not part of a municipal wastewater treatment system should ensure that their on-site septic systems are properly maintained. Provide homeowners with educational materials on how to identify improperly functioning septic systems and procedures to have systems inspected, cleaned, and repaired or upgraded.
5. Promote Community Involvement: Community involvement is a vital component in developing and implementing a successful watershed management plan. Community events focused on Wappinger Creek Watershed are also an effective way to provide public outreach and stewardship. Promote, publicize, and support community existing events such as environmental leadership workshops, monitoring water quality in streams, watershed cleanups, etc.

8.0 Subwatershed Characteristics, Issues and Recommendations

8.1 Cold Spring Creek

Subwatershed Characteristics

The Cold Spring Creek subwatershed encompasses 6,992 acres and is in the north-central portion of the watershed and includes portions of the towns of Pine Plains, Milan, and Stanford. Subwatershed and use varies greatly, and is comprised of 10% agriculture, 78% forest, 9% wetlands and waterbodies, and 3% developed land. The dominant soil types in the subwatershed are Nassau-Cardigan complex (32%) and Dutchess-Cardigan complex (16%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 86% of the soils in this subwatershed tend to be poor for septic siting.

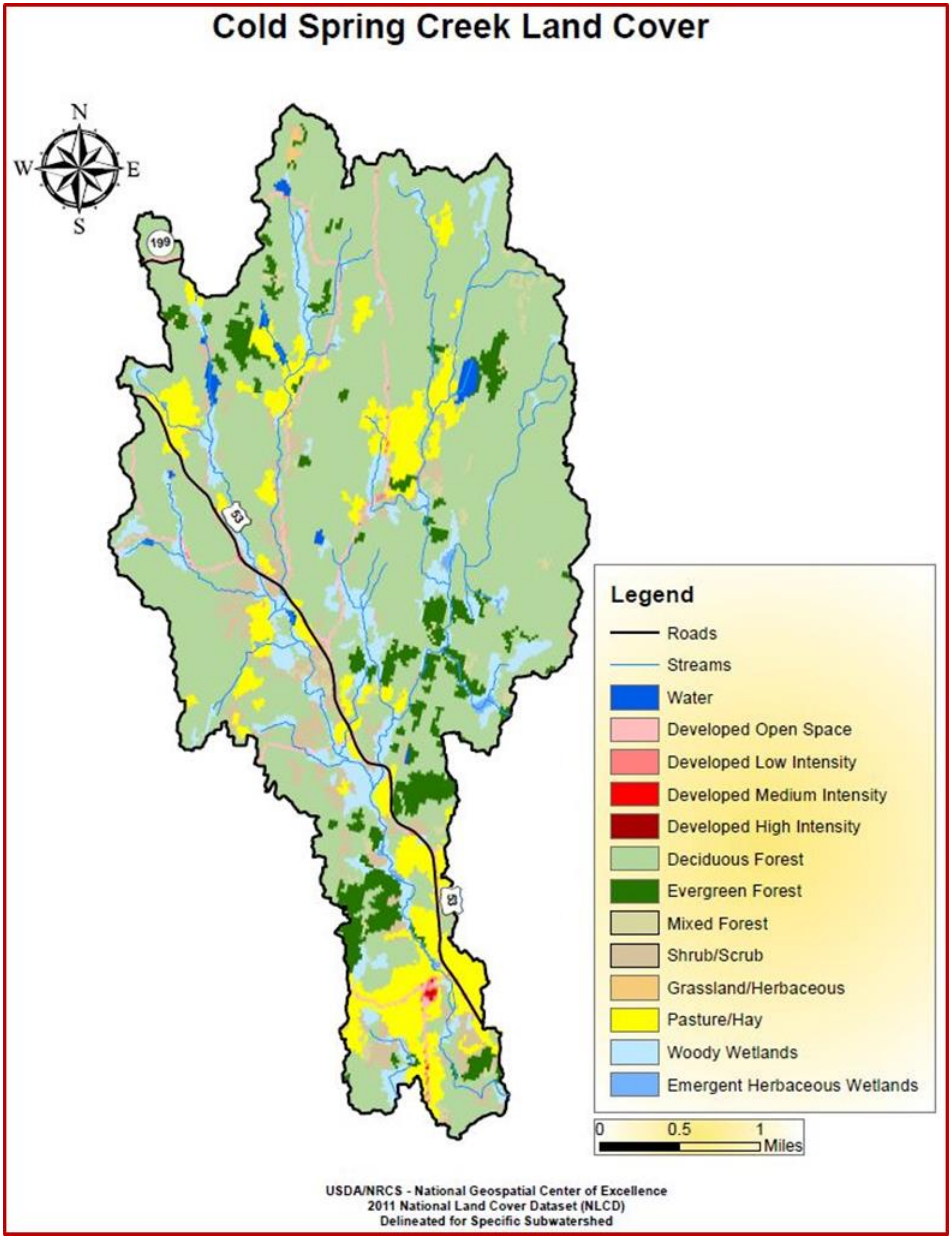

Figure 8.1 Cold Spring Creek Subwatershed Land Cover

According to NYSDEC, Cold Spring Creek is classified as a Class B stream, which makes it suitable for swimming, fish reproduction, and survival (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). The Cold Spring Creek subwatershed drainage area includes Mountain Brook stream, which is a Class C(T) and B(TS) stream with documented trout reproduction (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Almost 83% of the riparian areas in this subwatershed are naturally vegetated. There are no known SPDES sites in this subwatershed.

Summary of Key Issues

Key issues affecting water quality in the Cold Spring Creek subwatershed:

- Septic Systems - Almost 100 percent of this subwatershed population rely on on-site septic systems, with a model estimated phosphorus load of 105 lbs/yr from septic systems.

Key Recommendations for Cold Spring Creek Subwatershed

- Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.
- Promote and implement wetlands protection, land conservation and roadside ditch management programs.

8.2 Direct Drainage to Wappinger Creek

Subwatershed Characteristics

Direct Drainage to Wappinger Creek subwatershed encompasses 35,703 acres in the central portion of the Wappinger Creek Watershed, and is the largest subwatershed, including portions of the towns of Pine Plains, Stanford, Washington, Clinton, Pleasant Valley, Lagrange, Poughkeepsie and Wappinger. Subwatershed land use comprises of 22% agriculture, 49% forest and barren land, 9% wetland and waterbodies, and 21% developed land. The dominant soil types in the subwatershed are Nassau-Cardigan complex (21%) and Hoosic gravelly loam (16%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Hoosic gravelly loam soils are somewhat excessively drained with high to very high hydraulic conductivity. These soils tend to have rapid to moderately rapid permeability in the surface and subsoil, and very rapid permeability in the substratum. They have a moderate erosion hazard and tend to be poor for septic system siting due to poor filtering. Based on the NRCS web soil survey soil characteristics, 74% of the soils in this subwatershed tend to be poor for septic siting.

This subwatershed encompasses the origin point of Wappinger Creek. These headwaters are classified as Class C and C(T) streams, indicating that they will support fish (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). The tributaries to the headwaters are classified as B and C waters and some portions of the downstream headwaters should be able to support trout populations. The headwaters originate from a chain of lakes named Twin Island Pond, Stissing Pond, and Thompson Pond, and are classified as Class B waterbodies. The downstream headwaters originating from the Tamarack Swamp Creek are classified as Class B, C, C(T) and C(TS), meaning they support swimming, fishing, and fish reproduction and survival (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Further downstream, this subwatershed receives water from portions of the towns of Pleasant Valley, La Grange, Poughkeepsie, and Wappinger Falls. The waters in the southern portion of this subwatershed are classified as Class B and C, meaning they support swimming, fishing, and will also support fish reproduction. Most of the streams in this subwatershed discharge directly into Wappinger Creek located in the southern portion of this subwatershed.

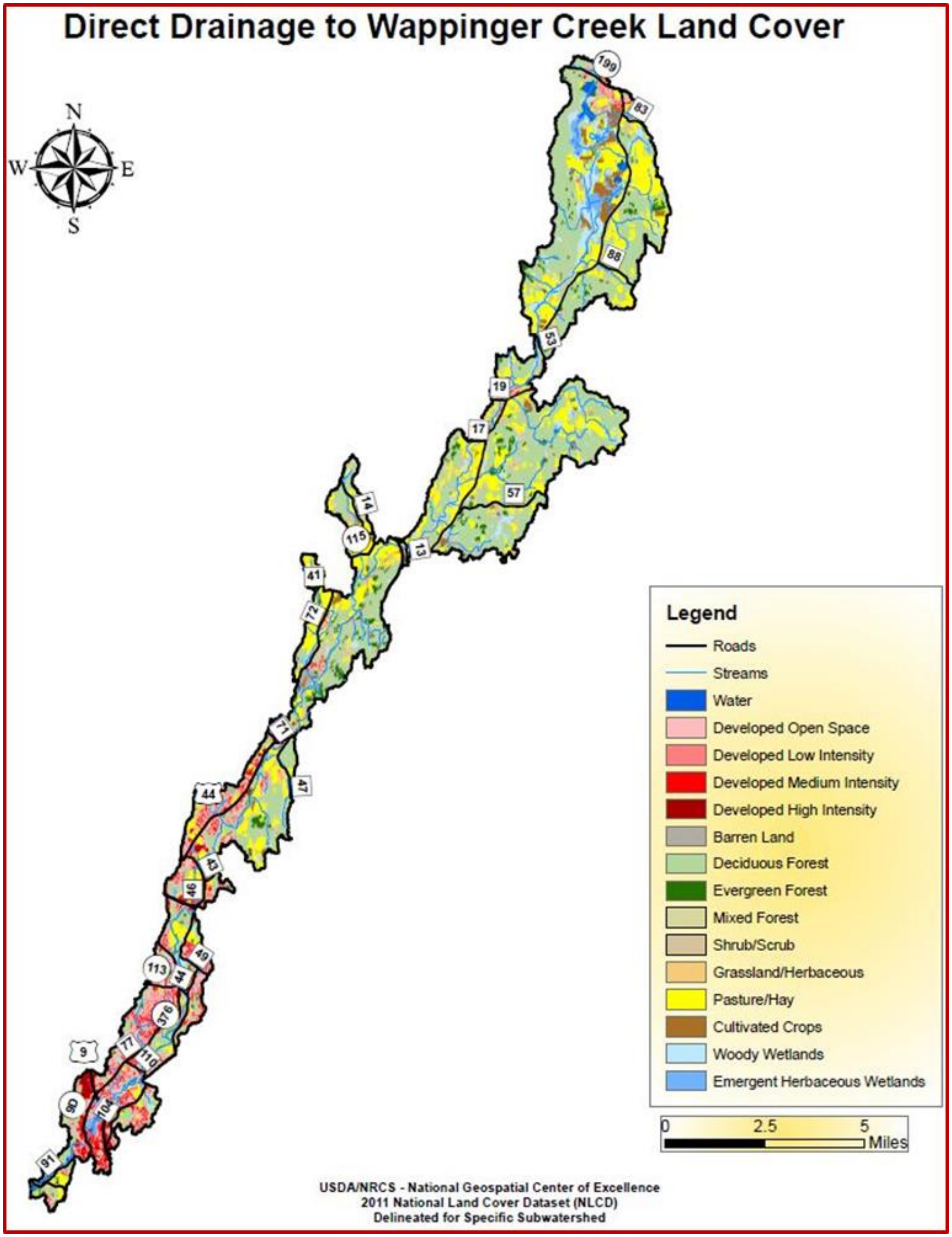

Figure 8.2 Direct Drainage to Wappinger Creek Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Direct Drainage to Wappinger Creek subwatershed:

- Total Sediment Load – This subwatershed releases a total sediment load of 49.8 pounds per acre from land cover sources. Of the total land cover sediment load, 48 percent comes from agricultural lands and 29 percent from streambanks.
- Total Nitrogen Load - This subwatershed releases a total nitrogen load of 0.49 pounds per acre from land cover sources. Of the total land cover nitrogen load, 47 percent comes from developed lands and 42 percent from agricultural lands.
- Total Phosphorus Load - This subwatershed releases a total phosphorus load of 2,141 pounds (0.061 pounds per acre) from land cover sources, which is highest of all the 13 subwatersheds. Of the total land cover phosphorus load, 40 percent comes from agricultural lands and 37 percent from developed lands.
- Point Sources – This subwatershed has the highest number of SPDES sites of all the 13 subwatersheds, with a model estimated yearly point source load of 1,927 pounds.
- Septic Systems – This subwatershed has the highest number of septic systems of all the 13 subwatersheds, with a model estimated yearly load of 879 pounds from septic systems
- NYSDEC TMDL Requirement – TMDLs are required for waterbodies within this subwatershed.
- Water Quality – This subwatershed was monitored at seven monitoring stations during the 2017-2018 watershed sampling. The recorded median phosphorus concentration ranged from 0.024 mg/L to 0.081 mg/L exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The high phosphorus contributions in the upstream waters can be attributed to headwaters originating from Twin Island Pond, Stissing Pond, and Thompson Ponds which are stressed by excess nutrients and pathogens and agricultural and livestock operations. The high phosphorus contributions along the waters downstream can be attributed to significant amount of developed land including residential fertilizer applications, runoff from roads and other impervious surfaces and failing septic systems. It can be assumed that seven SPDES facilities located in this subwatershed are also possible phosphorus contributors with a yearly estimated combined load of 1,927 pounds.

Key Recommendations for Direct Drainage to Wappinger Creek Subwatershed

- Agricultural landowners should continue to work with Dutchess County Soil and Water Conservation District to implement AEM program on farms in the subwatershed, focusing on identification of management practices that reduce phosphorus loads.
- Out of the seven SPDES facilities in this subwatershed, only Titusville WWTP monitors phosphorus and has a phosphorus permit limit. Permits for the other facilities should be modified to include phosphorus monitoring. The non-POTW facilities should be encouraged to tie into the municipal sewer system, where available.
- Work with NYSDEC to develop TMDL for Wappinger Lake and/or implement BMPs to address impairment from sediment and phosphorus.
- Given the proximity of many residences to Wappinger Creek, implement a surveying and testing program to document locations of septic systems and verify failing systems requiring replacement in accordance with the State Sanitary Code. Where appropriate, the proper infrastructure should be installed to connect failing septic systems to the municipal system.
- Preserve and enhance riparian buffers for projects that provide public access to the Wappinger Creek.
- Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.

8.3 Dutchess County Airport

The Dutchess County Airport subwatershed encompasses 7,520 acres in the southern portion of the watershed and includes portions of the towns of Lagrange and Wappinger. Subwatershed uses consist of 13% agriculture, 38% forest, 9% wetlands and waterbodies, and 40% developed land. The dominant soil types in the subwatershed are Dutchess-Cardigan complex (26%) and Bernardston silt loam (25%). The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Bernardston silt loam soils are well drained with moderately low to moderately high hydraulic conductivity. These soils tend to have moderate permeability in the surface layer and subsoil and slow permeability in

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the dense substratum with moderate erosion hazard. They tend to be poor for septic system siting due to slow percolation. Based on the NRCS web soil survey soil characteristics, 49% of the soils in this subwatershed tend to be poor for septic siting.

The Dutchess County Airport subwatershed incorporates Greens Pond, which is a Class D waterbody (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Two tributaries, classified as Class B and C, form Greens Pond. Waters downstream of Greens Pond are classified as Class C, which are suitable for fishing and boating (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*).

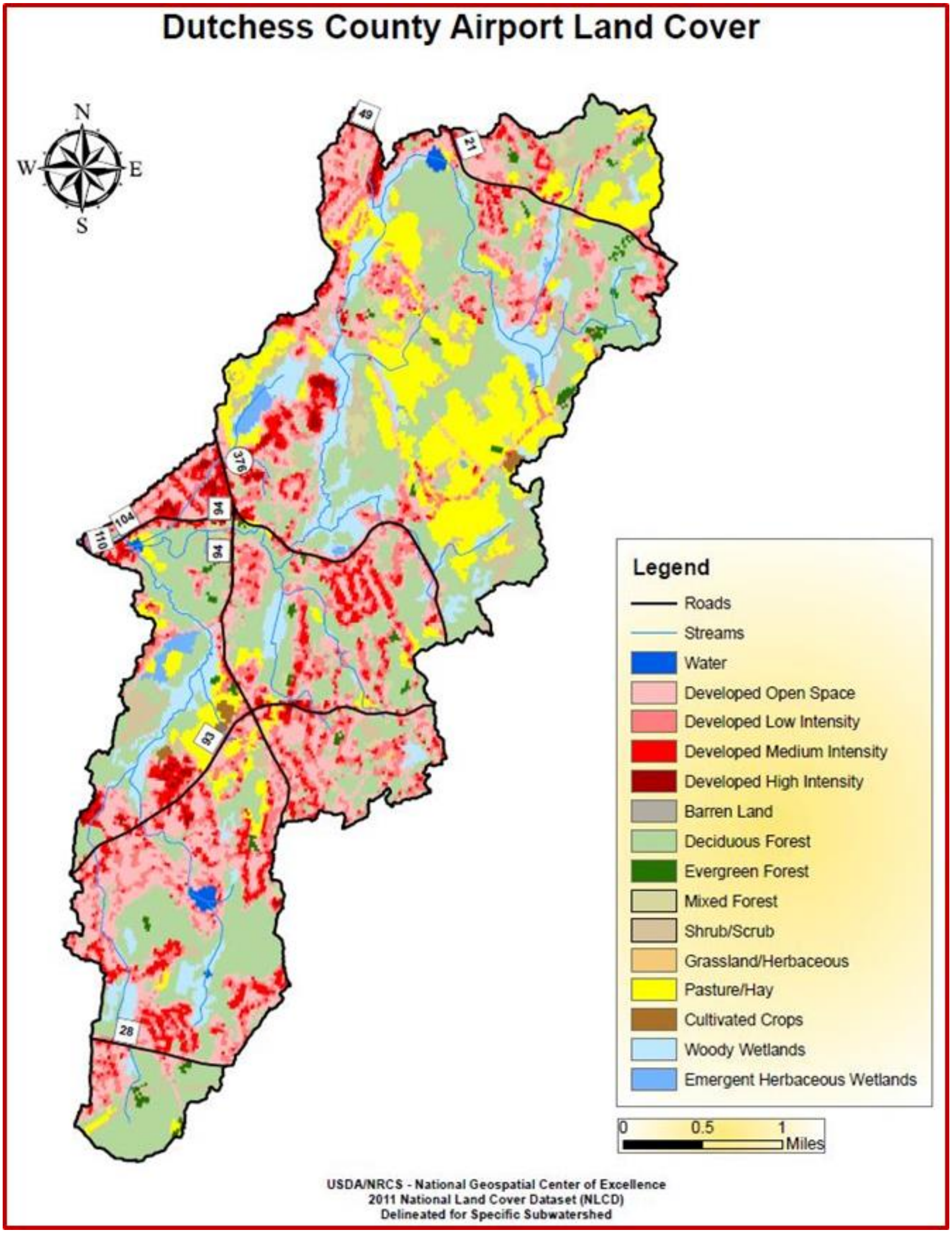

Figure 8.3 Dutchess County Airport Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Dutchess County Airport subwatershed:

- Total Nitrogen Load - This subwatershed releases a total nitrogen load of 0.54 pounds per acre from land cover sources. Of the total land cover nitrogen load, 73 percent comes from developed lands and 19 percent from agricultural lands.
- Total Phosphorus Load - This subwatershed releases a total phosphorus load of 0.06 pounds per acre from land cover sources. Of the total land cover phosphorus load, 65 percent comes from developed lands and 24 percent from agricultural lands.
- Water Quality – This subwatershed recorded the third highest median phosphorus concentration of 0.081 mg/L exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The high phosphorus contribution can be attributed to significant amount of developed land in the watershed and failing septic systems. The most probable attributions could be from residential fertilizer applications, runoff from roads and other impervious surfaces. It can be assumed that Midpoint Park and Noxon Knolls Brookside sewage treatment plant are also possible phosphorus contributors with a yearly estimated combined load of 909 pounds. Greens Pond which is one of the major waterbodies of this subwatershed appeared to be highly eutrophic with excessive growth of plants and algae based on visual observation during sampling events.
- Point Sources - This subwatershed has two SPDES sites, which release a model estimated yearly point source phosphorus load of 909 pounds.

Key Recommendations for Dutchess County Airport Subwatershed

- Given the amount of developed land in this subwatershed, the municipalities should consider opportunities to retrofit existing properties with new facilities, such as stormwater detention/retention ponds; also attempt natural conveyance restoration wherever possible.
- Promote lawn care practices and educate residential and property owners about impacts of fertilizer and pesticide/herbicide use in the watershed.
- Amend the permits for the two SPDES facilities in the subwatershed to monitor phosphorus.

- Install small scale BMPs such as rain gardens that treat impervious or slow-draining surfaces like driveways and rooftops.

8.4 East Branch Wappinger Creek

The East Branch subwatershed comprises of 21,521 acres in the eastern portion of the watershed, the second largest of all the subwatersheds and includes portions of the towns of Washington, Millbrook, Pleasant Valley, Stanford and Clinton. Subwatershed land use consists of 30% agriculture, 54% forest, 7% wetlands and waterbodies, and 9% developed land. The dominant soil types in the subwatershed are Nassau-Cardigan complex (26%) and Dutchess-Cardigan complex (19%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 72% of the soils in this subwatershed tend to be poor for septic siting.

Waters of the East Branch Wappinger Creek originate at the confluence of Shaw Brook and Mill Brook. These streams are classified as Class A, making them suitable for drinking when treated and disinfected. Downstream, towards the confluence with Wappinger Creek, the classifications change to Classes B and C (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*).

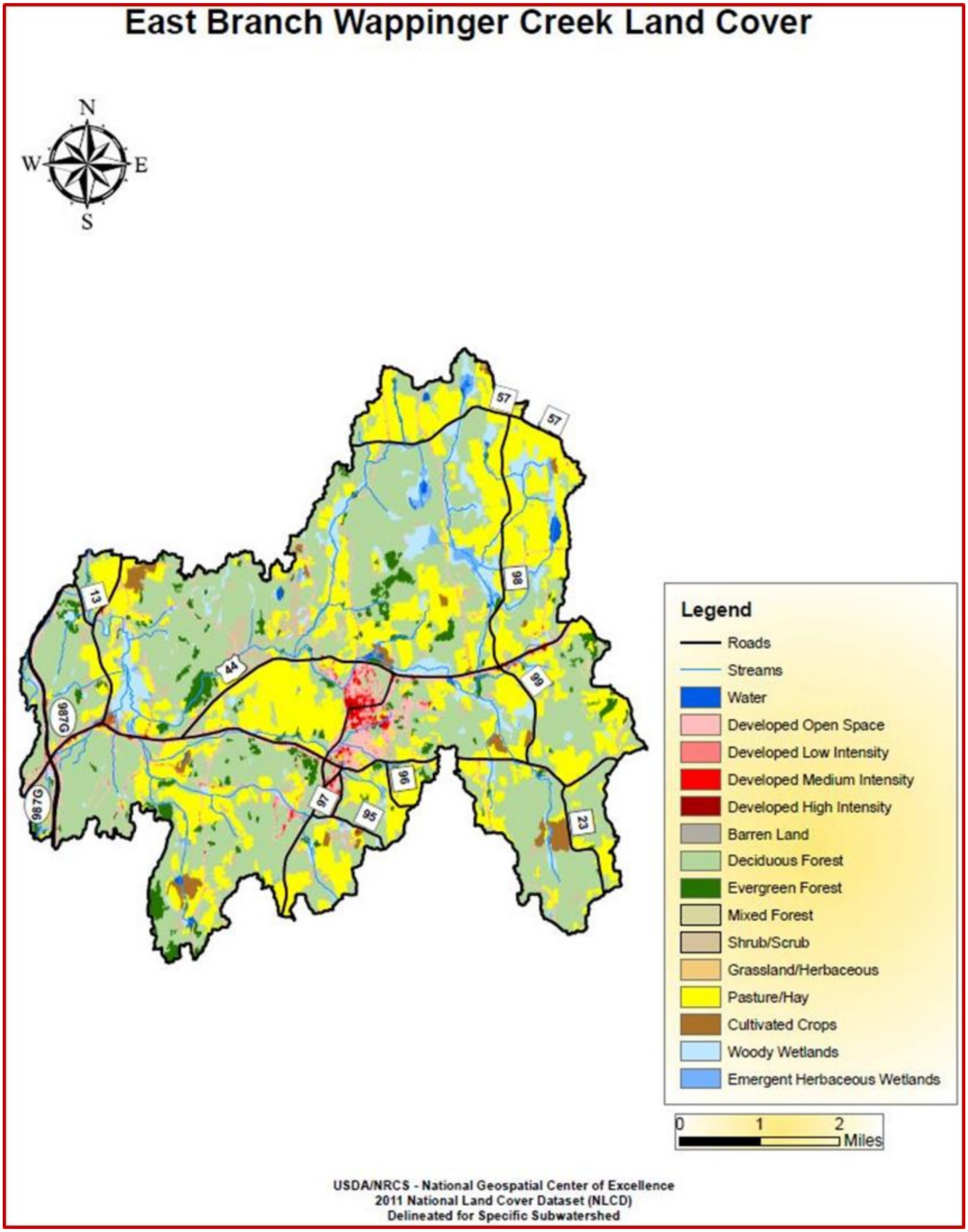

Figure 8.4 East Branch Wappinger Creek Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the East Branch Wappinger Creek subwatershed:

- Total Sediment Load - This subwatershed releases a total sediment load of 49.0 pounds per acre from land cover sources. Of the total land cover sediment load, 58 percent comes from agricultural lands and 27 percent from streambanks.
- Total Phosphorus Load - This subwatershed releases a total phosphorus load of 0.05 pounds per acre from land cover sources. Of the total land cover phosphorus load, 73 percent comes from agricultural lands and 13 percent from developed lands.
- Livestock – This subwatershed releases a model estimated yearly phosphorus load of 2,257 pounds from farm animal operations.
- Water Quality - This subwatershed recorded a median phosphorus concentration of 0.044 mg/L exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The phosphorus contribution can be attributed to agricultural and livestock operations and failing septic systems. It can be assumed Millbrook sewage treatment plant located in the central portion of the subwatershed is also a possible phosphorus contributor with a yearly estimated load of 1,875 pounds.

Key Recommendations for the East Branch Wappinger Creek Subwatershed

- Identify the farms that would be candidates for conservation easements, or conversion of cropland to hay. Develop a Comprehensive Nutrient Management Plan (CMP) for farms with phosphorus indexing.
- Encourage farmers to implement BMPs that focus on manure storage facilities, pasture practices, stream stabilization projects and calf facilities.
- Amend the SPDES permit for the Millbrook sewage treatment plant to incorporate a phosphorus permit limit.
- Work with NYSDEC to complete assessments of Unassessed streams. Unassessed streams are segments where there is insufficient water quality information available to assess the support of designated uses.

8.5 Great Spring Creek

The Great Spring Creek encompasses 10,012 acres in the central portion of the watershed and includes portions of towns of Clinton, Pleasant Valley and Hyde Park. Subwatershed land use consists of 31% agriculture, 47% forest, 12% wetlands and waterbodies, and 10% developed land. The dominant soil types in the subwatershed are Dutchess-Cardigan complex (34%) and Nassau-Cardigan complex (22%). The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 71% of the soils in this subwatershed tend to be poor for septic siting. Great Spring Creek and its tributary streams are classified as Class B streams, indicating that they are suitable for swimming, fishing, and fish survival. Almost 63 percent of the riparian areas in this subwatershed are naturally vegetated. This subwatershed has one known SPDES facility.

Summary of Key Issues

Key issues affecting water quality in the Great Spring Creek subwatershed:

- Total Sediment Load – This subwatershed releases a yearly total sediment load of 48.1 pounds per acre from land cover sources. Of the total land cover sediment load, 46 percent comes from agricultural lands and 42 percent from streambanks.
- Total Phosphorus Load - This subwatershed releases a yearly total phosphorus load of 0.052 pounds per acre. Of the total land cover phosphorus load, 66 percent comes from agricultural lands and 16 percent from developed lands.
- Livestock – This subwatershed releases a model estimated yearly phosphorus load of 907 pounds from farm animal operations.
- Water Quality - Water Quality – This subwatershed recorded the second highest median phosphorus concentration of 0.090 mg/L exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The high phosphorus contribution can be attributed to significant amount of agricultural land along with highest density of livestock operations in the

watershed and failing septic systems. It can be assumed that Brookside Meadows sewage treatment plant is also a possible phosphorus contributor with a yearly estimated load of 380 pounds.

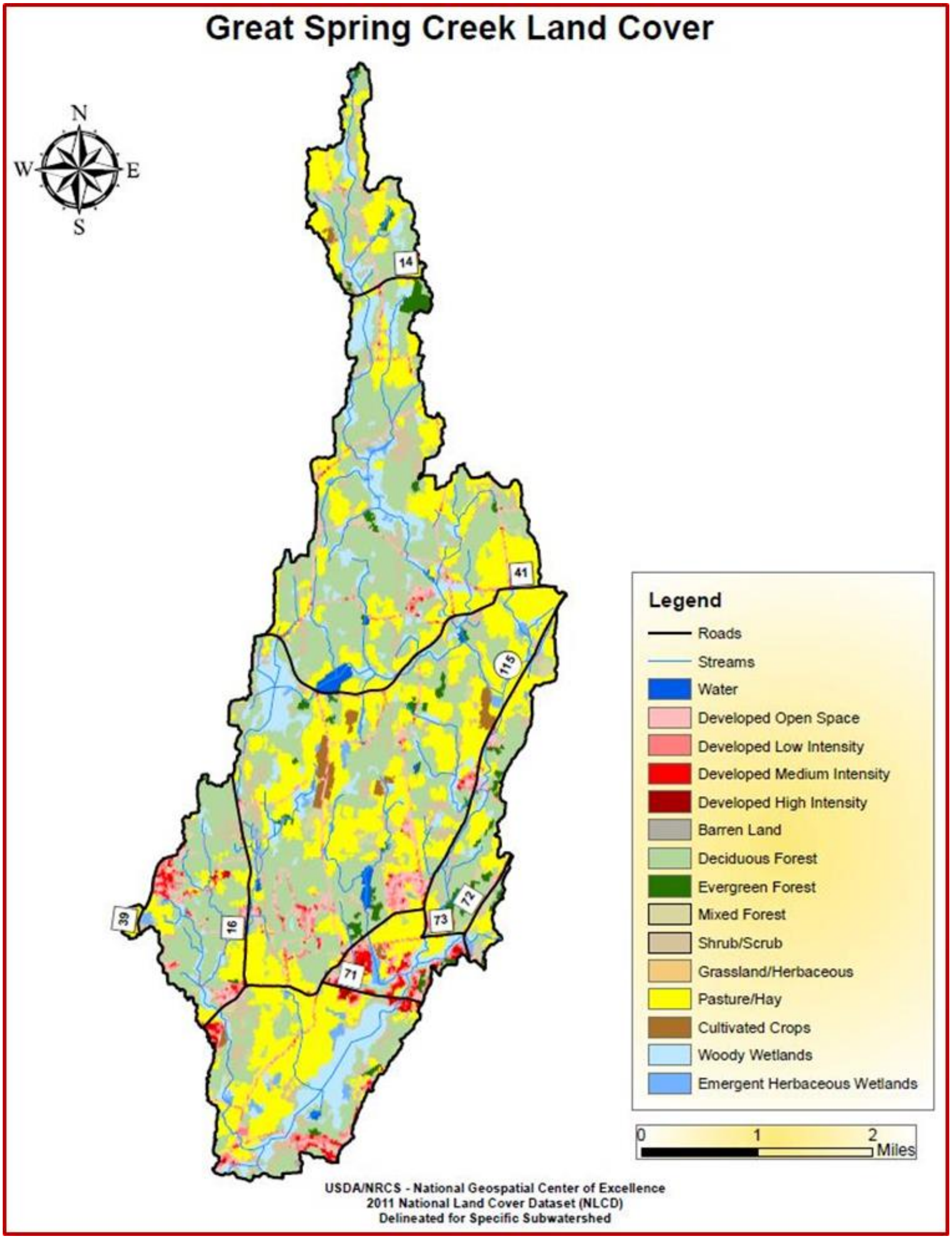

Figure 8.5 Great Spring Creek Subwatershed Land Cover

Key Recommendations for the Great Spring Creek Subwatershed

- Agricultural landowners should continue to work with their Dutchess County Soil and Water Conservation District to enact agricultural land Best Management Practices (BMPs) including cover crops, vegetative filter strips, no till crops and Comprehensive Nutrient Management Plans.
- Reduce access of livestock to streams and stream banks vulnerable to erosion.
- Amend the SPDES permit for the Brookside Meadows sewage treatment plant to incorporate phosphorus monitoring and a phosphorus permit limit.

8.6 Grist Mill Creek

The Grist Mill Creek subwatershed encompasses 3,711 acres in the north central area of the watershed and includes portions of Town of Stanford. Subwatershed land use consists of 26% agriculture, 58% forest, 11% wetlands and waterbodies, and 5% developed land. The dominant soil types in the subwatershed are Nassau-Cardigan complex (33%) and Dutchess-Cardigan complex (18%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 76% of the soils in this subwatershed tend to be poor for septic siting.

Grist Mill Creek is classified by NYSDEC as a Class B stream, meaning it is suitable for swimming, and will support fish reproduction and survival (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Almost 73 percent of the riparian areas in this subwatershed are naturally vegetated. This subwatershed has no known SPDES facilities.

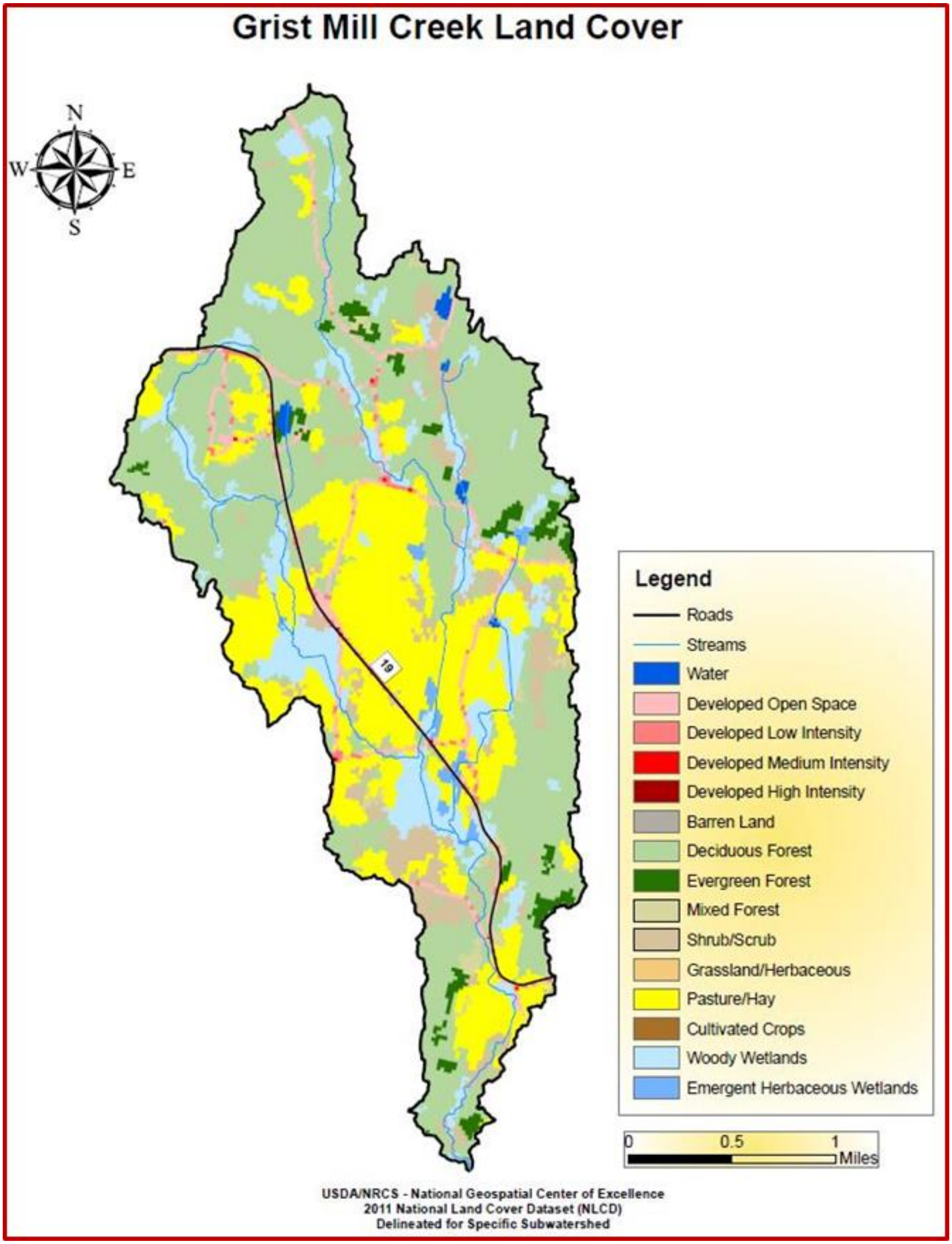

Figure 8.6 Grist Mill Creek Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Grist Mill Creek subwatershed:

- Water Quality - This subwatershed was not monitored during the 2017-2018 watershed sampling due to its scattered nature of streams. This watershed releases a model estimated yearly phosphorus load of 477 lbs, out of which 262 lbs come from farm animal systems.

Key Recommendations for the Grist Mill Creek subwatershed

- Promote and implement wetlands protection, land conservation and roadside ditch management programs.

8.7 Hunns Lake Creek

The Hunns Lake Creek subwatershed is 4,903 acres large and is in the northeastern portion of the watershed and includes portions of Town of Stanford. It comprises 4% of the Wappinger Creek watershed. The Hunns Lake Creek subwatershed land use consists of 32% agriculture, 56% barren and forest, 7% wetland and water bodies, and 4% developed land. The dominant soil types in the subwatershed are Nassau-Cardigan complex (37%) and Stockbridge silt loam (27%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Stockbridge silt loam soils are well drained with moderately low to moderately high hydraulic conductivity. These soils tend to have moderate permeability in the surface layer and subsoil, and slow to moderately slow permeability in the substratum. They have a slight erosion hazard and tend to be poor for septic system siting due to the seasonal high-water table. Based on the NRCS web soil survey soil characteristics, 75% of the soils in this subwatershed tend to be poor for septic siting.

Hunns Lake Creek is classified as a Class B and C stream by NYSDEC, indicating it supports swimming in select areas, and is limited to fishing in other areas (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). These waters should also support trout populations. The headwaters of this subwatershed originate from Hunns Lake, a 65-acre lake, which is classified as Class B by NYSDEC (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Hunns Lake has been listed in NYSDEC PWL as stressed by nutrients, aquatic vegetation, and sediment, with possible attributions to septic systems, fertilizer applications, and agricultural operations. Almost 67 percent of the riparian areas in this subwatershed are naturally vegetated. This subwatershed has no knows SPDES facilities.

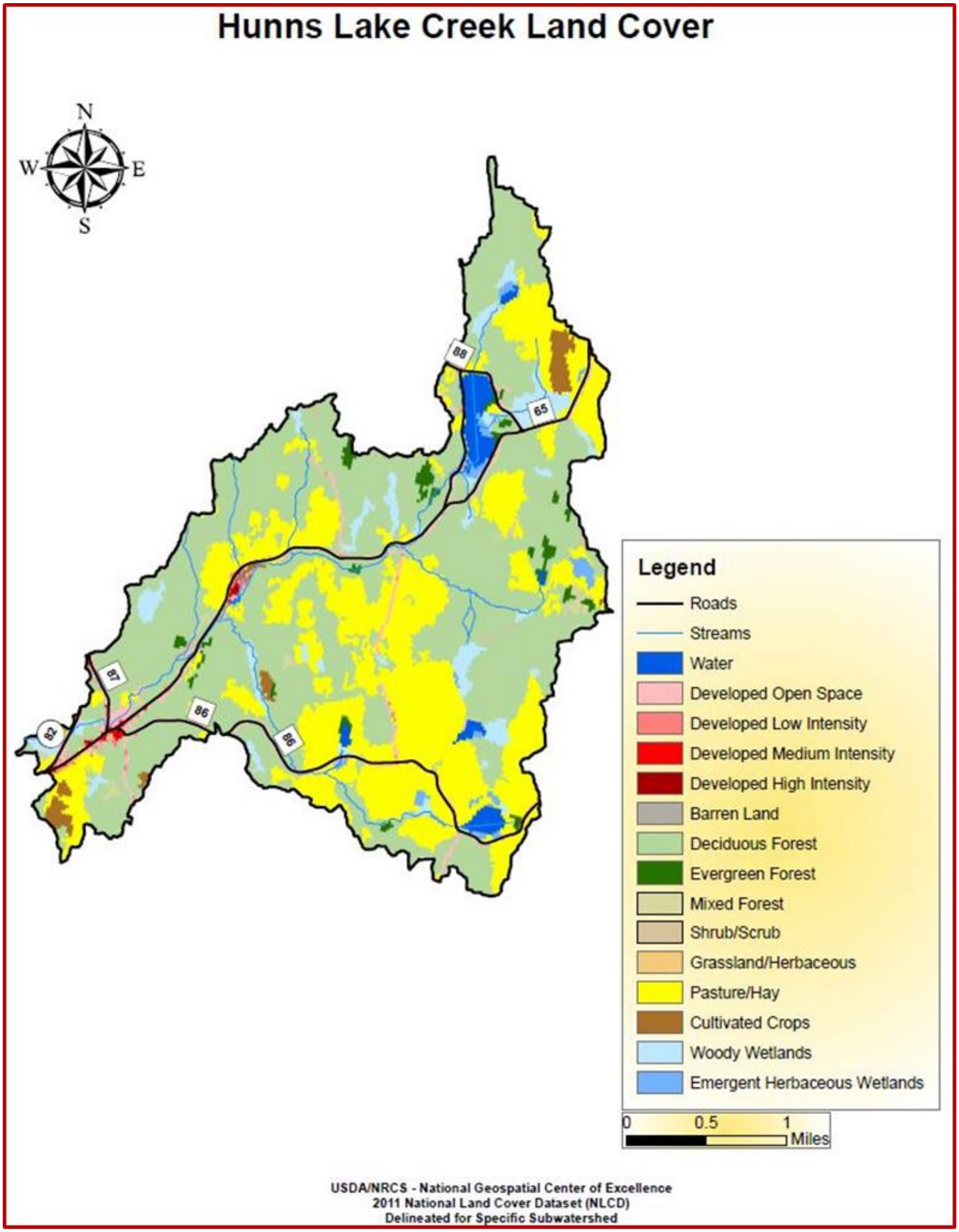

Figure 8.7 Hunns Lake Creek Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Hunns Lake Creek subwatershed:

- Livestock – This subwatershed releases a model estimated yearly phosphorus load of 469 pounds from farm animal operations.
- Water Quality - This subwatershed recorded the lowest median phosphorus concentration of 0.015 mg/L below the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. Although the recorded concentrations below the ambient guidance, future threats to the subwatershed would include failing septic systems from development.

Key Recommendations for Hunns Lake Creek Subwatershed

- Promote and implement land conservation/protection and roadside ditch management programs.
- Encourage farmers to implement BMPs that focus on manure storage facilities, pasture practices, stream stabilization projects, composting and calf facilities.
- Reduce access of livestock to streams and stream banks vulnerable to erosion.

8.8 Little Wappinger Creek

The Little Wappinger Creek subwatershed encompasses 21,277 acres and is in the northwestern part of the watershed and includes portions of towns of Milan, Stanford, Clinton and Pleasant Valley.

Subwatershed land use consists of 17% agriculture, 66% forest, 8% wetlands and waterbodies, and 7% developed land. The dominant soil types in this subwatershed are Dutchess-Cardigan complex (26%) and Nassau-Cardigan complex (26%). The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 79% of the soils in this subwatershed tend to be poor for septic siting.

Little Wappinger Creek is classified as a Class B stream by NYSDEC, indicating it is suitable for swimming, fishing, and fish reproduction (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). A chain of lakes, consisting of Silver Lake, Mud Pond, and Long Pond, are part of this subwatershed. Silver Lake and Long Pond are classified as AA and AA(T), indicating they can be used as drinking water when disinfected, and support trout. Mud Pond is classified as Class B, meaning it is suitable for swimming, fishing, and fish reproduction (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Although having the highest water quality classifications, Silver Lake and Long Pond are listed on the NYSDEC PWL as stressed by nutrients and aquatic vegetation. Almost 74 percent of the riparian areas in this subwatershed are naturally vegetated.

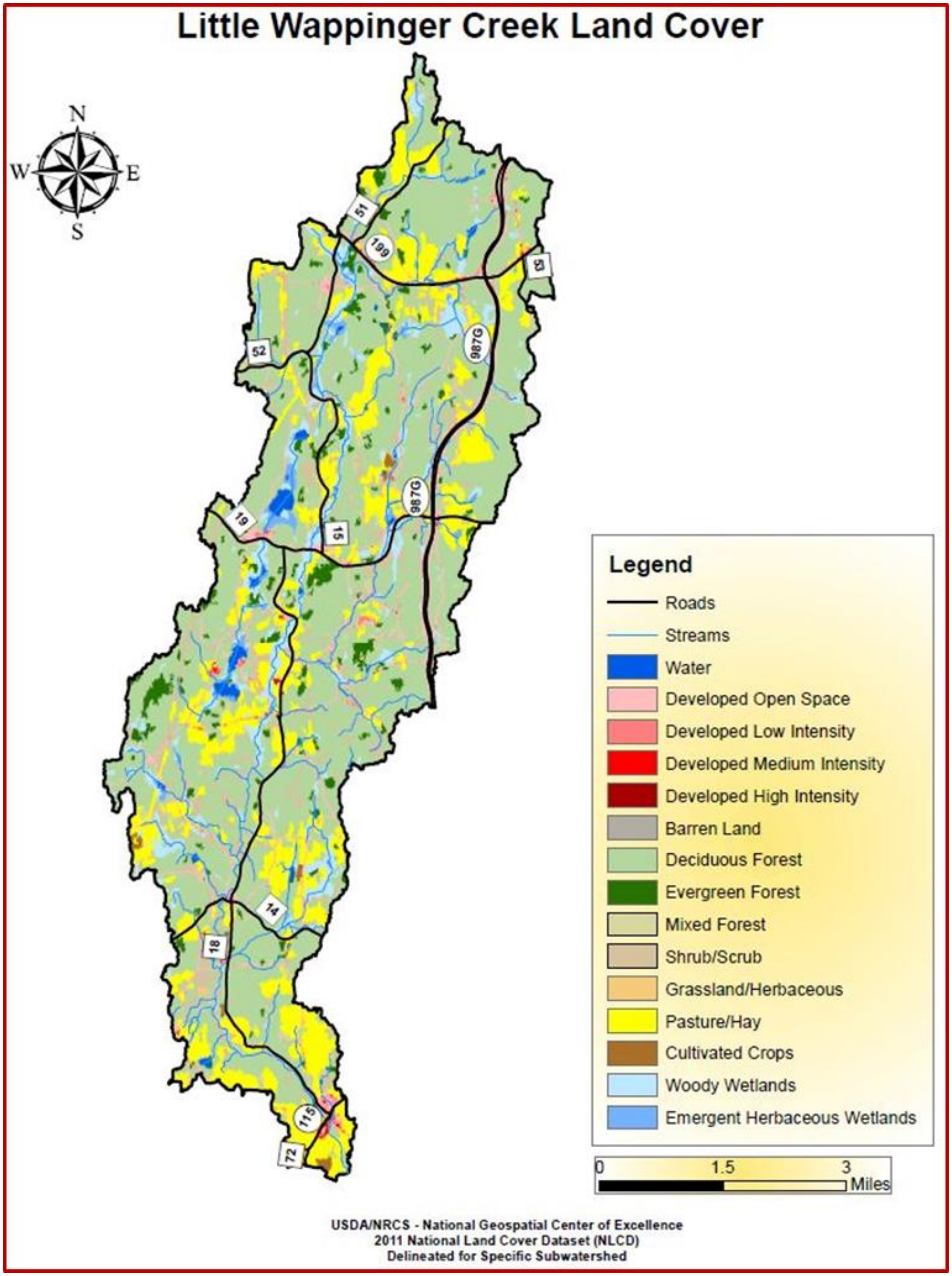

Figure 8.8 Little Wappinger Creek Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Little Wappinger Creek subwatershed

- Livestock - This subwatershed releases a model estimated yearly phosphorus load of 1,002 pounds from farm animal operations.
- Water Quality - This subwatershed recorded a median phosphorus concentration of 0.036 mg/L (third lowest of all the monitored sites) exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The phosphorus contribution can be attributed to agricultural farm animal operations and failing septic systems. The recorded median TSS concentration was one of the lowest of all the monitored sites.

Key Recommendations for Little Wappinger Creek Subwatershed

- Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.
- Work with residential homeowners to identify improperly functioning septic systems and develop procedures to have systems inspected, cleaned, and repaired or upgraded.
- Encourage farmers to implement BMPs that focus on land application of manure, manure collection, handling and storage.
- Reduce access of livestock to streams and stream banks vulnerable to erosion.

8.9 Overlook Road

The Overlook Road subwatershed encompasses 4,209 acres, located in the south-central portion of the watershed and includes portions of town of Lagrange. Subwatershed land use consists of 12% agriculture, 47% forest, 8% wetlands and waterbodies, and 33% developed land. The dominant soil types in the subwatershed are Dutchess-Cardigan complex (31%) and Pittstown silt loam (12%). The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Pittstown silt loam soils are moderately well drained with moderately low to moderately high hydraulic conductivity. These soils tend to have moderate permeability in the surface and subsoil, and slow or moderate permeability in the substratum. They have a slight erosion hazard and tend to be poor for septic system siting due to seasonal high-water table and slow percolation. Based on

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the NRCS web soil survey soil characteristics, 58% of the soils in this subwatershed tend to be poor for septic siting.

This subwatershed consists of smaller streams with NYSDEC classifications B and C (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). They discharge directly into Wappinger Creek. These waters are suitable for swimming (Class B), fishing, and boating (Class C). This subwatershed has one known SPDES facility.

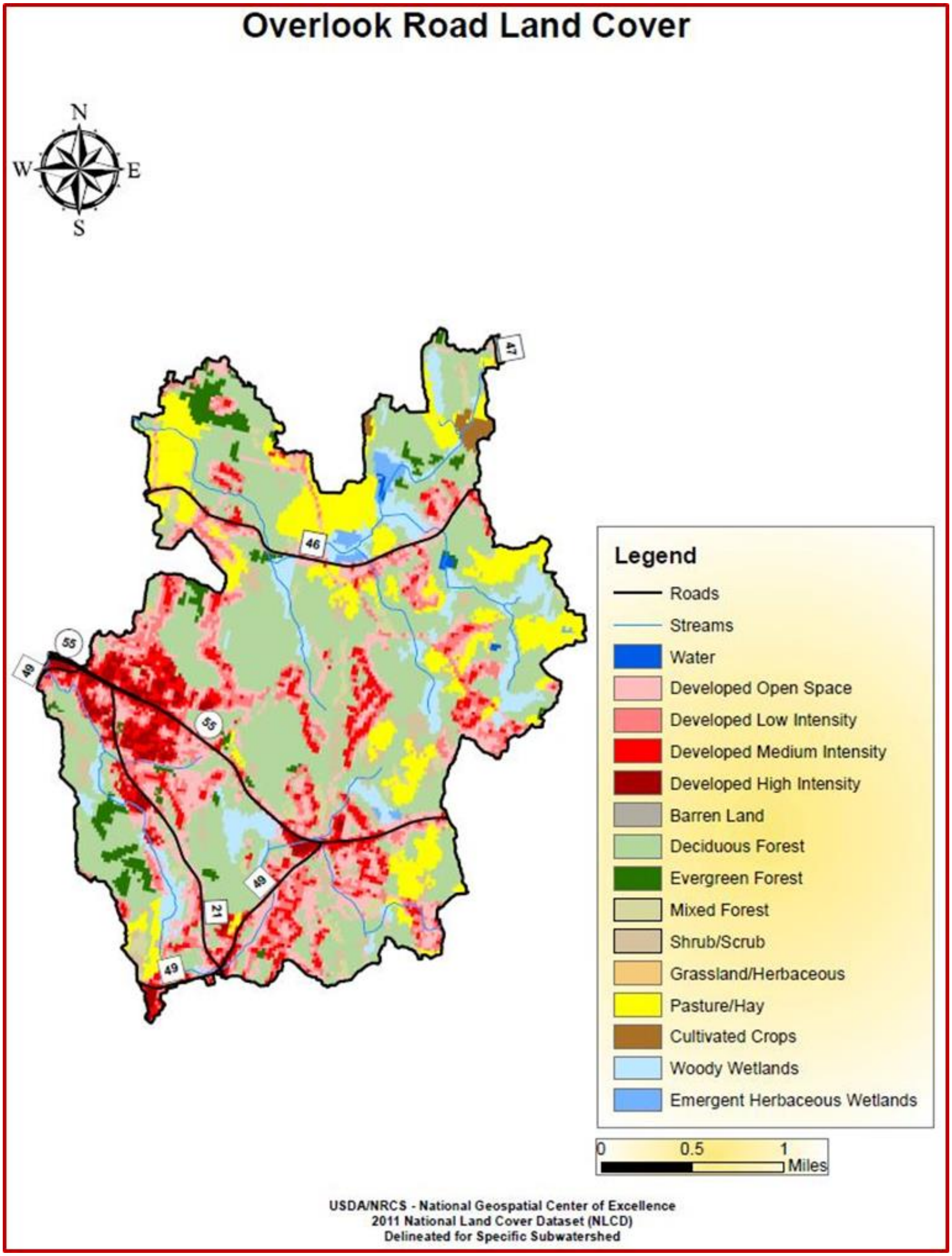


Figure 8.9 Overlook Road Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Overlook Road subwatershed:

- Total Phosphorus Load - This subwatershed releases a yearly total phosphorus load of 0.061 pounds per acre from land cover sources. Of the total phosphorus load, 64 percent comes from developed lands and 24 percent from agricultural lands.

Key Recommendations for the Overlook Road Subwatershed

- Incorporate effective stormwater BMPs into new construction and existing development. Potential BMPs could include rain gardens, down spout disconnects, permeable pavement, infiltration basins, detention ponds, rain barrels and cisterns, trees and tree boxes, and green roofs.
- Educate public regarding lawn care, cleaning up pet waste and management.

8.10 Pleasant Valley East

The Pleasant Valley East Creek subwatershed encompasses 7,389 acres in the eastern portion of the watershed and includes portions of towns of Pleasant Valley and Lagrange. Subwatershed land use consists of 12% agriculture, 56% forest, 6% wetlands and waterbodies, and 22% developed land. The dominant soil types in the subwatershed are Nassau-Cardigan complex (60%) and Dutchess-Cardigan complex (14%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 79% of the soils in this subwatershed tend to be poor for septic siting.

The Pleasant Valley East subwatershed streams are classified as Class B and B(T) by NYSDEC making them suitable for swimming, fishing, and supportive of fish reproduction and survival. Some areas may also support trout (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Almost 76 percent of the riparian areas in this subwatershed are naturally vegetated. This subwatershed has one know SPDES facility.

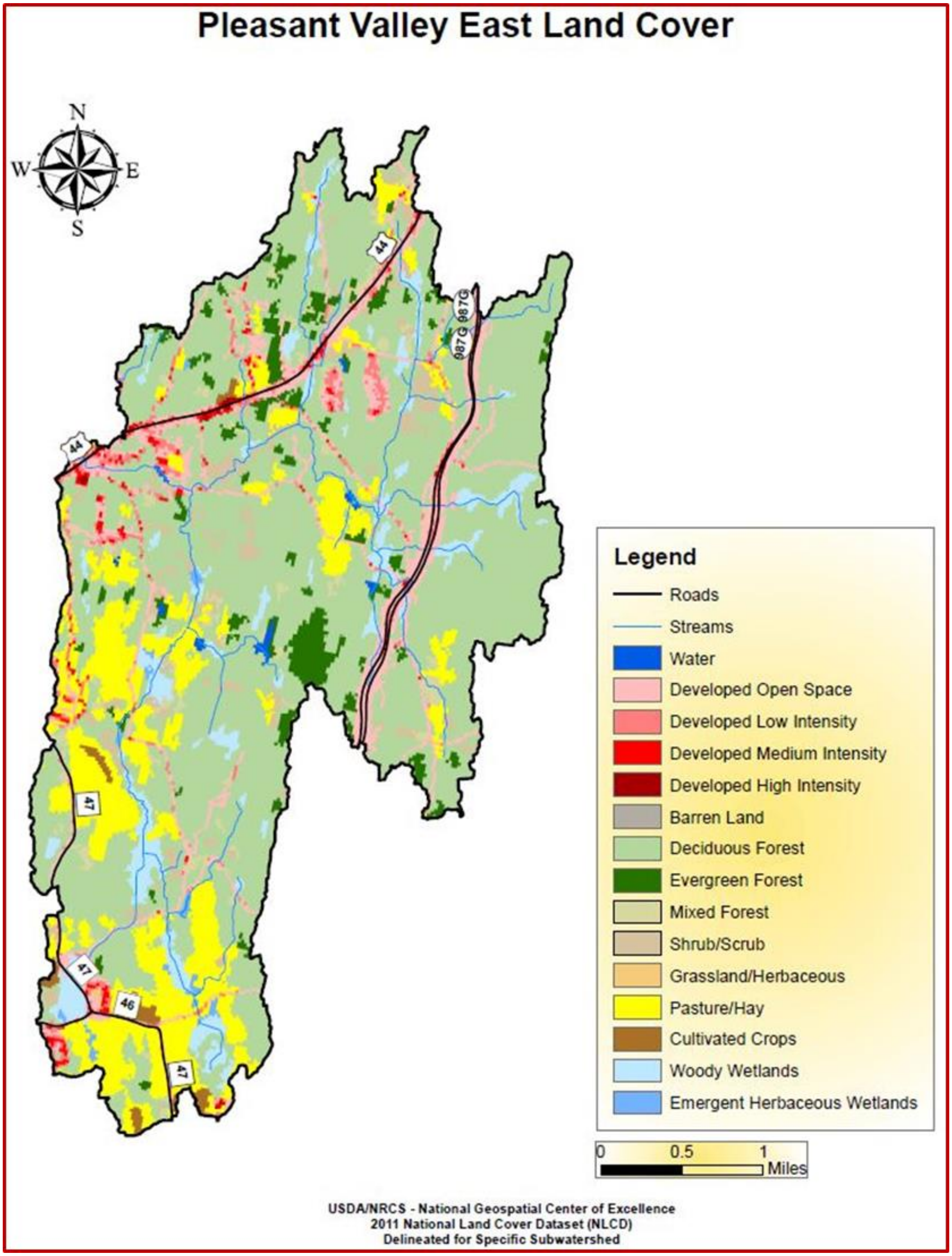


Figure 8.10 Pleasant Valley East Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Pleasant Valley East subwatershed:

- Septic Systems – This subwatershed releases a model estimated yearly phosphorus load of 369 pounds from septic systems.
- Livestock – This subwatershed releases a model estimated yearly phosphorus load of 327 pounds from farm animal operations.
- Water Quality – This subwatershed recorded the highest median phosphorus concentration of 0.096 mg/L exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The high phosphorus contribution can be attributed to high amount of residential development and agricultural land uses along the downstream area in closer proximity to the sampling site. It can be assumed that Valley Dale sewage treatment plant is also a possible phosphorus contributor with a yearly estimated load of 225 pounds. The subwatershed also recorded the single highest TSS concentration of 140 mg/L along with a median TSS concentration of 4.3 mg/L.

Key Recommendations for Pleasant Valley East Subwatershed

- Amend the SPDES permit for the Valley Dale sewage treatment plant to incorporate phosphorus monitoring.
- Property owners should be educated on proper maintenance of their septic systems and encouraged to make preventative repairs.

8.11 Upton Lake Creek

The Upton Lake Creek subwatershed comprises 4,077 acres in the north-central portion of the watershed and includes portions of towns of Clinton, Stanford and Washington. Subwatershed land use comprises of 32% agriculture, 43% forest, 5% wetlands and waterbodies, and 12% developed land. The dominant soil types are Nassau-Cardigan complex (38%) and Hoosic gravelly loam (14%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Hoosic gravelly loam soils are somewhat excessively drained with high to very high hydraulic conductivity. These soils tend to have rapid moderately rapid permeability in the surface and subsoil, and very rapid permeability in the substratum. They have a moderate erosion hazard and tend to be poor for septic system siting due to poor filtering. Based on the NRCS web soil survey soil characteristics, 82% of the soils in this subwatershed tend to be poor for septic siting.

The Upton Lake Creek is classified as a Class B and C(T) stream by NYSDEC, meaning it is suitable for swimming and fishing, and should support fish reproduction and survival, including trout populations (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). Upton Lake has been listed on NYSDEC PWL as stressed by nutrients and aquatic vegetation, with attributions to septic systems and fertilizer applications on lakeside properties (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*).

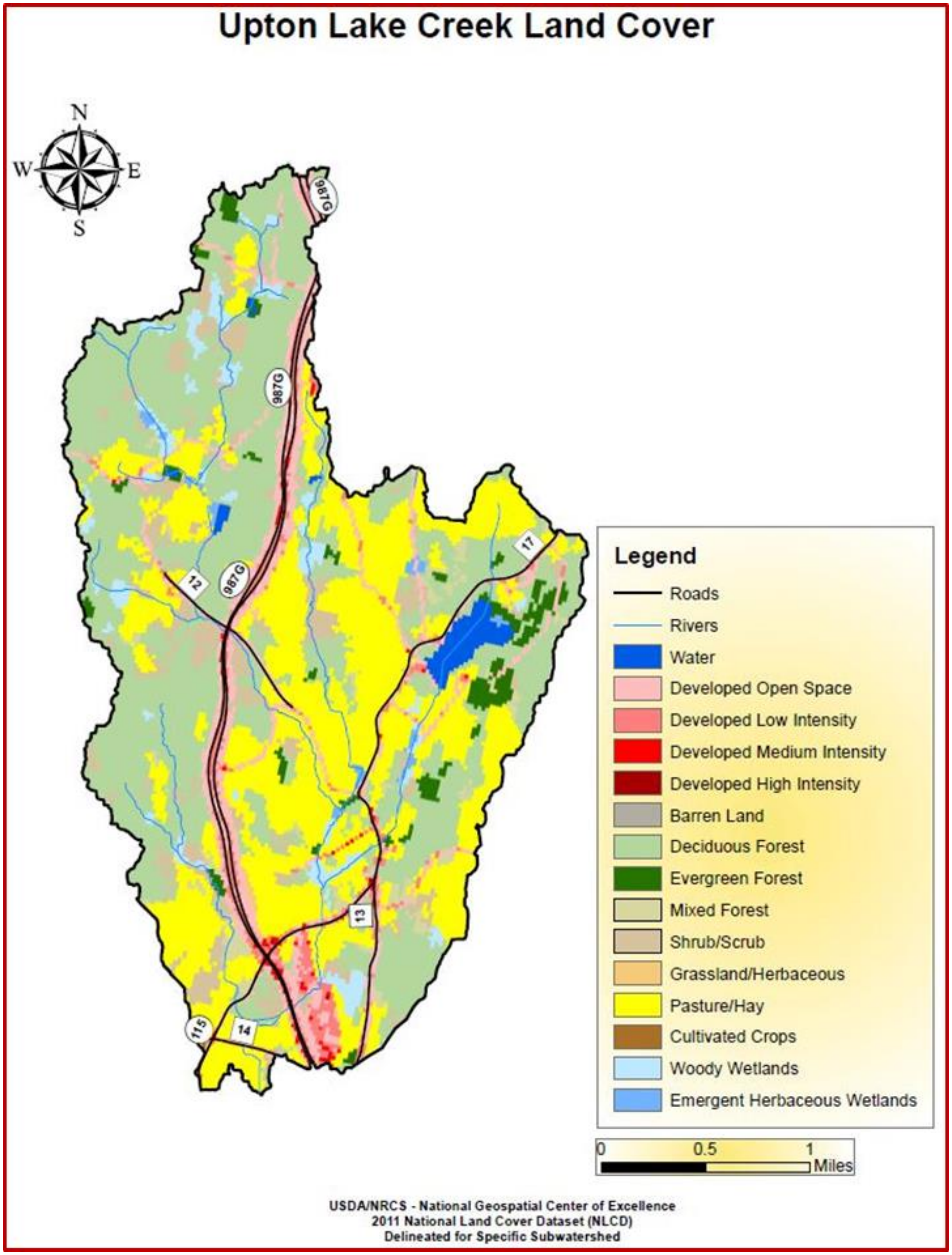


Figure 8.11 Upton Lake Creek Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Upton Lake Creek Subwatershed

- Septic Systems - This subwatershed releases a model estimated yearly phosphorus load of 249 pounds from septic systems.

Key Recommendations for Upton Lake Creek Subwatershed

- Work with landowners to reduce pollution from on-site septic systems and encourage the use of alternative/innovative wastewater treatment systems such as cluster/community-based septic systems, sand filters, constructed wetlands, or composting toilets.

8.12 Wappingers Falls

The Wappingers Falls subwatershed encompasses 5,411 acres, located southern portion of the Wappinger Creek Watershed and includes portions of towns of Wappinger and Fishkill and Village of Wappingers Falls. Subwatershed land use consists of 4% agriculture, 44% forest, 13% wetlands and waterbodies, and 39% developed land. This subwatershed is substantially residential. The dominant soil types are Dutchess-Cardigan complex (55%) and Bernardston silt loam (14%). The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Bernardston silt loam soils are well drained with moderately low to moderately high hydraulic conductivity. These soils tend to have moderate permeability in the surface layer and subsoil and slow permeability in the dense substratum with moderate erosion hazard. They tend to be poor for septic system siting due to slow percolation. Based on the NRCS web soil survey soil characteristics, 62% of the soils in this subwatershed tend to be poor for septic siting.

This subwatershed is comprised of smaller streams with NYSDEC classifications B and C (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). They discharge directly into Wappinger Creek. These waters are suitable for swimming (Class B), fishing, and boating (Class C). Almost 79 percent of the riparian areas in this subwatershed are naturally vegetated. This subwatershed has two known SPDES sites.

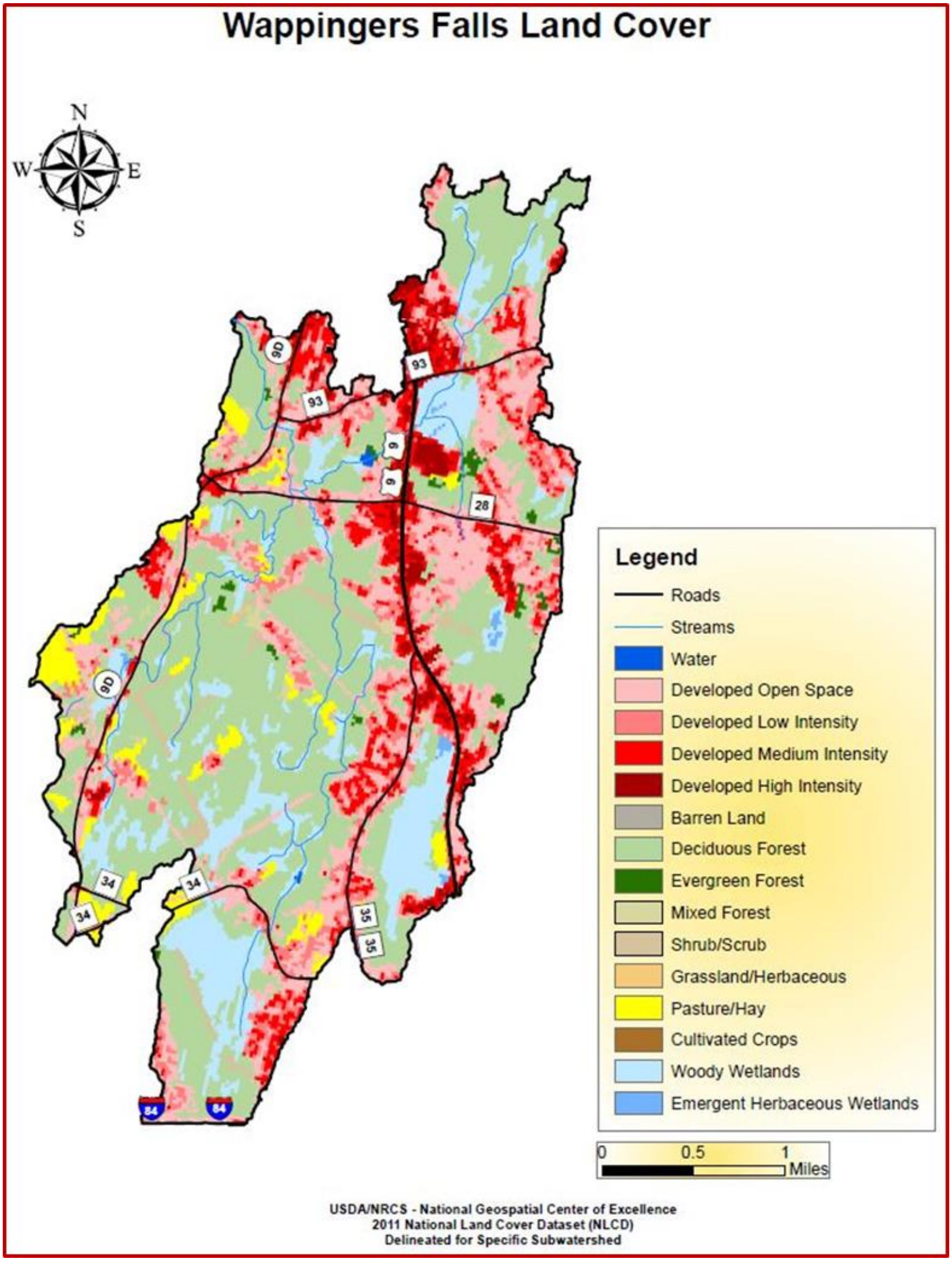


Figure 8.12 Wappingers Falls Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Wappingers Falls Subwatershed:

- Total Nitrogen Load - This subwatershed releases a total yearly nitrogen load of 0.58 pounds per acre from land cover sources. Of the total land cover source nitrogen load, 85 percent comes from developed lands.
- Total Phosphorus Load - This subwatershed releases a total yearly phosphorus load of 0.059 pounds per acre from land cover sources. Of the total land cover source phosphorus load, 81 percent comes from developed lands.
- Point Sources - This subwatershed has two SPDES sites, which release a model estimated yearly point source phosphorus load of 680 pounds.

Key Recommendations for Wappingers Falls Subwatershed

- Municipalities should consider opportunities to retrofit existing properties with new facilities, such as stormwater detention/retention ponds; also attempt natural conveyance restoration wherever possible.
- Promote lawn care practices and educate residential and property owners about using phosphorus-free products, cleaning up pet waste.
- Amend the permits for the two SPDES facilities in the subwatershed to monitor phosphorus and establish phosphorus permit limits.

8.13 Willow Brook

The Willow Brook subwatershed is 2,427 acres and is smallest of all the subwatersheds. Located in the north-central portion of the watershed it includes portions of town of Stanford. Subwatershed land use consists of 41% agriculture, 47% forest, 5% wetlands and waterbodies, and 7% developed land. Willow Brook contains the highest amount of agricultural land use. The dominant soil types in the subwatershed are Nassau-Cardigan complex (24%) and Dutchess-Cardigan complex (23%). The Nassau-Cardigan complex soils are somewhat excessively drained with low to moderately low hydraulic conductivity. These soils tend to have moderate permeability with slight erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. The Dutchess-Cardigan complex soils are well drained with moderately high to high hydraulic conductivity. These soils tend to have moderate permeability with moderate erosion hazard and tend to be poor for septic system siting due to shallow depth to bedrock and rock outcroppings. Based on the NRCS web soil survey soil characteristics, 67% of the soils in this subwatershed tend to be poor for septic siting.

The Willow Brook subwatershed streams are classified as Class C by NYSDEC, making them suitable for fishing and boating (NYSDEC, 2008. *WI/PWL Fact Sheets – Wappinger Creek/ Hudson River*). This subwatershed has no known SPDES facilities.

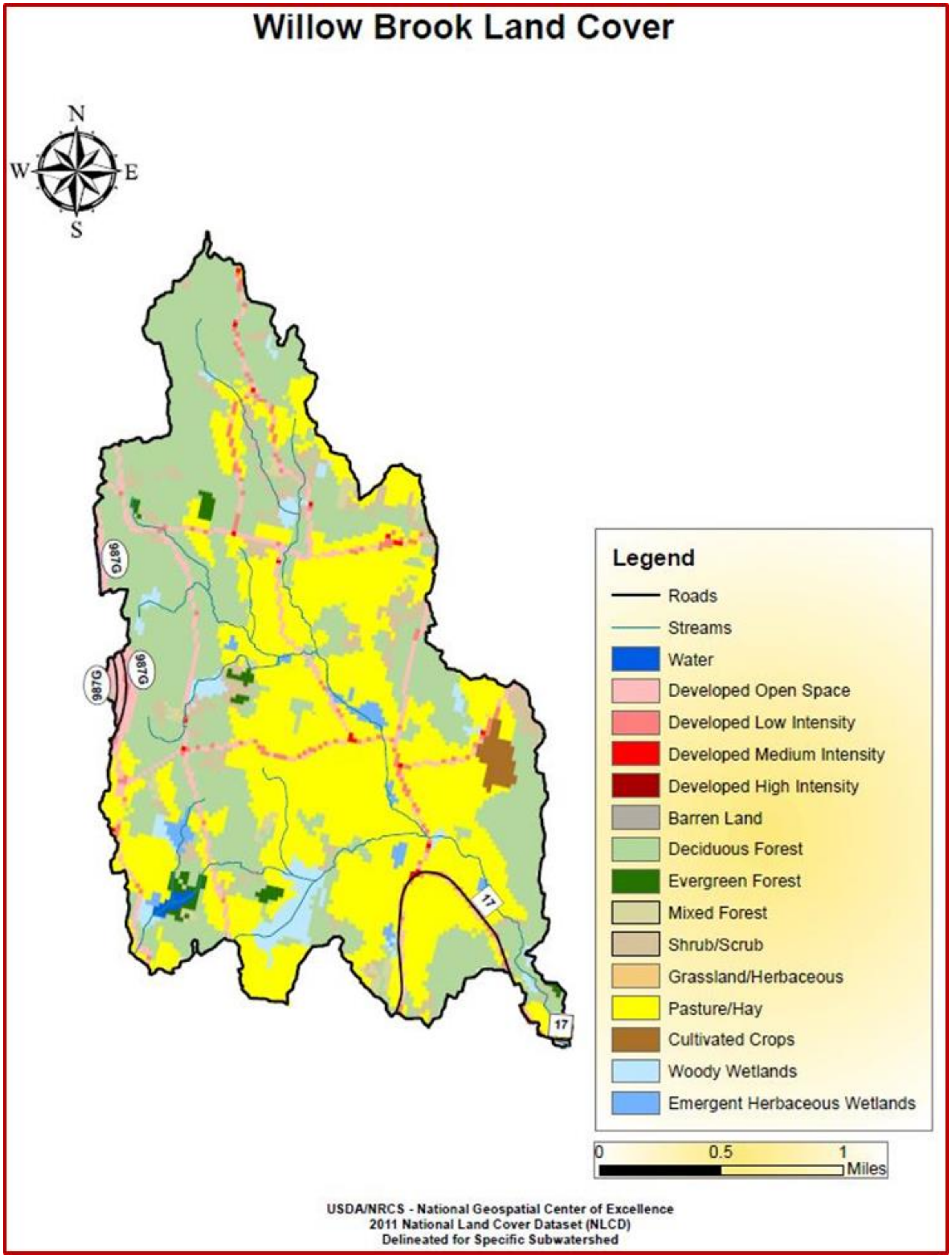


Figure 8.13 Willow Brook Subwatershed Land Cover

Summary of Key Issues

Key issues affecting water quality in the Willow Brook Subwatershed:

- Total Sediment Load – This watershed releases a yearly total sediment load of 55.2 pounds per acre from land cover sources, which is highest of all the 13 subwatersheds. Of the total land cover source sediment load, 56 percent comes from agricultural lands and 34 percent from streambanks.
- Total Phosphorus Load - This subwatershed releases a yearly total phosphorus load of 0.056 pounds per acre from land cover sources. Of the total phosphorus load, 79 percent comes from agricultural lands.
- Livestock – This subwatershed releases a model estimated yearly phosphorus load of 505 pounds from farm animal operations.
- Water Quality - This subwatershed recorded median phosphorus concentration of 0.05 mg/L exceeding the New York ambient guidance value of 0.02 mg/L to protect recreational use of waters during the 2017-2018 watershed sampling. The high phosphorus contribution can be possibly attributed to agricultural operations involving livestock and failing septic systems.

Key Recommendations for Willow Brook Subwatershed

- Agricultural landowners should continue to work with Dutchess County Soil and Water Conservation District to implement AEM program on farms in the subwatershed, focusing on identification of management practices that reduce phosphorus loads.
- Restore and stabilize streambanks, particularly in areas characterized by steep slopes (> 15%) and highly erodible lands.
- Reduce access of livestock to streams and stream banks vulnerable to erosion.

9.0 Best Management Practices

Many stormwater BMPs address both water quantity and quality, however, some BMPs are more effective at reducing sediment and nutrients than others. The stormwater practices listed below keep the focus on techniques to reduce the impacts of stormwater runoff from agricultural and impervious surfaces. These BMPs were selected specifically for three reasons: 1) effectiveness for water quality improvement, 2) willingness among the public to adopt, and 3) implementable without limitations by other controls.

Agricultural Best Management Practices

Cover Crops

Cover Crops are annual or perennial crops that protect the soil from erosion during the time between the harvesting and planting of the primary crop. The use of such crops can also improve soil health and offer the opportunity for additional income. Additionally, cover crops can store needed nutrients over the winter, prevent their loss, and act as a type of "green" manure in the spring if the cover crop is left in the field or plowed under before planting the primary crop. Cover crops can also be used as living mulch, growing at the same time as the vegetable crop. This BMP reduces the erosion from wind and water and maintains soil health and organic matter content. Examples of cover crops that can add substantial organic matter to soil include cereal rye, oats, sorghum-sudangrass, and triticale.

Crop Rotation

Crop Rotation is a conservation practice defined as systematic planting of different crops in a specified sequence over several years in the same growing space. Crop rotations may be as simple as a 2-year rotation of corn and soybeans or an 8-year rotation of 4 years of silage corn and 4 years of hay. This BMP is primarily implemented to reduce soil erosion, thereby reducing the quantities of sediment and sediment-associated pollutants such as nitrogen and phosphorus.

Strip Cropping

Strip Cropping refers to growing planned rotations of erosion-resistant and erosion susceptible crops in a systematic arrangement of strips across a field. The strips are usually in even widths, although uneven widths may be required in areas with rolling or irregular topography. This BMP supports reduction of water and wind erosion and transport of sediment and other water and wind-borne contaminants.

Contour Farming

Contour farming refers to the practice of conducting tillage, planting and harvesting operations perpendicular to the gradient of a hill or slope to reduce erosion. It is more effective on moderate slopes of 3 to 8 percent when there are measurable ridges left from tillage and/or planting operations. This BMP reduces sheet and rill erosion and transport of sediment and other contaminants in particulate and dissolved forms. Contour farming also increases water infiltration.

Conservation Tillage

Conservation tillage refers to limiting soil disturbance to manage the amount, orientation and distribution of crop and plant residue on the soil surface year around. There are many forms of this management practice including no-till planting, mulch tillage, and other tillage techniques that leave crop residue on the soil surface. This is one of the most used BMPs and includes the use of residue from corn or soybean stalks, small grain straw, or the residue from vegetables and other crops. This BMP reduces sheet and rill erosion and excessive sediment in surface waters and maintains and increases soil health, organic matter content and plant-available moisture.

Terraces and Diversions

Terraces and diversions are earthen channels that intercept runoff on sloping land parcels, transforming long slopes into a series of shorter ones, thereby reducing runoff velocities and allowing soil particles to settle out. Terraces are designed to handle areas of concentrated flow where ephemeral gullies might otherwise form. Diversions are permanently vegetated and are often used on slopes where a terrace would be too expensive or difficult to build, maintain, or grow crops on. These BMPs are usually most effective when used in combination with other conservation practices such as crop residue management, contour farming and crop rotation.

Grazing Land Management

Grazing land management refers to the utilization of practices that ensure adequate vegetation cover to prevent excessive soil erosion due to over-grazing and other forms of overuse. Grazing land management improves soil and plant health, water quality, and minimizes off-site impacts. Rotational grazing systems are often established on improved pastureland or by planting legumes and hay as feed for livestock. In addition to providing feed for livestock, establishing grasses and legumes as part of crop rotations also protects land areas from excessive soil erosion and adds needed nitrogen to the soil base.

Buffers and Vegetative Filter Strips

Buffers and filter strips are areas of permanent herbaceous vegetation located within and between agricultural fields and the water courses to which they drain and are intended to intercept and slow runoff thereby providing water quality benefits. In addition, in many settings they are also intended to intercept shallow groundwater moving through the root zone below the buffer.

Streambank Protection

Streambank Protection refers to several practices that can be employed to mitigate the effects of eroding and slumping stream banks on the adjacent streams. The most frequently used form of protection includes fencing, stable crossings, and streambank stabilization. Fencing prohibits cattle from trampling stream banks, destroying protective vegetation, and stirring up sediment in the streambed. Stable crossings allow for the movement of animals across streams while at the same time reducing impacts to streambanks. Streambank stabilization includes installation of riprap, gabion walls, or a “bio-engineering” solution of some type along the edges of a stream to protect the banks during periods of heavy stream flow, thereby reducing direct stream bank erosion. the banks are often covered with rocks, grass, trees, shrubs, and other protective surfaces to reduce erosion as well.

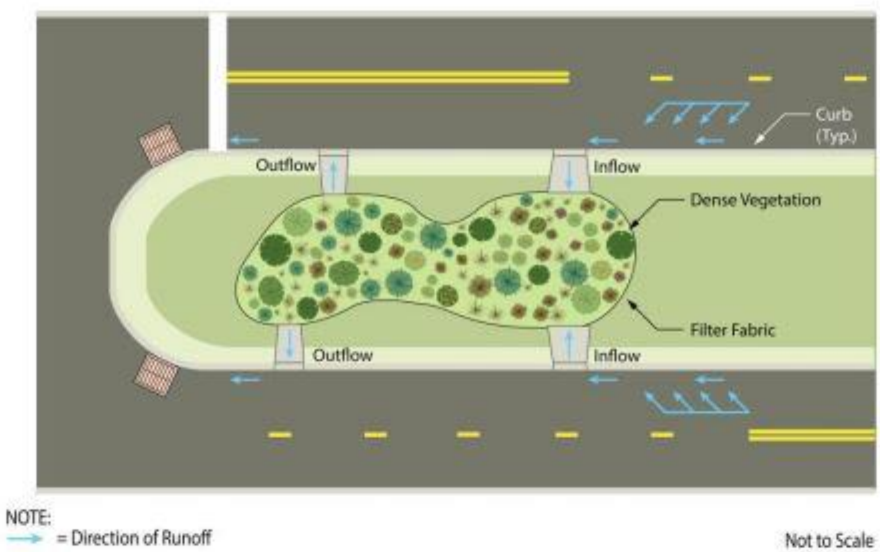
Animal Waste Management Systems

Animals Waste Management Systems refer to systems that are designed for proper handling, storage, and utilization of wastes generated from animal confinement operations and include a means of collecting, scraping and washing wastes from confinement areas into appropriate waste storage structures such as lagoons, ponds, or steel or concrete tanks. Controlling runoff from roofs, feedlots and loafing areas are also part of these systems. Proper and adequate storage ensures wastes are only applied when crops use the accompanying nutrients and soil and weather conditions are appropriate.

Developed Land and Highway Best Management Practices

Bioretention Systems

Bioretention systems are vegetated stormwater management facilities that are used to remove a wide range of pollutants from land development sites; these pollutants include suspended solids, nutrients, metals, hydrocarbons and bacteria. Bioretention areas are designed as small-scale vegetated depressions to provide stormwater storage and filtration through engineered media. These areas offer flexibility in design and can easily be incorporated into new or existing infrastructure such as parking lot islands and edges, street rights-of-way and medians, roundabouts, pedestrian walkways, public transit stops, or building drainage areas.



An example of Median Bioretention Systems (Source: NJDEP)

Cisterns and Rain Barrels

Cisterns and rain barrels are storage vessels used to collect, store rooftop runoff from a downspout for later use (typically for irrigation or toilet flushing). These systems are sized according to rooftop area and desired volume and can be used to collect both residential and commercial building runoff. Cisterns are available commercially in numerous sizes, shapes, and materials.

Cistern for collection of rooftop runoff (Photo: New Baltimore Welcome Center, Greene County, NY)

Rooftop Disconnection

Rooftop disconnection is one of the simplest means of reducing stormwater from residential lots. This practice takes roof runoff that has been collected in gutters and piped directly to streets, storm drains, and streams and redirects it away from impervious surfaces to landscaped areas. It is a very sustainable practice because it controls pollutants in runoff near their source. Redirected runoff is infiltrated, filtered, treated or reused prior to draining to a stormwater conveyance system.

Simple Rooftop Disconnection – (Photo: Center for Watershed Protection)

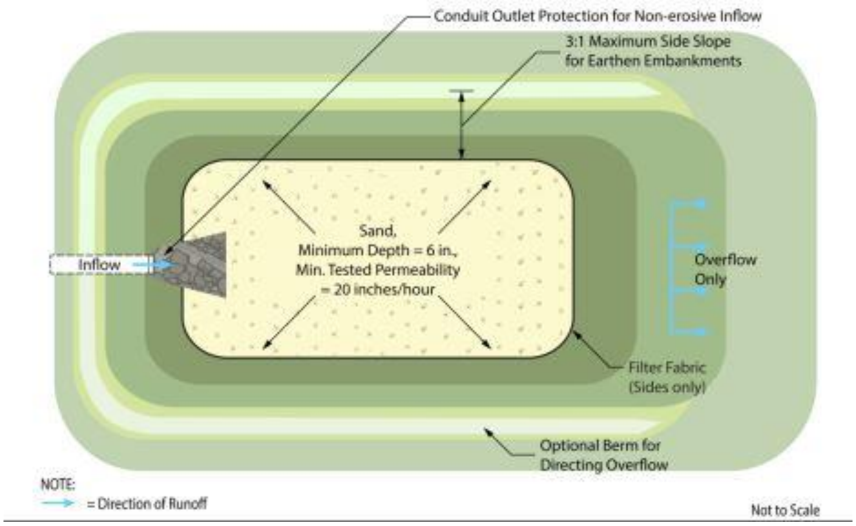
Permeable Pavement

Permeable pavement allows for percolation of stormwater through subsurface aggregate and offers an alternative to conventional concrete and asphalt paving. Typically, stormwater that drains through the permeable surface infiltrates to underlying soils and excess runoff drains through perforated underdrain pipes. The use of permeable pavement is encouraged for sites such as parking lots, driveways, pedestrian plazas, rights-of-way, and other lightly traveled areas.

Pervious Pavers in Parking Lot (Photo : San Diego County LID Handbook)

Infiltration Basins

Infiltration basins are stormwater management systems constructed with highly permeable components designed to both maximize the removal of pollutants from stormwater and to promote groundwater recharge. These systems are constructed in areas of highly permeable soil that provide temporary storage of stormwater runoff and can help reduce increases in both the peak rate and total volume of runoff caused by land development. Pollutants in runoff are treated through the processes of filtration through and biological and chemical activity within the soil.



An example of Surface Infiltration Basin (Source: NJDEP)

Green Roofs

Green roofs are vegetated surfaces generally installed on flat or gently sloped rooftops consisting of drought tolerant vegetation grown in a thin layer of media underlain by liner and drainage components. Vegetated roofs can be implemented on a wide range of building types and settings and can integrate with other roof infrastructure such as HVAC components, walkways, and solar panels. Green roofs can serve as passive recreation areas and provide wildlife habitat.

Green Roof (Photo: High Line Park, NYC)

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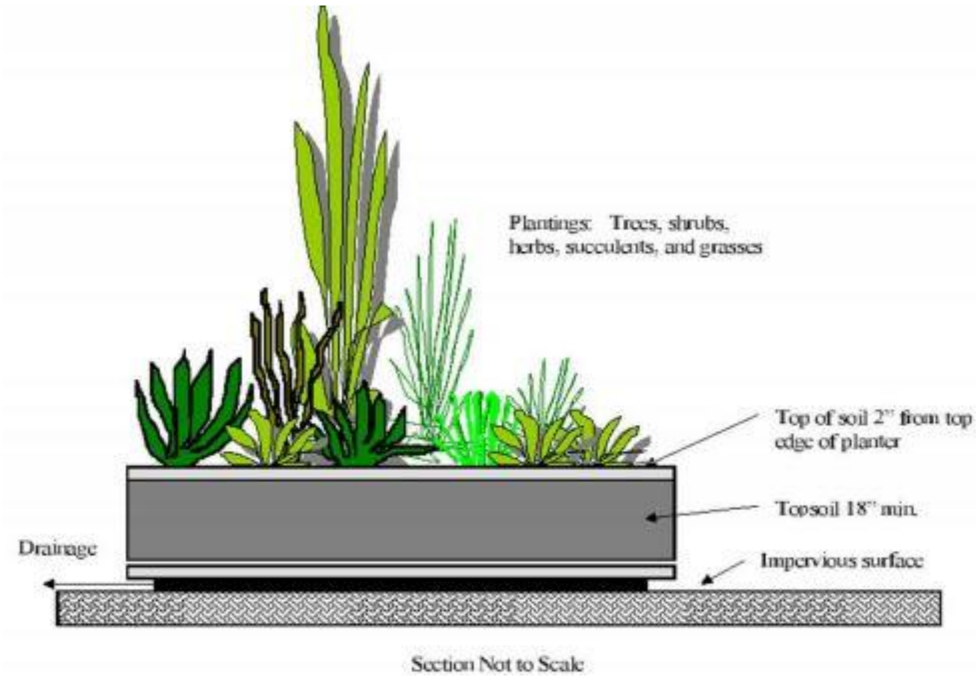
Planter Boxes

A stormwater planter is a small, contained vegetated area that collects and treats stormwater using infiltration or filtering practices. Stormwater planters use soil infiltration and biogeochemical processes to decrease stormwater quantity and improve water quality, similar to rain gardens and green roofs. Three versions of stormwater planters include contained planters, infiltration planters, and flow-through planters. Stormwater planters do not require a large amount of space and can add aesthetic appeal and wildlife habitat to city streets, parking lots, and commercial and residential properties. Stormwater planters typically contain native, hydrophilic flowers, grasses, shrubs and trees.



Contained stormwater planter (Source: NYSDEC)

Street Sweeping

Street sweeping reduces the potential loading of sediment and debris into waterbodies, as well as associated pollutants that may be adsorbed or absorbed by sediments. Vacuum-assisted street sweeping offers an alternative method for stormwater management to areas that may have limitations for the installation of structural practices to control stormwater runoff. Factors to consider for street sweeping may consist of categorizing roads based on traffic volumes, number of accidents (increased likelihood of spills), number of catch basins, proximity to wetlands and watercourses, amount of litter and debris, and tree cover.

10.0 Financial and Technical Assistance Needed

Most, if not all of the management practices recommended will require some financial investment. Costs associated with the development and implementation of each proposed measure will need to be estimated individually as management strategies are undertaken.

A variety of local, state, and federal sources are potentially available to provide funding for water quality improvement implementations and municipal outreach efforts, in addition to potential funds contributed by local grassroots organizations and concerned citizens. Highway/public works departments include annual budget line items for infrastructure repair, maintenance and improvements. Conservation Commission and Park & Recreation Commission budgets can include line items for environmental education and outreach programs/campaigns and materials. When municipalities apply for outside grants, loans and/or foundation support, they can leverage local funds as match. Additionally, numerous grant applications are strengthened by the availability of in-kind services provided by municipal staff.

Financial assistance in the form of grants and cost-sharing is available from multiple sources, including federal, state, and local sources. These include but not limited to, US Environmental Protection Agency (Clean Water Act 319 Non-Point Source Program); Natural Resources Conservation Service (Agricultural Management Assistance, Conservation Stewardship Program (CSP), Environmental Quality Incentives Program (EQIP)), Department of State, NYSDEC (Clean Water Act Section 604(b) Water Quality Planning Grants, Water Quality Improvement Project (WQIP) Program, NYS DEC/EFC Wastewater Infrastructure Engineering Planning Grant (EPG)), Department of Housing and Development (Community Development Block Grant (CDGB)), New England Interstate Water Pollution Control Commission. Local and regional sources may include banks, chambers of commerce, civic/social organizations, private, commercial, and institutional foundations, and environmental/professional organizations grants.

Appendix A

Summary of Land Cover by Subwatershed

Summary of Land Cover by Subwatershed

Subwatershed	Water		Developed Open Space		Developed Low Intensity		Developed Medium Intenstity		Developed High Intensity		Barren Land		Deciduous Forest		Evergreen Forest		Mixed Forest		Shrub/Scrub		Grassland/Herbaceous		Hay/Pasture		Cultivated Crops		Woody Wetlands		Emergent Wetlands		Total	
	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area
Cold Spring Creek	48.0	0.7	160.0	2.3	26.0	0.4	3.0	0.0	1.0	0.0	0.0	0.0	4597.0	65.8	414.0	5.9	88.0	1.3	345.0	4.9	8.0	0.1	728.0	10.4	0.0	0.0	553.0	7.9	21.0	0.3	**6992.0**	**100**
Direct Drainage to Wappinger Creek	311.0	0.9	3743.0	10.5	1993.0	5.6	1366.0	3.8	445.0	1.2	131.0	0.4	14109.0	39.5	1225.0	3.4	547.0	1.5	1246.0	3.5	33.0	0.1	7078.0	19.8	742.0	2.1	2059.0	5.8	675.0	1.9	**35703.0**	**100**
Dutchess County Airport	27.0	0.4	1421.0	18.9	984.0	13.1	520.0	6.9	75.0	1.0	1.0	0.0	2364.0	31.4	63.0	0.8	136.0	1.8	306.0	4.1	6.0	0.1	933.0	12.4	22.0	0.3	597.0	7.9	63.0	0.8	**7518.0**	**100**
East Branch Wappinger Creek	96.0	0.4	1251.0	5.8	391.0	1.8	154.0	0.7	31.0	0.1	3.0	0.0	10005.0	46.5	764.0	3.6	225.0	1.0	625.0	2.9	14.0	0.1	6196.0	28.8	305.0	1.4	1244.0	5.8	218.0	1.0	**21522.0**	**100**
Great Spring Creek	64.0	0.6	508.0	5.1	346.0	3.5	137.0	1.4	16.0	0.2	5.0	0.0	3673.0	36.7	170.0	1.7	209.0	2.1	619.0	6.2	3.0	0.0	3009.0	30.1	101.0	1.0	1005.0	10.0	146.0	1.5	**10011.0**	**100**
Grist Mill Creek	16.0	0.4	135.0	3.6	37.0	1.0	2.0	0.1	0.0	0.0	0.0	0.0	1757.0	47.3	88.0	2.4	39.0	1.0	280.0	7.5	0.0	0.0	950.0	25.6	0.0	0.0	378.0	10.2	29.0	0.8	**3711.0**	**100**
Hunns Lake Creek	94.0	1.9	139.0	2.8	42.0	0.9	12.0	0.3	3.0	0.1	2636.0	53.8	63.0	1.3	36.0	0.7	0.0	0.0	20.0	0.4	0.0	0.0	1528.0	31.2	65.0	1.3	215.0	4.4	47.0	1.0	**4900.0**	**100**
Little Wappinger Creek	189.0	0.9	1128.0	5.3	353.0	1.7	77.0	0.4	6.0	0.0	0.0	0.0	11906.0	56.0	672.0	3.2	292.0	1.4	1441.0	6.8	8.0	0.0	3616.0	17.0	58.0	0.3	1296.0	6.1	236.0	1.1	**21278.0**	**100**
Overlook Road	7.0	0.2	562.0	13.3	439.0	10.4	302.0	7.2	102.0	2.4	0.0	0.0	1635.0	38.9	114.0	2.7	94.0	2.2	117.0	2.8	3.0	0.1	500.0	11.9	22.0	0.5	278.0	6.6	32.0	0.8	**4207.0**	**100**
Pleasant Valley East	22.0	0.3	561.0	7.6	214.0	2.9	76.0	1.0	9.0	0.1	0.0	0.0	4281.0	57.9	280.0	3.8	168.0	2.3	245.0	3.3	2.0	0.0	1074.0	14.5	50.0	0.7	376.0	5.1	31.0	0.4	**7389.0**	**100**
Upton Lake Creek	54.0	1.3	318.0	7.8	159.0	3.9	27.0	0.7	1.0	0.0	0.0	0.0	1591.0	39.0	93.0	2.3	81.0	2.0	290.0	7.1	3.0	0.1	1311.0	32.2	0.0	0.0	126.0	3.1	22.0	0.5	**4076.0**	**100**
Wappingers Falls	5.0	0.1	941.0	17.4	527.0	9.7	491.0	9.1	157.0	2.9	0.0	0.0	2177.0	40.2	37.0	0.7	36.0	0.6	97.0	1.8	2.0	0.0	225.0	4.2	0.0	0.0	703.0	13.0	14.0	0.3	**5412.0**	**100**
Willow Brook	6.0	0.2	124.0	5.1	45.0	1.8	5.0	0.2	0.0	0.0	0.0	0.0	987.0	40.7	23.0	0.9	24.0	1.0	112.0	4.6	0.0	0.0	979.0	40.3	18.0	0.8	74.0	3.0	31.0	1.3	**2428.0**	**100**
Total	**939.0**	**0.7**	**10991.0**	**8.1**	**5556.0**	**4.1**	**3172.0**	**2.3**	**846.0**	**0.6**	**2776.0**	**2.1**	**59145.0**	**43.8**	**3979.0**	**2.9**	**1939.0**	**1.4**	**5743.0**	**4.2**	**82.0**	**0.1**	**28127.0**	**20.8**	**1383.0**	**1.0**	**8904.0**	**6.6**	**1565.0**	**1.2**	**135147.0**	**100.0**

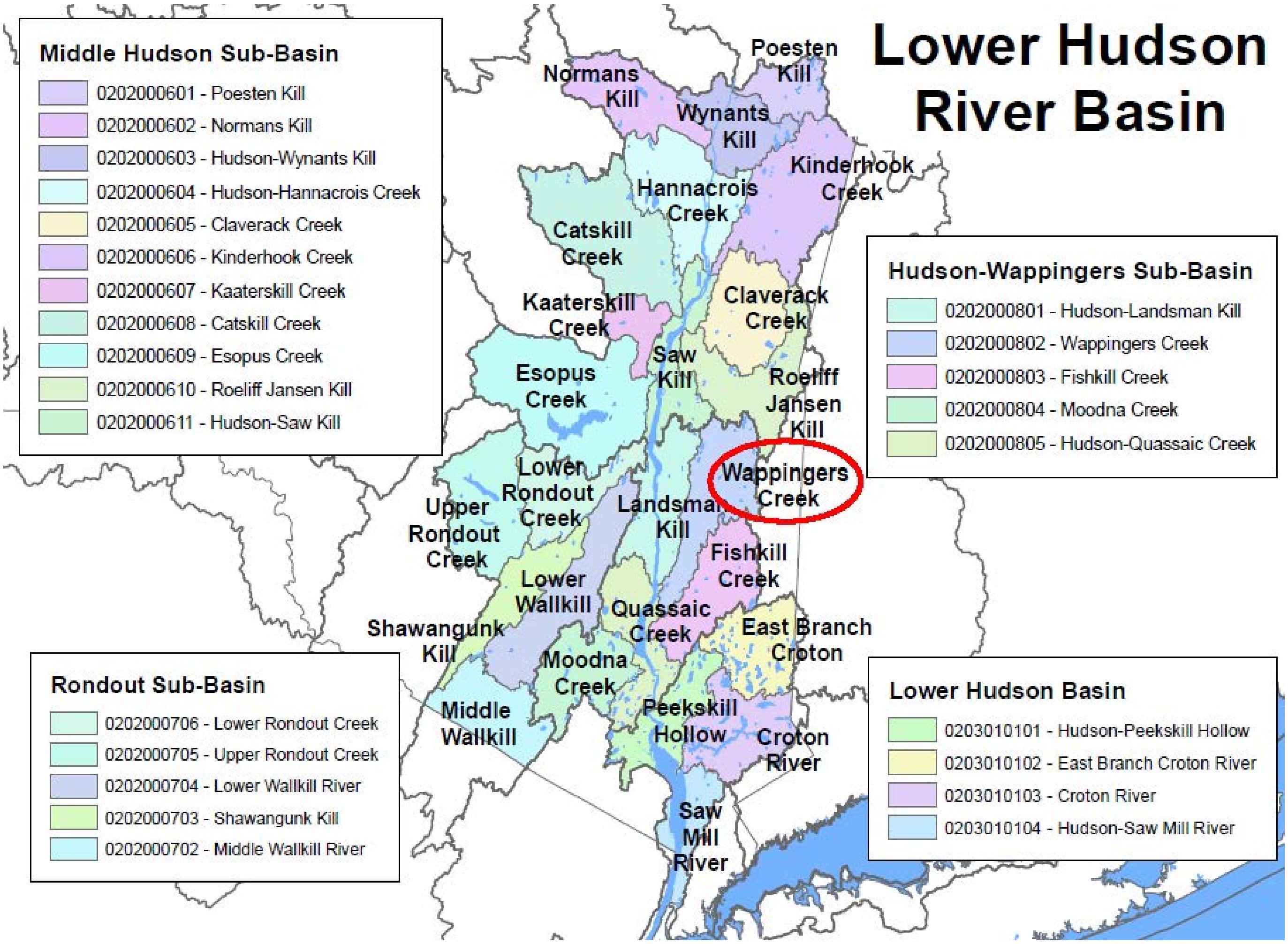
Appendix B

Summary of Land Use by Subwatershed

Summary of Land Uses by Subwatershed																						
Subwatershed	**No Data**		**Agricultural**		**Residential**		**Vacant Land**		**Commercial**		**Recereation & Entertainment**		**Community Services**		**Industrial**		**Public Services**		**Parklands**		**Totals**	
	Acres	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Cold Spring Creek	0.0	0.0	206.0	2.9	3218.0	46.0	2254.0	32.2	15.0	0.2	0.0	0.0	31.0	0.4	0.0	0.0	0.0	0.0	1268.0	18.1	**6992.0**	**100.0**
Direct Drainage to Wappinger Creek	97.0	0.3	5951.0	16.7	17373.0	48.7	6273.0	17.6	1225.0	3.4	565.0	1.6	1321.0	3.7	678.0	1.9	663.0	1.9	1558.0	4.4	**35704.0**	**100.0**
Dutchess County Airport	76.0	1.0	474.0	6.3	4035.0	53.7	1767.0	23.5	344.0	4.6	72.0	1.0	220.0	2.9	114.0	1.5	335.0	4.5	83.0	1.1	**7520.0**	**100.0**
East Branch Wappinger Creek	33.0	0.2	8403.0	39.0	7480.0	34.8	3299.0	15.3	174.0	0.8	206.0	1.0	1717.0	8.0	47.0	0.2	160.0	0.7	0.0	0.0	**21519.0**	**100.0**
Great Spting Creek	1.0	0.0	1672.0	16.7	5842.0	58.3	1759.0	17.6	306.0	3.1	100.0	1.0	103.0	1.0	28.0	0.3	202.0	2.0	0.0	0.0	**10013.0**	**100.0**
Grist Mill Creek	0.0	0.0	277.0	7.5	2320.0	62.5	1108.0	29.9	0.0	0.0	0.0	0.0	6.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	**3711.0**	**100.0**
Hunns Lake Creek	67.0	1.4	1611.0	32.9	2137.0	43.6	936.0	19.1	32.0	0.7	0.0	0.0	42.0	0.9	74.0	1.5	2.0	0.0	0.0	0.0	**4901.0**	**100.0**
Little Wappinger Creek	3.0	0.0	1954.0	9.2	11963.0	56.2	6178.0	29.0	266.0	1.2	119.0	0.6	487.0	2.3	3.0	0.0	12.0	0.1	291.0	1.4	**21276.0**	**100.0**
Overlook Road	16.0	0.4	672.0	16.0	2815.0	66.9	8.0	0.2	352.0	8.4	8.0	0.2	22.0	0.5	7.0	0.2	121.0	2.9	188.0	4.5	**4209.0**	**100.0**
Pleasant Valley East	0.0	0.0	1066.0	14.4	3915.0	53.0	1772.0	24.0	236.0	3.2	227.0	3.1	60.0	0.8	5.0	0.1	91.0	1.2	16.0	0.2	**7388.0**	**100.0**
Upton Lake Creek	0.0	0.0	351.0	8.6	2574.0	63.1	837.0	20.5	13.0	0.3	0.0	0.0	279.0	6.8	0.0	0.0	0.0	0.0	23.0	0.6	**4077.0**	**100.0**
Wappingers Falls	121.0	2.2	115.0	2.1	2486.0	45.9	1588.0	29.3	433.0	8.0	100.0	1.9	507.0	9.4	0.0	0.0	51.0	0.9	9.0	0.2	**5410.0**	**100.0**
Willow Brook	0.0	0.0	550.0	22.7	1327.0	54.7	547.0	22.5	1.0	0.0	0.0	0.0	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**2427.0**	**100.0**
Total	**414.0**	**0.3**	**23302.0**	**17.2**	**67485.0**	**49.9**	**28326.0**	**21.0**	**3397.0**	**2.5**	**1397.0**	**1.0**	**4797.0**	**3.5**	**956.0**	**0.7**	**1637.0**	**1.2**	**3436.0**	**2.5**	**135147.0**	**100.0**

Appendix C

Wappinger Creek WI/PWL



Wappingers Creek
(0202000802)

Water Index Number	Waterbody Name	Waterbody Category
H-101 (portion 1)	Wappingers Cr, Lower, and minor tribs (1305-0012)	UnAssessed
H-101 (portion 2)/P365	Wappingers Lake (1305-0001)	Impaired Seg
H-101 (portion 3)	Wappingers Cr, Middle, and minor tribs (1305-0013)	Need Verific
H-101 (portion 4)	Wappingers Cr, Middle, and minor tribs (1305-0014)	NoKnownImpct
H-101 (portion 5)	Wappingers Cr, Upper, and tribs (1305-0011)	NoKnownImpct
H-101- 1- 1a	Unnamed Trib to Hughsonville Cr (1305-0015)	UnAssessed
H-101- 4	Unnamed Trib to Wappingers Cr and tribs (1305-0016)	UnAssessed
H-101- 4- 2- 1-P366b	Lake Oniad (1305-0017)	UnAssessed
H-101-11	Unnamed Trib to Wappingers Cr and tribs(1305-0018)	UnAssessed
H-101-12	Great Spring Brook and tribs (1305-0030)	NoKnownImpct
H-101-18	Little Wappingers Cr, Lower, and tribs (1305-0019)	NoKnownImpct
H-101-18	Little Wappingers Cr, Upper, and tribs (1305-0020)	UnAssessed
H-101-18-11-P375	Long Pond (1305-0003)	Need Verific
H-101-18-13-P378	Silver Lake (1305-0002)	Need Verific
H-101-18-13-P378- 1-P379	Mud Pond (1305-0021)	UnAssessed
H-101-20-P384	Upton Lake (1305-0005)	Need Verific

H-101-21	East Br Wappingers Cr, Lower, and tribs (1305-0022)	UnAssessed
H-101-21	East Br Wappingers Cr, Upper, and tribs (1305-0023)	UnAssessed
H-101-21- 7-P395	Round Pond (1305-0024)	UnAssessed
H-101-21-P390	Dieterich Pond (1305-0025)	UnAssessed
H-101-21-P396	Shaw Pond (1305-0026)	UnAssessed
H-101-30..P401,P403	Ryder Pond, Hunns Lake (1305-0004)	**Need Verific**
H-101-31- 4- 2-P405	Miller Pond (1305-0027)	UnAssessed
H-101-38-P407	Halcyon Pond (1305-0028)	UnAssessed
H-101-P408,P409,P410	Thompson, Stissing, Mud/Twin Isl Ponds(1305-0010)	**Need Verific**

Wappingers Lake (1305-0001) Impaired Seg

Waterbody Location Information

Revised: 07/11/2008

Water Index No: H-101 (portion 2)/P365
Hydro Unit Code: 02020008/060 **Str Class:** B
Waterbody Type: Lake
Waterbody Size: 80.2 Acres
Seg Description: entire lake

Drain Basin: Lower Hudson River
Low Hudson-Wappinger
Reg/County: 3/Dutchess Co. (14)
Quad Map: WAPPINGERS FALLS (O-25-4)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
PUBLIC BATHING	Impaired	Known
Aquatic Life	Stressed	Possible
RECREATION	Impaired	Known
Aesthetics	Stressed	Known

Type of Pollutant(s)

Known: NUTRIENTS (phosphorus), Algal/Weed Growth (aquatic vegetation)
Suspected: SILT/SEDIMENT
Possible: Pathogens

Source(s) of Pollutant(s)

Known: - - -
Suspected: URBAN/STORM RUNOFF, Agriculture, Construction (resident.develop.), Hydro Modification
Possible: Streambank Erosion, Other Sanitary Disch

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 4 (Source Identified, Strategy Needed)
Lead Agency/Office: DOW/Reg3 **Resolution Potential:** Medium
TMDL/303d Status: 3a->1

Further Details

Overview
Public bathing and other recreational uses in Wappingers Lake are impaired by nutrient (phosphorus) and silt/sediment loadings attributed to urban runoff and other nonpoint sources.

Water Quality Sampling
Wappingers Lake was sampled as part of the NYSDEC Lake Classification and Inventory (LCI) Program in 2003. Results of this sampling indicate that the lake is best characterized as eutrophic, or highly productive. Average phosphorus levels (60 ug/l) in the lake easily exceed the state guidance values indicating impacted/stressed recreational uses (20 ug/l). Corresponding transparency measurements also fail to meet what is the recommended minimum for swimming beaches. Upstream tributaries transport considerable silt and sediment to the lake. Urban/stormwater runoff in this highly developed urban/suburban watershed are thought to be a significant source of nutrient and silt/sediment loadings. Some of the remaining agriculture operations in the watershed may also contribute to the water quality impacts on the lake. (DEC/DOW, BWAM/SWQM, October 2005)
Lake Uses
This lake waterbody is designated class B, suitable for use as a public bathing beach, general recreation and aquatic life

support, but not as a water supply. Water quality monitoring by NYSDEC focuses primarily on support of general recreation and aquatic life. Samples to evaluate the bacteriological condition and bathing use of the lake or to evaluate contamination from organic compounds, metals or other inorganic pollutants have not been collected as part of the CSLAP monitoring program. Monitoring to assess potable water supply and public bathing use is generally the responsibility of state and/or local health departments.

Section 303(d) Listing

Wappingers Lake is included on the NYS 2008 Section 303(d) List of Impaired Waters due to phosphorus and silt/sediment. The lake is included on Part 3 of the List as an Impaired Water for which TMDL Development May be Deferred due to the need to verify the impairment, the pollutant, or pending implementation/evaluation of other restoration measures. However this updated assessment suggests that the suspected impairments are confirmed and the lake be moved to Part 1 of the List as Waterbody Requiring TMDL Development (or other strategy to attain water quality standards). This waterbody was first listed on the 1996 Section 303(d) List for phosphorus and in 2002 for silt/sediment.

Wappingers Cr, Middle, and minor tribs (1305-0013) Need Verific

Waterbody Location Information

Revised: 06/05/2008

Water Index No: H-101 (portion 3) **Drain Basin:** Lower Hudson River
Hydro Unit Code: **Str Class:** B(T)
Waterbody Type: River **Reg/County:** 3/Dutchess Co. (14)
Waterbody Size: 42.7 Miles **Quad Map:** PLEASANT VALLEY (O-25-2)
Seg Description: stream and select tribs, fr Wapp.Falls to Pleasnt.Vall.

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Recreation	Stressed	Possible

Type of Pollutant(s)
Known: - - -
Suspected: PATHOGENS, Metals
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: Tox/Contam. Sediment
Possible: UNKNOWN SOURCE, On-Site/Septic Syst

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/Reg3 **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in this portion of Wappingers Creek may experience impacts due to elevated pathogen levels from as yet unidentified sources. Slightly elevated levels of some metals in sediments have also been noted.

Water Quality Sampling
NYSDEC Rotating Intensive Basin Studies (RIBS) Intensive Network monitoring of Wappingers Creek in Poughkeepsie, Dutchess County, (at Jackson Road) was conducted in 2003. Intensive Network sampling typically includes macroinvertebrate community analysis, water column chemistry, sediment and invertebrate tissues analysis and toxicity evaluation. During this sampling the biological (macroinvertebrate) sampling results indicated non-impacted water quality conditions. Water column sampling revealed iron and coliform to be parameters of concern. However, iron can be considered to be naturally occurring and not a source of water quality impacts. Bottom sediment sampling results revealed various metals (copper, nickel, zinc) to be exceeding the Threshold Effects level - levels at which adverse impacts occasionally occur. Toxicity testing of the water column showed significant mortality and reproductive impacts in one of three test. Based on the consensus of these established assessment methods, overall water quality at this site is thought to experience impacts to uses that need further investigation. (DEC/DOW, BWAM/RIBS, January 2005)

A biological (macroinvertebrate) assessment of Wappingers Creek at this site was also conducted in 2002 during the

Biological Screening effort in the basin. Sampling results also indicated non-impacted water quality conditions. The sampling was part of a biological (macroinvertebrate) survey of Wappingers Creek at multiple sites between Wappingers Falls and Stanfordville. Sampling results indicated non-impacted water quality conditions at most sites. Excellent water quality was noted at four of the five sites sampled, including the three sites within this reach. Water quality at the most upstream site in Stanfordville was assessed as slightly impacted, however nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. These condition represent an improvement from previous sampling which should most sites to be slightly impacted. (DEC/DOW, BWAM/SBU, June 2005)

Segment Description
This segment includes the portion of the stream and selected/smaller tribs from Wappingers Lake (P365) in Wappingers Falls to unnamed trib (-11) in Pleasant Valley. The waters of this portion of the stream are Class B,B(T). Tribs to this reach/segment are Class B,B(T),C,C(T). An unnamed trib (-4) near New Hackensack and other portions of Wappingers Creek are listed separately.

Wappingers Cr, Middle, and minor tribs (1305-0014) NoKnownImpct

Waterbody Location Information

Revised: 02/20/2008

Water Index No: H-101 (portion 4) **Drain Basin:** Lower Hudson River
Hydro Unit Code: **Str Class:** B(T)
Waterbody Type: River **Reg/County:** 3/Dutchess Co. (14)
Waterbody Size: 91.8 Miles **Quad Map:** MILLBROOK (N-26-4)
Seg Description: stream and select tribs, fr Pleasnt Val to Stanfrdville

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) survey of Wappingers Creek at multiple sites between Wappingers Falls and Stanfordville was conducted in 2002. Sampling results indicated non-impacted water quality conditions at most sites. Excellent water quality was noted at four of the five sites sampled, including two of three sites within (or representative of) this reach. Water quality at the most upstream site in Stanfordville was assessed as slightly impacted, however nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. These condition represent an improvement from previous sampling which should most sites to be slightly impacted. (DEC/DOW, BWAM/SBU, June 2005)

Segment Description
This segment includes the portion of the stream and selected/smaller tribs from to/including unnamed trib (-11) in Pleasant Valley to unnamed trib (-29) in Stanfordville. The waters of this portion of the stream are Class B(T),B(TS). Tribs to this reach/segment, including Clinton Corners Brook (-20) and Willow Brook (-27), are Class B,B(T),C,C(T),C(TS). Great Spring Brook (-12), Little Wappingers Creek (-18), East Branch (-21) and other portions of Wappingers Creek are listed separately.

Wappingers Cr, Upper, and tribs (1305-0011) NoKnownImpct

Waterbody Location Information

Revised: 02/20/2008

Water Index No: H-101 (portion 5)
Hydro Unit Code: 02020008/060 **Str Class:** C(TS)*
Waterbody Type: River
Waterbody Size: 81.5 Miles
Seg Description: stream and tribs, above Stanfordville

Drain Basin: Lower Hudson River
Low Hudson-Wappinger
Reg/County: 3/Dutchess Co. (14)
Quad Map: MILLBROOK (N-26-4)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) survey of Wappingers Creek at multiple sites between Wappingers Falls and Stanfordville was conducted in 2002. Sampling results indicated non-impacted water quality conditions at most sites. Excellent water quality was noted at four of the five sites sampled. The lone site within this reach (in Stanfordville) was assessed as slightly impacted by nonpoint sources of nutrient enrichment, however nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. These condition represent an improvement from previous sampling which should most sites to be slightly impacted. (DEC/DOW, BWAM/SBU, June 2005)

Previous Assessment
The recreational use (swimming), fishery and aesthetics in Hunns Lake Creek may be affected by agricultural runoff and streambank erosion. BMPs have been implemented on watershed croplands to address erosion and nutrient runoff. Continuing efforts by the county are focusing on the access of cattle to the stream itself. (Dutchess County WQCC, July 1999)

Segment Description

This segment includes the portion of the stream and selected/smaller tribs above unnamed trib (-29) in Stanfordville. The waters of this portion of the stream are Class C,C(TS). Tribs to this reach/segment, including Cold Spring Creek (-30), are Class B,B(T),B(TS),C,C(T),C(TS). Other portions of Wappingers Creek are listed separately.

Great Spring Brook and tribs (1305-0030) NoKnownImpct

Waterbody Location Information

Revised: 03/26/2008

Water Index No: H-101-12
Hydro Unit Code: **Str Class:** B
Waterbody Type: River (Low Flow)
Waterbody Size: 31.3 Miles
Seg Description: entire stream and tribs

Drain Basin: Lower Hudson River
Reg/County: 3/Dutchess Co. (14)
Quad Map: SALT POINT (N-25-3)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) survey/assessment of Great Spring Brook near Pleasant Valley (at Route 73) was conducted in 2002. Sampling results indicated slightly impacted water quality conditions. Mayflies and stoneflies were noted in the sample, but the fauna was dominated by algal-feeding riffle beetles. Nonpoint source nutrient enrichment was identified as the primary cause of the impacts. However, nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. (DEC/DOW, BWAM/SBU, June 2005)

Segment Description
This segment includes the entire stream and all tribs. The waters of the stream and Class B. Tribs to the stream are also Class B.

Little Wappingers Cr, Lower, and tribs (1305-0019) NoKnownImpct

Waterbody Location Information

Revised: 02/20/2008

Water Index No: H-101-18
Drain Basin: Lower Hudson River
Hydro Unit Code:
Str Class: B(T)
Waterbody Type: River
Reg/County: 3/Dutchess Co. (14)
Waterbody Size: 28.2 Miles
Quad Map: SALT POINT (N-25-3)
Seg Description: stream and tribs, mouth to Schultzville

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a
Resolution Potential: n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Little Wappingers Creek near Salt Point (at Halstead Road) was conducted in 2002. Sampling results indicated non-impacted water quality conditions. The stream appeared sluggish and silty - less than ideal habitat - but the fauna was dominated by clean-water mayflies. (DEC/DOW, BWAM/SBU, December 2004)

Segment Description
This segment includes the portion of the stream and all tribs from the mouth to/including unnamed trib (-10) near Schultzville. The waters of this portion of the stream are Class B,B(T). Tribs to this reach/segment are primarily Class B; with some waters Class C. Upper Little Wappingers Creek is listed separately.

Long Pond (1305-0003) Need Verific

Waterbody Location Information

Revised: 07/11/2008

Water Index No: H-101-18-11-P375
Hydro Unit Code: 02020008/060 **Str Class:** AA
Waterbody Type: Lake
Waterbody Size: 81.9 Acres
Seg Description: entire lake

Drain Basin: Lower Hudson River
Low Hudson-Wappinger
Reg/County: 3/Dutchess Co. (14)
Quad Map: ROCK CITY (N-25-2)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Recreation	Stressed	Possible

Type of Pollutant(s)
Known: - - -
Suspected: ALGAL/WEED GROWTH (aquatic vegetation), Nutrients
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: ON-SITE/SEPTIC SYST, Urban/Storm Runoff
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in Long Pond may experience minor impacts/threats due to excessive aquatic vegetation and/or algal growth. This assessment is based on previously reported concerns and conditions in the lake need to be verified.

Previous Assessment
Recreational uses (swimming, boating) and aesthetics in the lake were reported as being affected by excessive aquatic weed growth. Inadequate and/or failing on-site septic systems serving residences along the shore were the suspected source of nutrient loads that promote the growth of aquatic vegetation. (Dutchess County WQCC, 1999)

Silver Lake (1305-0002) Need Verific

Waterbody Location Information

Revised: 07/11/2008

Water Index No:	H-101-18-13-P378	**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020008/060 **Str Class:** AA(T)		Low Hudson-Wappinger
Waterbody Type:	Lake	**Reg/County:**	3/Dutchess Co. (14)
Waterbody Size:	110.7 Acres	**Quad Map:**	ROCK CITY (N-25-2)
Seg Description:	entire lake		

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
Recreation	Stressed	Possible

Type of Pollutant(s)

Known: - - -
Suspected: ALGAL/WEED GROWTH (aquatic vegetation), Nutrients
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: ON-SITE/SEPTIC SYST
Possible: Urban/Storm Runoff

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in Silver Lake may experience minor impacts/threats due to excessive aquatic vegetation and/or algal growth. This assessment is based on previously reported concerns and conditions in the lake need to be verified.

Previous Assessment
Recreational uses (swimming, boating) and aesthetics in the lake were reported as being affected by excessive aquatic weed growth. Inadequate and/or failing on-site septic systems serving residences along the shore were the suspected source of nutrient loads that promote the growth of aquatic vegetation. (Dutchess County WQCC, 1999)

Upton Lake (1305-0005) Need Verific

Waterbody Location Information

Revised: 07/11/2008

Water Index No:	H-101-20-P384			**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020008/060	**Str Class:**	B		Low Hudson-Wappinger
Waterbody Type:	Lake			**Reg/County:**	3/Dutchess Co. (14)
Waterbody Size:	45.5 Acres			**Quad Map:**	SALT POINT (N-25-3)
Seg Description:	entire lake				

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
Recreation	Stressed	Possible

Type of Pollutant(s)

Known: - - -
Suspected: ALGAL/WEED GROWTH (aquatic vegetation), Nutrients
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: ON-SITE/SEPTIC SYST
Possible: Urban/Storm Runoff

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in Long Pond may experience minor impacts/threats due to excessive aquatic vegetation and/or algal growth. This assessment is based on previously reported concerns and conditions in the lake need to be verified.

Previous Assessment
Recreational uses (swimming, boating) and aesthetics in the lake were reported as being affected by excessive aquatic weed growth. Inadequate and/or failing on-site septic systems serving residences along the shore were the suspected source of nutrient loads that promote the growth of aquatic vegetation. (Dutchess County WQCC, 1999)

Ryder Pond, Hunns Lake (1305-0004) Need Verific

Waterbody Location Information

Revised: 07/11/2008

Water Index No: H-101-30..P401,P403
Hydro Unit Code: 02020008/060 **Str Class:** B
Waterbody Type: Lake
Waterbody Size: 78.8 Acres
Seg Description: total area of both lakes

Drain Basin: Lower Hudson River
Low Hudson-Wappinger
Reg/County: 3/Dutchess Co. (14)
Quad Map: PINE PLAINS (N-26-1)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Recreation	Stressed	Possible

Type of Pollutant(s)
Known: - - -
Suspected: ALGAL/WEED GROWTH (aquatic vegetation), Nutrients
Possible: Silt/Sediment

Source(s) of Pollutant(s)
Known: - - -
Suspected: ON-SITE/SEPTIC SYST, Agriculture
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in Ryder Pond and Hunns Lake may experience minor impacts/threats due to excessive aquatic vegetation and/or algal growth. This assessment is based on previously reported concerns and conditions in the lake need to be verified.

Previous Assessment
Recreational uses (swimming, boating) and aesthetics in the lake were reported as being affected by excessive aquatic weed growth. Inadequate and/or failing on-site septic systems serving residences along the shore and runoff from agricultural activity in the watershed were the suspected source of nutrient loads that promote the growth of aquatic vegetation. (Dutchess County WQCC, 1999)

Thompson, Stissing, Mud/Twin Isl Ponds (1305-0010) Need Verific

Waterbody Location Information

Revised: 07/11/2008

Water Index No:	H-101-P408,P409,P410			**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020008/060	**Str Class:**	B		Low Hudson-Wappinger
Waterbody Type:	Lake			**Reg/County:**	3/Dutchess Co. (14)
Waterbody Size:	204.4 Acres			**Quad Map:**	PINE PLAINS (N-26-1)
Seg Description:	total area of all three lakes				

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Recreation	Stressed	Possible
Recreation	Stressed	Possible

Type of Pollutant(s)

Known: - - -
Suspected: ALGAL/WEED GROWTH, Nutrients
Possible: Pathogens

Source(s) of Pollutant(s)

Known: - - -
Suspected: OTHER SOURCE (waterfowl)
Possible: Agriculture, Urban/Storm Runoff

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview

Recreational uses in Thompson, Stissing and Mud/Twin Island Ponds may experience minor impacts/threats due to excessive aquatic vegetation and/or algal growth. This assessment is based on previously reported concerns and conditions in the lake need to be verified.

Previous Assessment

Recreational uses (swimming, boating) and aesthetics in the lake were reported as being affected by excessive aquatic weed growth. Waterfowl (geese, ducks) are the suspected source of nutrient loads that promote the growth of aquatic vegetation. (Dutchess County WQCC, 1996)

Appendix D

Mapshed Modeling

Mapshed Modeling Analysis

The MapShed model was developed in response to the need for a version of ArcView Generalized Watershed Loading Function (AVGWLF) that would operate in a non-proprietary GIS package. AVGWLF had previously been calibrated for the Northeastern U.S. in general and New York specifically. Conversion of the calibrated AVGWLF to MapShed involved the transfer of updated model coefficients and a series of verification model runs. The calibration and conversion of the models is discussed in detail in this section.

Northeast AVGWLF Model

The AVGWLF model was calibrated and validated for the northeast (Evans et al., 2007). AVGWLF requires that calibration watersheds have long-term flow and water quality data. For the northeast model, watershed simulations were performed for twenty-two (22) watersheds throughout New York and New England for the period 1997-2004. Flow data were obtained directly from the water resource database maintained by the U.S. Geological Survey (USGS). Water quality data were obtained from the New York and New England State agencies. These data sets included in-stream concentrations of nitrogen, phosphorus, and sediment based on periodic sampling.

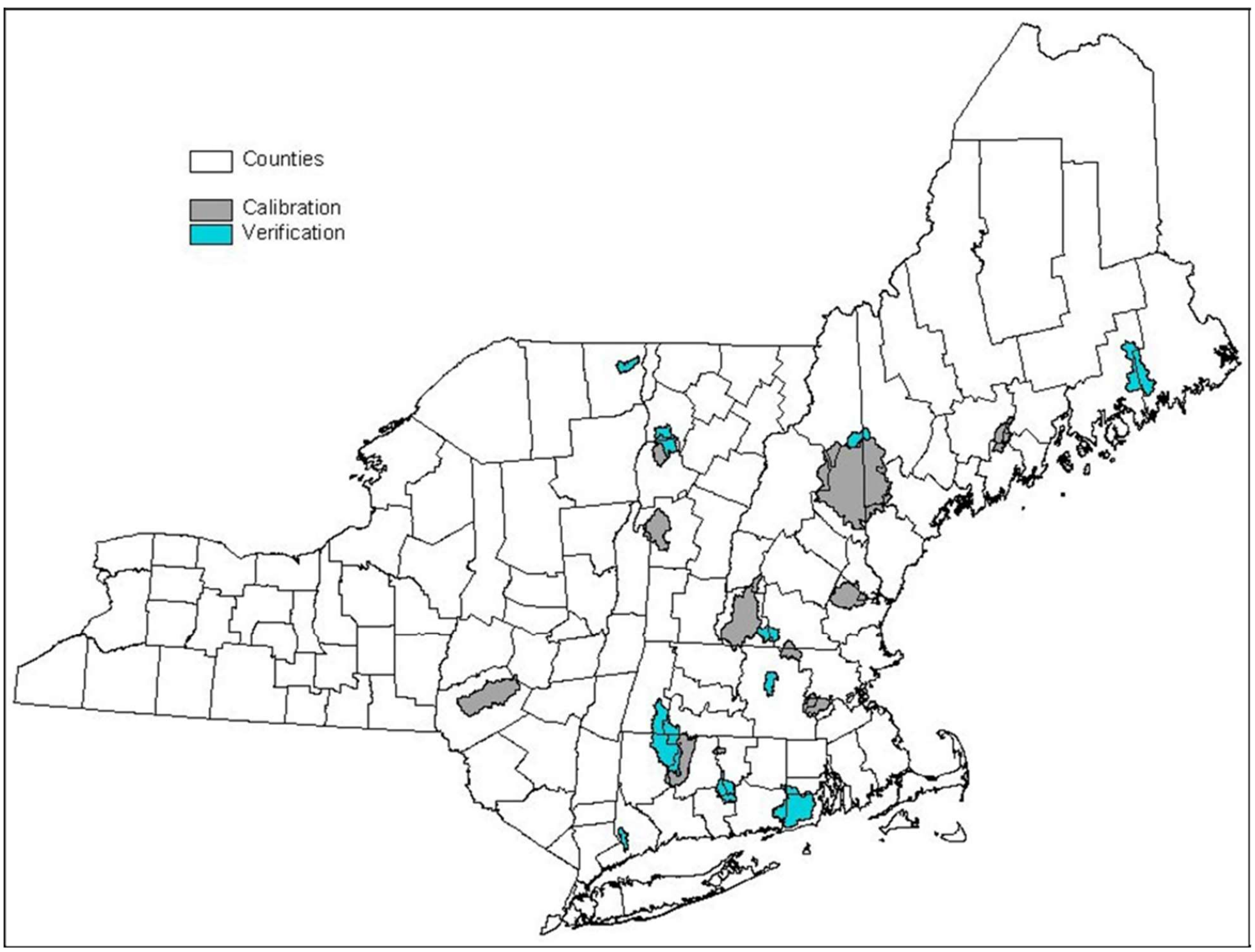


Figure 1: Location of Calibration & Verification Watersheds for the Original Northeast AVGWLF Model

Initial model calibration was performed on half of the 22 watersheds for the period 1997-2004. During this step, adjustments were iteratively made in various model parameters until a “best fit" was achieved between simulated and observed stream flow, and sediment and nutrient loads. Based on the calibration results, revisions were made in various AVGWLF routines to alter the manner in which model input parameters were estimated. To check the reliability of these revised routines, follow-up verification runs were made on the remaining eleven watersheds for the same time period. Finally, statistical evaluations of the accuracy of flow and load predictions were made.

To derive historical nutrient loads, standard mass balance techniques were used. First, the in-stream nutrient concentration data and corresponding flow rate data were used to develop load (mass) versus flow relationships for each watershed for the period in which historical water quality data were obtained. Using the daily stream flow data obtained from USGS, daily nutrient loads for the 1997-2004 time period were subsequently computed for each watershed using the appropriate load versus flow relationship (i.e., "rating curves"). Loads computed in this fashion were used as the "observed" loads against which model-simulated loads were compared.

During this process, adjustments were made to various model input parameters for the purpose of obtaining a "best fit" between the observed and simulated data. With respect to stream flow, adjustments were made that increased or decreased the amount of the calculated evapotranspiration and/or "lag time" (i.e., groundwater recession rate) for sub-surface flow. With respect to nutrient loads, changes were made to the estimates for sub-surface nitrogen and phosphorus concentrations. In regard to both sediment and nutrients, adjustments were made to the estimate for the "C" factor for cropland in the USLE equation, as well as to the sediment "a" factor used to calculate sediment loss due to stream bank erosion. Finally, revisions were also made to the default retention coefficients used by AVGWLF for estimating sediment and nutrient retention in lakes and wetlands.

Based upon an evaluation of the changes made to the input files for each of the calibration watersheds, revisions were made to routines within AVGWLF to modify the way in which selected model parameters were automatically estimated. The AVGWLF software application was originally developed for use in Pennsylvania, and based on the calibration results, it appeared that certain routines were calculating values for some model parameters that were either too high or too low. Consequently, it was necessary to make modifications to various algorithms in AVGWLF to better reflect conditions in the Northeast. A summary of the algorithm changes made to AVGWLF is provided below.

•**ET**: A revision was made to increase the amount of evapotranspiration calculated automatically by AVGWLF by a factor of 1.54 (in the "Pennsylvania" version of AVGWLF, the adjustment factor used is 1.16). This has the effect of decreasing simulated stream flow.

•**GWR:** The default value for the groundwater recession rate was changed from 0.1 (as used in Pennsylvania) to 0.03. This has the effect of "flattening" the hydrograph within a given area.

•**GWN:** The algorithm used to estimate "groundwater" (sub-surface) nitrogen concentration was changed to calculate a lower value than provided by the "Pennsylvania" version.

•**Sediment "a" Factor:** The current algorithm was changed to reduce estimated stream bank-derived sediment by a factor of 90%. The streambank routine in AVGWLF was originally developed using Pennsylvania data and was consistently producing sediment estimates that were too high based on the in-stream sample data for the calibration sites in the Northeast. While the exact reason for this is not known, it's likely that the glaciated terrain in the Northeast is less erodible than the highly erodible soils in Pennsylvania. Also, it is likely that the relative abundance of lakes, ponds and wetlands in the Northeast have an effect on flow velocities and sediment transport.

•**Lake/Wetland Retention Coefficients:** The default retention coefficients for sediment, nitrogen and phosphorus are set to 0.90, 0.12 and 0.25, respectively, and changed at the user's discretion.

To assess the correlation between observed and predicted values, two different statistical measures were utilized: 1) the Pearson product-moment correlation (R^2) coefficient and 2) the Nash-Sutcliffe coefficient. The R^2 value is a measure of the degree of linear association between two variables and represents the amount of variability that is explained by another variable (in this case, the model- simulated values). Depending on the strength of the linear relationship, the R^2 can vary from 0 to 1, with 1 indicating a perfect fit between observed and predicted values. Like the R^2 measure, the Nash- Sutcliffe coefficient is an indicator of "goodness of fit," and has been recommended by the American Society of Civil Engineers for use in hydrological studies (ASCE, 1993). With this coefficient, values equal to 1 indicate a perfect fit between observed and predicted data, and values equal to 0 indicate that the model is predicting no better than using the average of the observed data. Therefore, any positive value above 0 suggests that the model has some utility, with higher values indicating better model performance. In practice, this coefficient tends to be lower than R^2 for the same data being evaluated.

Adjustments were made to the various input parameters for the purpose of obtaining a "best fit" between the observed and simulated data. One of the challenges in calibrating a model is to optimize the results across all model outputs (in the case of AVGWLF, stream flows, as well as sediment, nitrogen, and phosphorus loads). As with any watershed model like GWLF, it is possible to focus on a single output measure (e.g., sediment or nitrogen) in order to improve the fit between observed and simulated loads. Isolating on one model output, however, can sometimes lead to less acceptable results for other measures. Consequently, it is sometimes difficult to achieve very high correlations (e.g., R^2 above 0.90) across all model outputs. Given this limitation, it was felt that very good results were obtained for the calibration sites. In model calibration, initial emphasis is usually placed on getting the hydrology correct. Therefore, adjustments to flow-related model parameters are usually finalized prior to making adjustments to parameters specific to sediment and nutrient production. This typically results in better statistical fits between stream flows than the other model outputs.

For the monthly comparisons, mean R^2 values of 0.80, 0.48, 0.74, and 0.60 were obtained for the calibration watersheds for flow, sediment, nitrogen and phosphorus, respectively. When considering the inherent difficulty in achieving optimal results across all measures as discussed above (along with the potential sources of error), these results are quite good. The sediment load predictions were less satisfactory than those for the other outputs, and this is not entirely unexpected given that this constituent is usually more difficult to simulate than nitrogen or phosphorus. An improvement in sediment prediction could have been achieved by isolating on this particular output during the calibration process; but this would have resulted in poorer performance in estimating the nutrient loads for some of the watersheds. Phosphorus predictions were less accurate than those for nitrogen. This is not unusual given that a significant portion of the phosphorus load for a watershed is highly related to sediment transport processes. Nitrogen, on the other hand, is often linearly correlated to flow, which typically results in accurate predictions of nitrogen loads if stream flows are being accurately simulated.

As expected, the monthly Nash-Sutcliffe coefficients were somewhat lower due to the nature of this particular statistic. As described earlier, this statistic is used to iteratively compare simulated values against the mean of the observed values, and values above zero indicate that the model predictions are better than just using the mean of the observed data. In other words, any value above zero would indicate that the model has some utility beyond using the mean of historical data in estimating the flows or loads for any particular time period. As with R^2 values, higher Nash-Sutcliffe values reflect higher degrees of correlation than lower ones.

Improvements in model accuracy for the calibration sites were typically obtained when comparisons were made on a seasonal basis. This was expected since short-term variations in model output can oftentimes be reduced by accumulating the results over longer time periods. In particular, month-to- month discrepancies due to precipitation events that occur at the end of a month are often resolved by aggregating output in this manner (the same is usually true when going from daily output to weekly or monthly output). Similarly, further improvements were noted when comparisons were made on a mean annual basis. What these particular results imply is that AVGWLF, when calibrated, can provide very good estimates of mean annual sediment and nutrient loads.

Following the completion of the northeast AVGWLF model, there were a number of ideas on ways to improve model accuracy. One of the ideas relates to the basic assumption upon which the work undertaken in that project was based. This assumption is that a "regionalized" model can be developed that works equally well (without the need for resource-intensive calibration) across all watersheds within a large region in terms of producing reasonable estimates of sediment and nutrient loads for different time periods. Similar regional model calibrations were previously accomplished in earlier efforts undertaken in Pennsylvania (Evans et al., 2002) and later in southern Ontario (Watts et al., 2005). In both cases this task was fairly daunting given the size of the areas involved. In the northeast effort, this task was even more challenging given the fact that the geographic area covered by the northeast is about three times the size of Pennsylvania, and arguably is more diverse in terms of its physiographic and ecological composition.

As discussed, AVGWLF performed very well when calibrated for numerous watersheds throughout the region. The regionalized version of AVGWLF, however, performed less well for the verification watersheds for which additional adjustments were not made subsequent to the initial model runs. This decline in model performance may be a result of the regionally-adapted model algorithms not being rigorous enough to simulate spatially-varying landscape processes across such a vast geographic region at a consistently high degree of accuracy. It is likely that un-calibrated model performance can be enhanced by adapting the algorithms to reflect processes in smaller geographic regions such as those depicted in the physiographic province map.

Fine-tuning & Re-Calibrating the Northeast AVGWLF for New York State

For the TMDL development work undertaken in New York, the original northeast AVGWLF model was further refined by The Cadmus Group, Inc. and Dr. Barry Evans to reflect the physiographic regions that exist in New York. Using data from some of the original northeast model calibration and verification sites, as well as data for additional calibration sites in New York, three new versions of AVGWLF were created for use in developing TMDLs in New York State. Information on the fourteen (14) sites is summarized in Table 1. Two models were developed based on the following two physiographic regions: Eastern Great Lakes/Hudson Lowlands area and the Northeastern Highlands area. The model was calibrated for each of these regions to better reflect local conditions, as well as ecological and hydrologic processes. In addition to developing the above mentioned physiographic-based model calibrations, a third model calibration was also developed. This model calibration represents a composite of the two physiographic regions and is suitable for use in other areas of upstate New York.

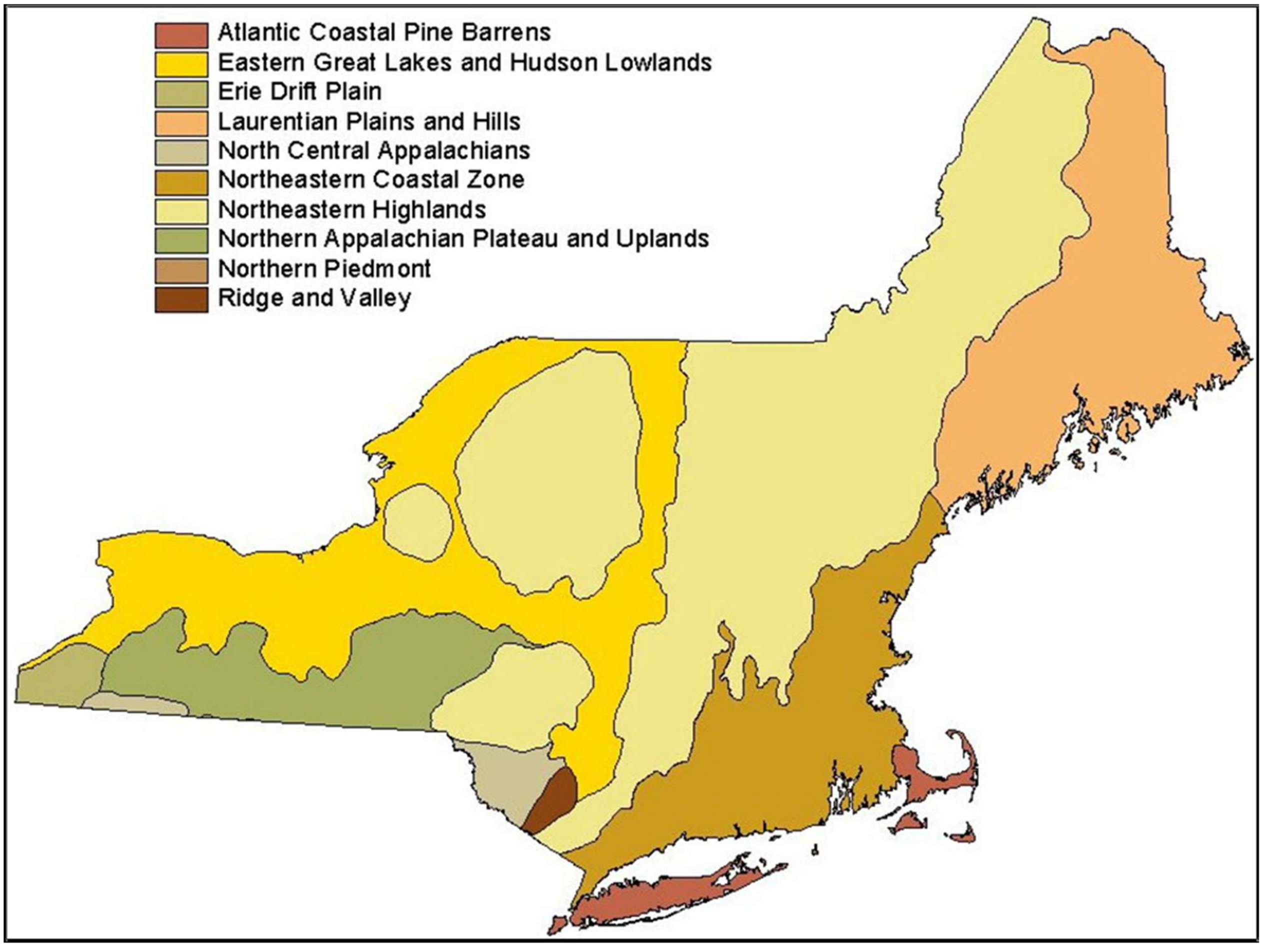


Figure 2: Location of Physiographic Provinces in New York and New England

Table 1: AVGWLF Calibration Sites for use in the New York TMDL Assessments

Site	Location	Physiographic Region
Owasco Lake	NY	Eastern Great Lakes/Hudson Lowlands
West Branch	NY	Northeastern Highlands
Little Chazy River	NY	Eastern Great Lakes/Hudson Lowlands
Little Otter Creek	VT	Eastern Great Lakes/Hudson Lowlands
Poultney River	VT/NY	Eastern Great Lakes/Hudson Lowlands & Northeastern Highlands
Farmington River	CT	Northeastern Highlands
Saco River	ME/NH	Northeastern Highlands
Squannacook River	MA	Northeastern Highlands
Ashuelot River	NH	Northeastern Highlands
Laplatte River	VT	Eastern Great Lakes/Hudson Lowlands
Wild River	ME	Northeastern Highlands
Salmon River	CT	Northeastern Coastal Zone
Norwalk River	CT	Northeastern Coastal Zone
Lewis Creek	VT	Eastern Great Lakes/Hudson Lowlands

Conversion of the AVGWLF Model to MapShed and Inclusion of RUNQUAL

The AVGWLF model requires that users obtain ESRI's ArcView 3.x with Spatial Analyst. The Cadmus Group, Inc. and Dr. Barry Evans converted the New York-calibrated AVGWLF model for use in a non-proprietary GIS package called MapWindow. The converted model is called MapShed and the software necessary to use it can be obtained free of charge and operated by any individual or organization who wishes to learn to use it. In addition to incorporating the enhanced GWLF model, MapShed contains a revised version of the RUNQUAL model, allowing for more accurate simulation of nutrient and sediment loading from urban areas.

RUNQUAL was originally developed by Douglas Haith (1993) to refine the urban runoff component of GWLF. Using six urban land use classes, RUNQUAL differentiates between three levels of imperviousness for residential and mixed commercial uses. Runoff is calculated for each of the six urban land uses using a simple water-balance method based on daily precipitation, temperature, and evapotranspiration. Pollutant loading from each land use is calculated with exponential accumulation and washoff relationships that were developed from empirical data. Pollutants, such as phosphorus, accumulate on surfaces at a certain rate (kg/ha/day) during dry periods. When it rains, the accumulated pollutants are washed off of the surface and have been measured to develop the relationship between accumulation and washoff. The pervious and impervious portions of each land use are modeled separately, and runoff and contaminant loads are added to provide total daily loads. RUNQUAL is also capable of simulating the effects of various urban best management practices (BMPs) such as street sweeping, detention ponds, infiltration trenches, and vegetated buffer strips.

Set-up of the Wappinger Creek Watershed MapShed Model

Using data for the time period 2009-2018, the calibrated GWLF-E model was used to estimate mean annual phosphorous loading in the Wappinger Creek Watershed. Table 2 provides the sources of data used for the GWLF-E modeling analysis.

Table 2: Data Sources for GWLF-E Modeling

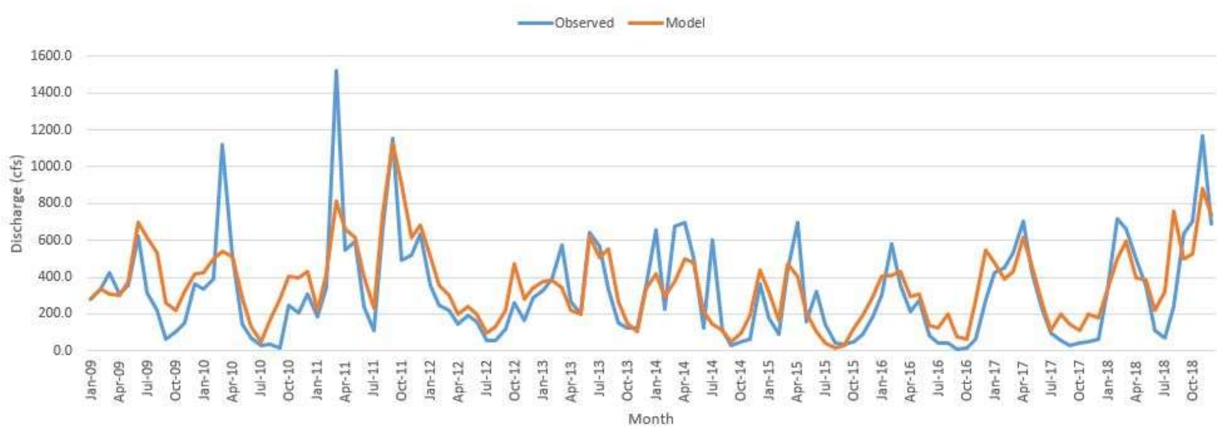
Data	Source or Value
Weather Data	
Precipitation and Temperature	Historical weather data from Dutchess County Airport, NY National Weather Service Station
Transport Data	
Basin size	GIS/derived from basin boundaries
Land use/cover	GIS/derived from land use/cover map
Curve numbers by source area	GIS/derived from landcover and soil maps
USLE (K, LS, C, P) factors by source area	GIS/derived from soil, land cover and DEM
ET cover coefficients	GIS/derived from land cover
Erosivity coefficients	GIS/derived from physiographic map
Daylights hours by month	Generated automatically for NY state
Growing season months	User input (May – September)
Sediment delivery ratio	GIS/based on watershed size
Recession coefficient	0.03 used for the watershed
Seepage coefficient	Default value of 0
Available water capacity	GIS/derived from soil map
Nutrient Data	
Dissolved N in runoff by land cover type	Default values/adjusted using GWLF manual

Dissolved P in runoff by land cover type	Default values/adjusted using GWLF manual
N/P buildup in urban areas	Default values from GWLF manual;
N/P concentrations in manure runoff	Default values
Background GW N/P concentrations	Derived from background map
Background N concentrations in soil	From GWLF manual
Background P concentrations in soil	Derived from soil P loading map/adjusted using GWLF manual
Population on septic systems	Derived from 2018 census
Per capita septic system loads (N/P)	Default values
Total number of farm animals	Derived from optimum stocking rates of different livestock based on available forage
BMP Data	
Rural land BMPs	Cornell Cooperative Extension/Dutchess County Soil & Water Conservation District

Model Calibration

The calibration was performed by changing evapotranspiration coefficient for different months and groundwater recession rate. The agreement of observed streamflow (USGS flow gauge at Red Oaks Mill) with the model output was tested using Nash Sutcliffe method, R2 and RSR methods. The values show satisfactory results as all the coefficients were in a satisfactory range of 0.55 to 0.65 for a hydrologic model.

Watershed	**Statistical Coefficient**		
	NS	**R2**	**RSR**
Wappinger Creek	0.62	0.64	0.61



On-site Wastewater Treatment Systems (Septic Systems) Modeling:

MapShed simulates nutrient loads from septic systems as a function of percentage of unsewered population served by normally functioning septic systems vs three types of malfunctioning systems: short-circuited, ponded and direct discharge (Haith et al., 1992).

Normal Systems: Normally functioning systems confirm to recommended construction and operational procedures, such as those suggested by EPA design manuals for onsite wastewater disposal systems. In normal systems, effluent infiltration into the soil and phosphates in the effluent are adsorbed and retained by soil, therefore normal systems do not provide phosphorous loads to nearby waters.

Short-circuited systems: These systems are located close enough to the surface water bodies (~ 15 meters) so that negligible adsorption of phosphorus takes place. Plant uptake is the only nutrient removal mechanism; therefore, these systems always contribute nutrient loads to nearby waters.

Ponded Systems: These systems exhibit hydraulic malfunctioning of the tank's adsorption field and result in surfacing of the effluent. Unless the surfaced effluent freezes, these systems deliver their nutrient loads to surface waters in the same month that they are generated through overland flow.

Direct Discharge Systems: These systems illegally discharge septic tank effluent directly into surface waters.

MapShed requires an estimation of population served by septic systems to generate septic systems phosphorus loadings. The number of dwellings relying on septic systems were estimated based on the GIS analysis of orthoimagery to account for proximity of septic systems to surface waters in the watershed. Greater attention was given to the dwellings that are located within 250 feet of the surface waters. To convert the number of septic systems to population served, an average household size of 2.57 people per dwelling was used based on the circa 2018 USBD census estimate for number of persons per household in New York State.

Malfunctioning systems were categorized based on their proximity from the surface waters, based on the best professional judgement and available data from local and national studies (Day, 2001; USEPA 2002).

Point Sources Modeling:

Permitted point sources within the watershed were identified and monthly flow and total phosphorus loads were determined using actual reported data from discharge monitoring reports. For facilities with no monitored phosphorus data, a concentration of 3mg/L was used to estimate the phosphorus loading.

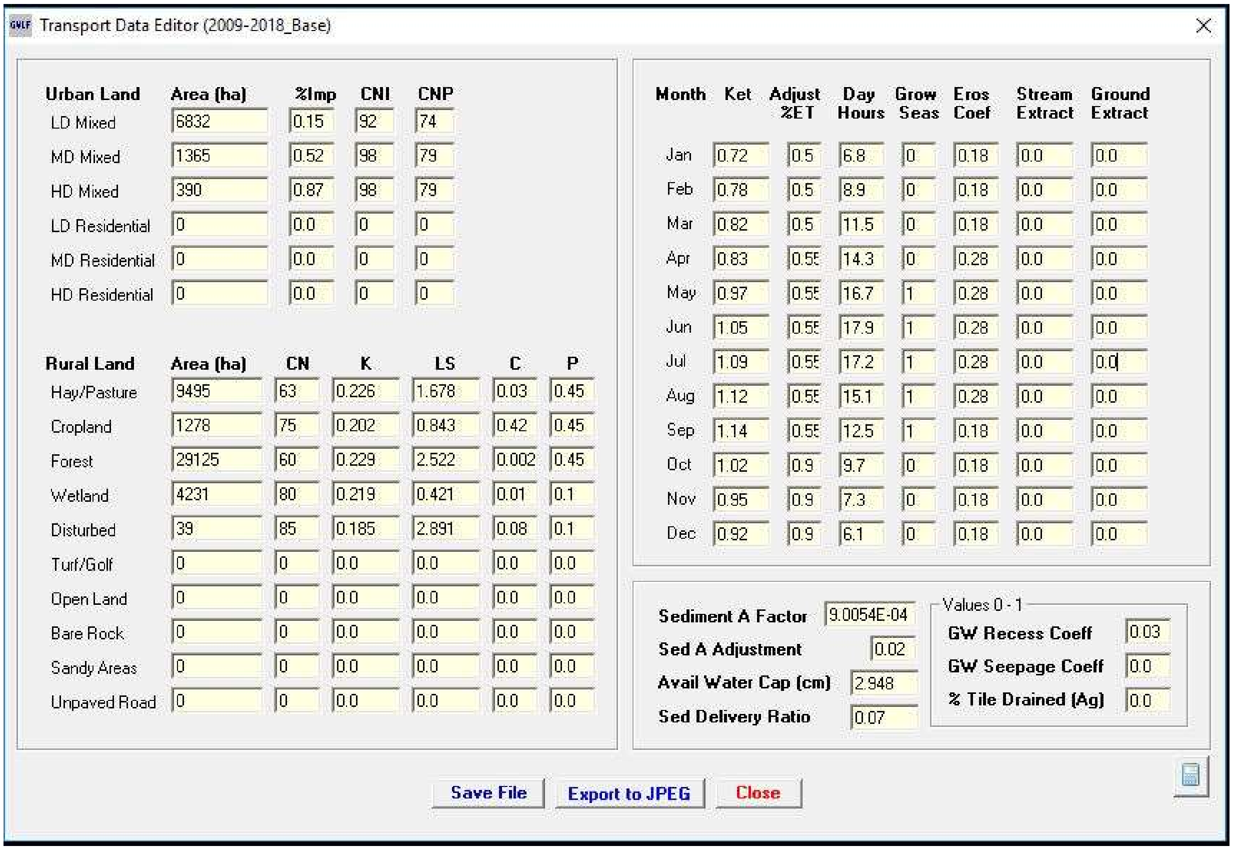
Farm Animal Modeling:

MapShed requires an estimation of total number of animals in the watershed to generate nutrient and pathogen loadings. The number of farm animals were estimated based on the amount of pasture land available for animal grazing. The animal stocking capacity assumed to be 500 pounds of grazing animal per acre.

Rural Land BMP Modeling:

MapShed estimates load reduction from BMPs for rural lands which include hay/pasture, row crops, animal operations, and agricultural stream banks. Appropriate BMPs were selected and applied based on the input gathered from Cornell Cooperative Extension of Dutchess County and Dutchess County Soil & Water Conservation District.

MapShed Model Simulation Inputs



Transport Data Editor (2009-2018_Base)

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	6832	0.15	92	74
MD Mixed	1365	0.52	98	79
HD Mixed	390	0.87	98	79
LD Residential	0	0.0	0	0
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

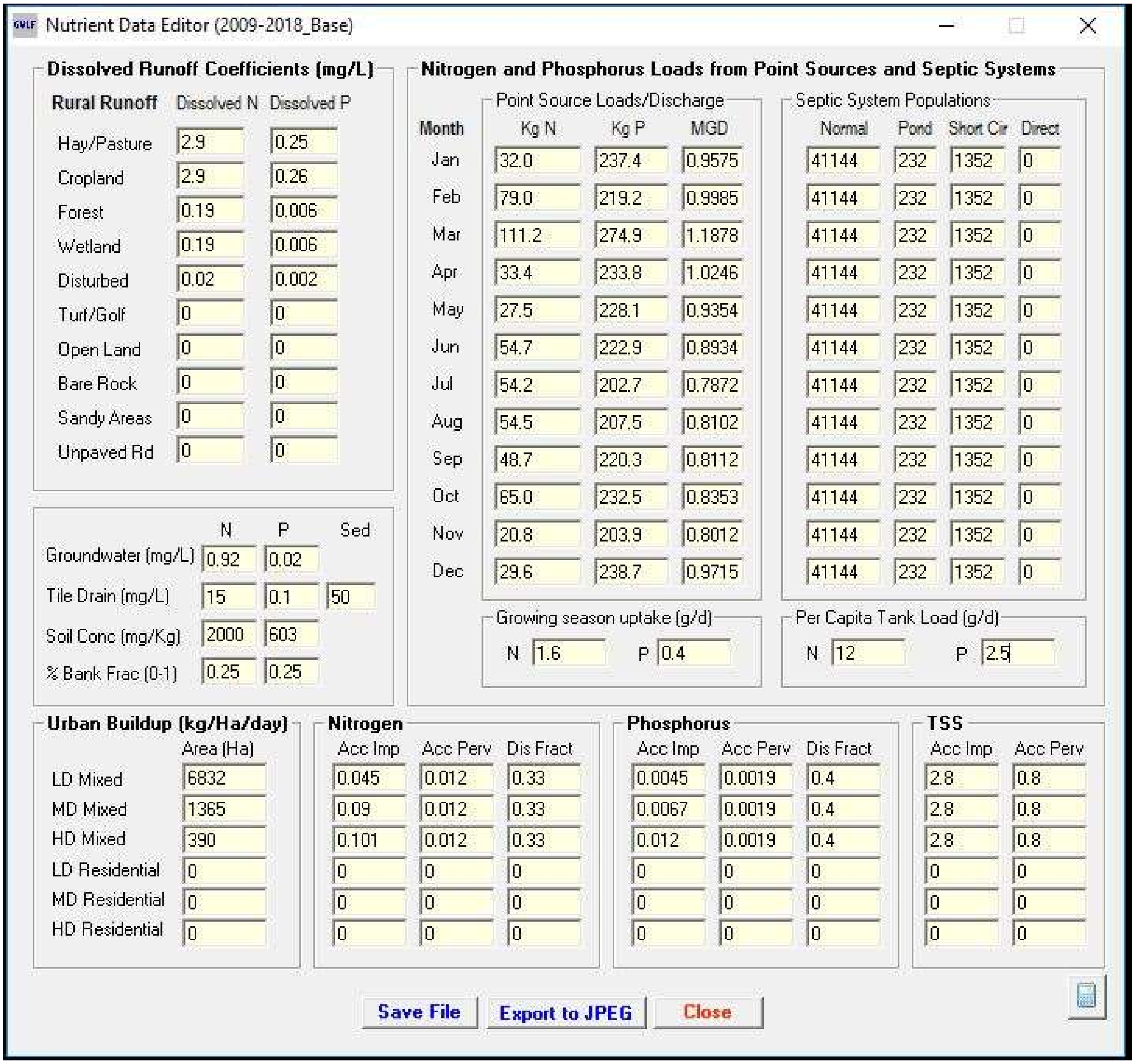
Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	9495	63	0.226	1.678	0.03	0.45
Cropland	1278	75	0.202	0.843	0.42	0.45
Forest	29125	60	0.229	2.522	0.002	0.45
Wetland	4231	80	0.219	0.421	0.01	0.1
Disturbed	39	85	0.185	2.891	0.08	0.1
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	0	0	0.0	0.0	0.0	0.0
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.72	0.5	6.8	0	0.18	0.0	0.0
Feb	0.78	0.5	8.9	0	0.18	0.0	0.0
Mar	0.82	0.5	11.5	0	0.18	0.0	0.0
Apr	0.83	0.55	14.3	0	0.28	0.0	0.0
May	0.97	0.55	16.7	1	0.28	0.0	0.0
Jun	1.05	0.55	17.9	1	0.28	0.0	0.0
Jul	1.09	0.55	17.2	1	0.28	0.0	0.0
Aug	1.12	0.55	15.1	1	0.28	0.0	0.0
Sep	1.14	0.55	12.5	1	0.18	0.0	0.0
Oct	1.02	0.9	9.7	0	0.18	0.0	0.0
Nov	0.95	0.9	7.3	0	0.18	0.0	0.0
Dec	0.92	0.9	6.1	0	0.18	0.0	0.0

Sediment A Factor	9.0054E-04
Sed A Adjustment	0.02
Avail Water Cap (cm)	2.948
Sed Delivery Ratio	0.07

Values 0 - 1

GW Recess Coeff	0.03
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0



Nutrient Data Editor (2009-2018_Base)

Dissolved Runoff Coefficients (mg/L)

Rural Runoff	Dissolved N	Dissolved P
Hay/Pasture	2.9	0.25
Cropland	2.9	0.26
Forest	0.19	0.006
Wetland	0.19	0.006
Disturbed	0.02	0.002
Turf/Golf	0	0
Open Land	0	0
Bare Rock	0	0
Sandy Areas	0	0
Unpaved Rd	0	0

	N	P	Sed
Groundwater (mg/L)	0.92	0.02	
Tile Drain (mg/L)	15	0.1	50
Soil Conc (mg/Kg)	2000	603	
% Bank Frac (0-1)	0.25	0.25	

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	Kg N	Kg P	MGD	Normal	Pond	Short Cir	Direct
Jan	32.0	237.4	0.9575	41144	232	1352	0
Feb	79.0	219.2	0.9985	41144	232	1352	0
Mar	111.2	274.9	1.1878	41144	232	1352	0
Apr	33.4	233.8	1.0246	41144	232	1352	0
May	27.5	228.1	0.9354	41144	232	1352	0
Jun	54.7	222.9	0.8934	41144	232	1352	0
Jul	54.2	202.7	0.7872	41144	232	1352	0
Aug	54.5	207.5	0.8102	41144	232	1352	0
Sep	48.7	220.3	0.8112	41144	232	1352	0
Oct	65.0	232.5	0.8353	41144	232	1352	0
Nov	20.8	203.9	0.8012	41144	232	1352	0
Dec	29.6	238.7	0.9715	41144	232	1352	0

Growing season uptake (g/d): N 1.6 P 0.4

Per Capita Tank Load (g/d): N 12 P 2.5

Urban Buildup (kg/Ha/day)	Area (Ha)	Nitrogen			Phosphorus			TSS	
		Acc Imp	Acc Perv	Dis Fract	Acc Imp	Acc Perv	Dis Fract	Acc Imp	Acc Perv
LD Mixed	6832	0.045	0.012	0.33	0.0045	0.0019	0.4	2.8	0.8
MD Mixed	1365	0.09	0.012	0.33	0.0067	0.0019	0.4	2.8	0.8
HD Mixed	390	0.101	0.012	0.33	0.012	0.0019	0.4	2.8	0.8
LD Residential	0	0	0	0	0	0	0	0	0
MD Residential	0	0	0	0	0	0	0	0	0
HD Residential	0	0	0	0	0	0	0	0	0

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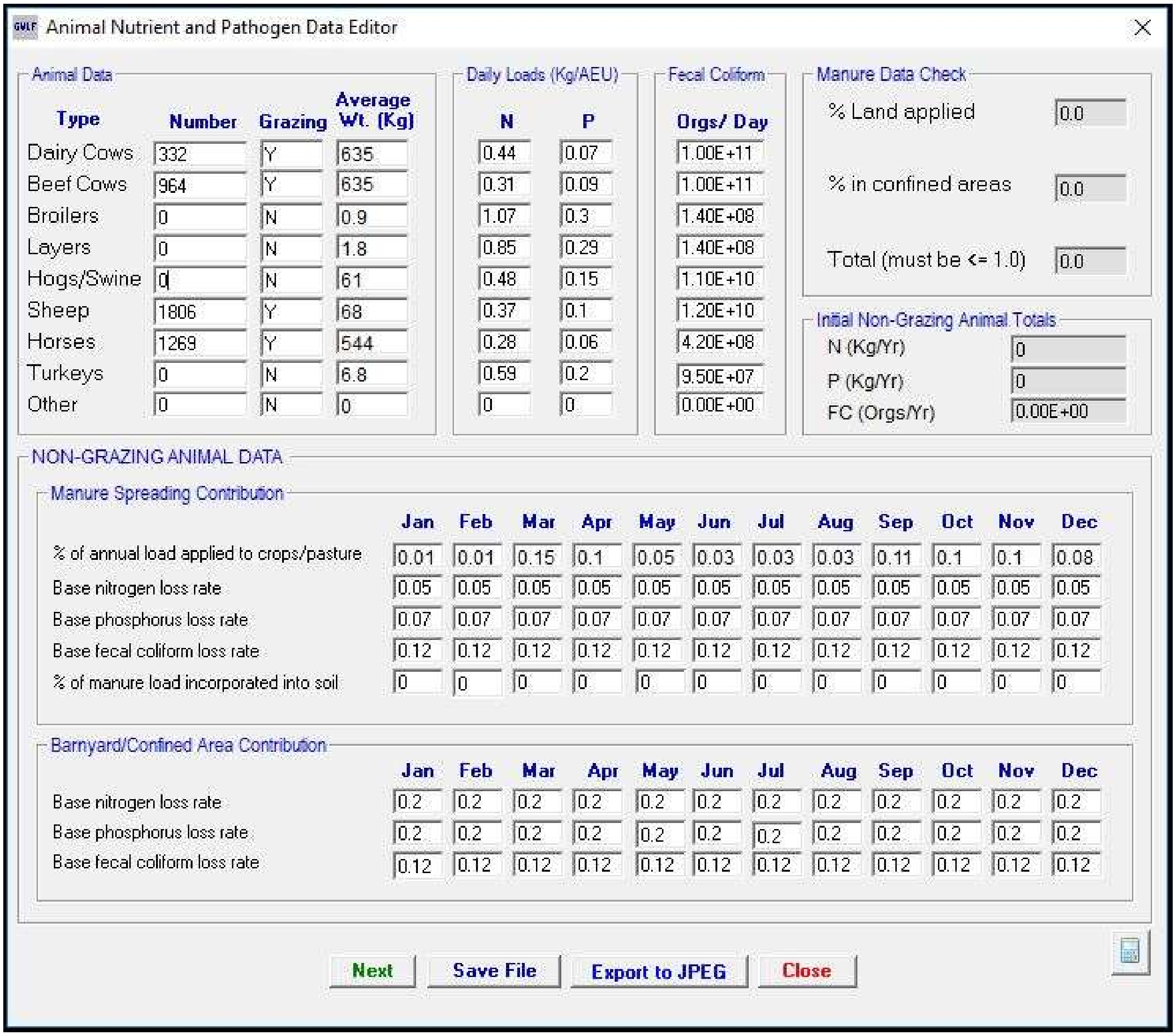
Animal Nutrient and Pathogen Data Editor
Animal Data
Type Number Grazing Average Wt. (Kg)
Dairy Cows 332 Y 635
Beef Cows 964 Y 635
Broilers 0 N 0.9
Layers 0 N 1.8
Hogs/Swine 0 N 61
Sheep 1806 Y 68
Horses 1269 Y 544
Turkeys 0 N 6.8
Other 0 N 0
Daily Loads (Kg/AEU)
N P
0.44 0.07
0.31 0.09
1.07 0.3
0.85 0.29
0.48 0.15
0.37 0.1
0.28 0.06
0.59 0.2
0 0
Fecal Coliform
Orgs/ Day
1.00E+11
1.00E+11
1.40E+08
1.40E+08
1.10E+10
1.20E+10
4.20E+08
9.50E+07
0.00E+00
Manure Data Check
% Land applied 0.0
% in confined areas 0.0
Total (must be <= 1.0) 0.0
Initial Non-Grazing Animal Totals
N (Kg/Yr) 0
P (Kg/Yr) 0
FC (Orgs/Yr) 0.00E+00
NON-GRAZING ANIMAL DATA
Manure Spreading Contribution
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
% of annual load applied to crops/pasture 0.01 0.01 0.15 0.1 0.05 0.03 0.03 0.03 0.11 0.1 0.1 0.08
Base nitrogen loss rate 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
Base phosphorus loss rate 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07
Base fecal coliform loss rate 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12
% of manure load incorporated into soil 0 0 0 0 0 0 0 0 0 0 0 0
Barnyard/Confined Area Contribution
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Base nitrogen loss rate 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
Base phosphorus loss rate 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
Base fecal coliform loss rate 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12
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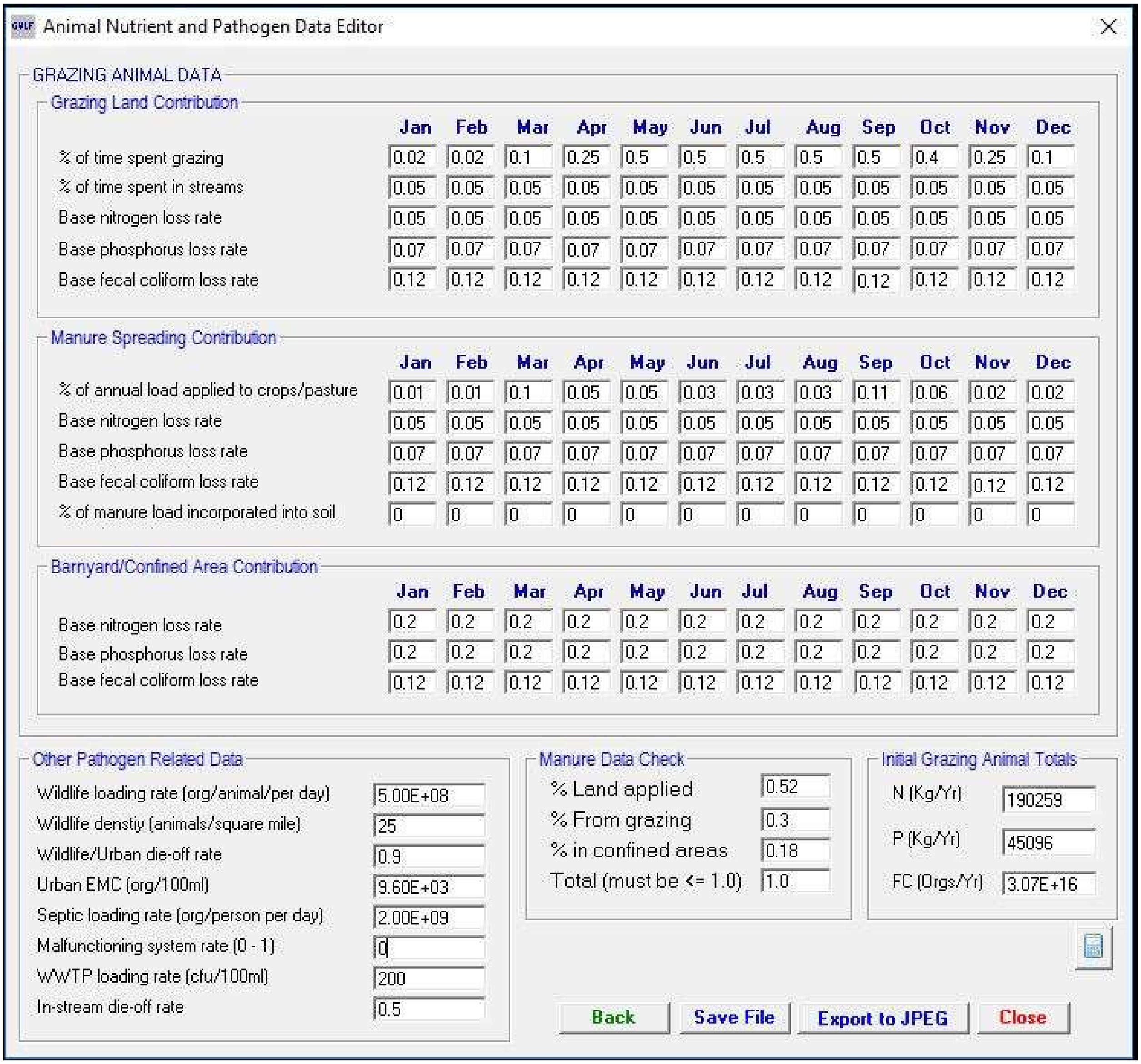
Animal Nutrient and Pathogen Data Editor
GRAZING ANIMAL DATA
Grazing Land Contribution
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
% of time spent grazing 0.02 0.02 0.1 0.25 0.5 0.5 0.5 0.5 0.5 0.4 0.25 0.1
% of time spent in streams 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
Base nitrogen loss rate 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
Base phosphorus loss rate 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07
Base fecal coliform loss rate 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12
Manure Spreading Contribution
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
% of annual load applied to crops/pasture 0.01 0.01 0.1 0.05 0.05 0.03 0.03 0.03 0.11 0.06 0.02 0.02
Base nitrogen loss rate 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
Base phosphorus loss rate 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.07
Base fecal coliform loss rate 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12
% of manure load incorporated into soil 0 0 0 0 0 0 0 0 0 0 0 0
Barnyard/Confined Area Contribution
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Base nitrogen loss rate 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
Base phosphorus loss rate 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
Base fecal coliform loss rate 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.12
Other Pathogen Related Data
Wildlife loading rate (org/animal/per day) 5.00E+08
Wildlife denstiy (animals/square mile) 25
Wildlife/Urban die-off rate 0.9
Urban EMC (org/100ml) 9.60E+03
Septic loading rate (org/person per day) 2.00E+09
Malfunctioning system rate (0 - 1) 0
WWTP loading rate (cfu/100ml) 200
In-stream die-off rate 0.5
Manure Data Check
% Land applied 0.52
% From grazing 0.3
% in confined areas 0.18
Total (must be <= 1.0) 1.0
Initial Grazing Animal Totals
N (Kg/Yr) 190259
P (Kg/Yr) 45096
FC (Orgs/Yr) 3.07E+16
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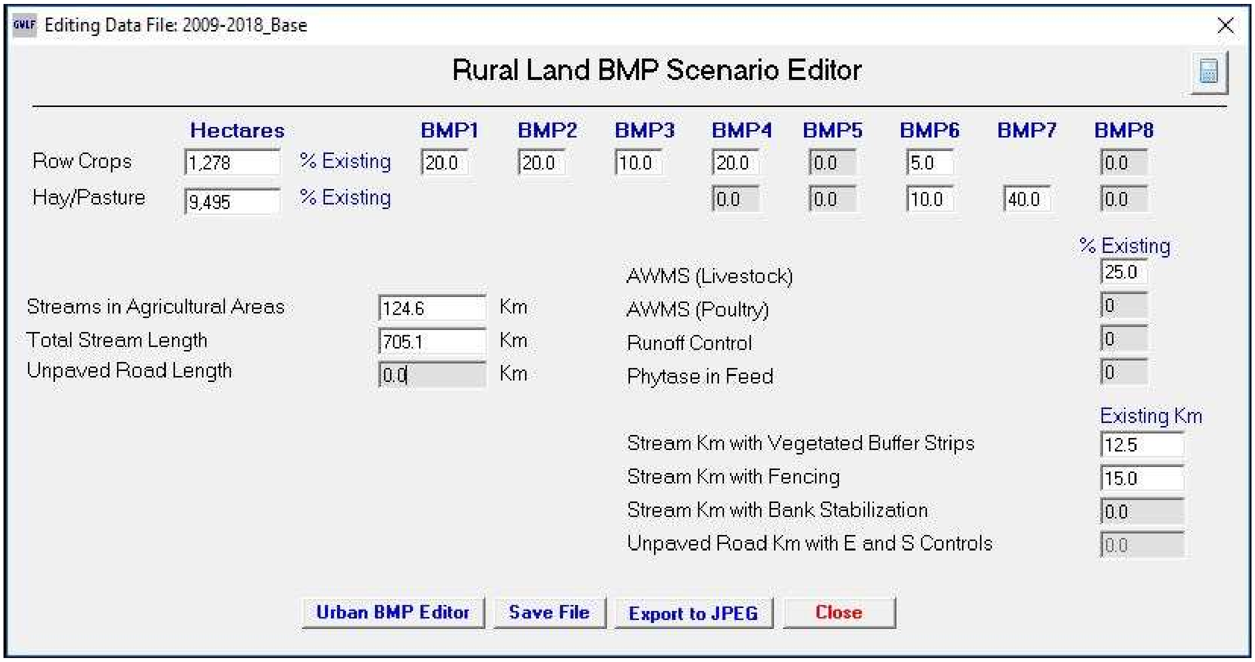
Editing Data File: 2009-2018_Base
Rural Land BMP Scenario Editor
Hectares
BMP1
BMP2
BMP3
BMP4
BMP5
BMP6
BMP7
BMP8
Row Crops
1,278
% Existing
20.0
20.0
10.0
20.0
0.0
5.0
0.0
Hay/Pasture
9,495
% Existing
0.0
0.0
10.0
40.0
0.0
% Existing
AWMS (Livestock)
25.0
AWMS (Poultry)
0
Runoff Control
0
Phytase in Feed
0
Streams in Agricultural Areas
124.6
Km
Total Stream Length
705.1
Km
Unpaved Road Length
0.0
Km
Existing Km
Stream Km with Vegetated Buffer Strips
12.5
Stream Km with Fencing
15.0
Stream Km with Bank Stabilization
0.0
Unpaved Road Km with E and S Controls
0.0
Urban BMP Editor
Save File
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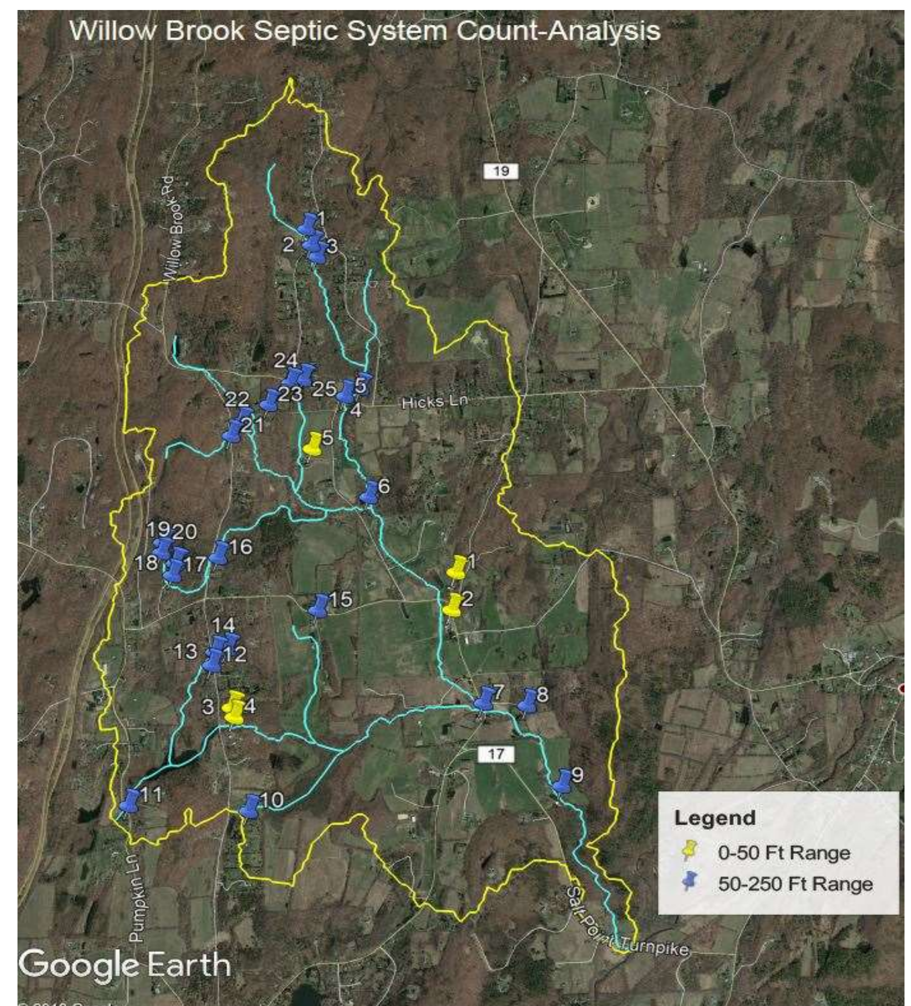
Close

Appendix E

Summary of Septic Systems in Wappinger Creek Watershed

Summary of Estimated Septic Systems and Population Equals for in Wappinger Creek Watershed								
Subwatershed	**Septic Systems**				**Population Equals**			
	Short Ciruiting	**Ponding**	**Normal**	**Total**	**Short Circuiting**	**Ponding**	**Normal**	**Total**
Cold Spring Creek	19	3	405	**427**	49	7	1041	**1097**
Direct Drainage to Wappinger Creek	150	32	5295	**5476**	385	82	13608	**14075**
Dutchess County Airport	22	7	2012	**2041**	57	18	5171	**5245**
East Branch Wappinger Creek	37	7	1135	**1179**	94	18	2917	**3029**
Great Spring Creek	39	11	1480	**1530**	100	28	3804	**3932**
Grist Mill Creek	12	2	196	**209**	31	4	502	**538**
Hunns Lake Creek	33	4	239	**276**	84	10	615	**709**
Little Wappingers Creek	56	7	1398	**1462**	144	19	3593	**3756**
Overlook Road	19	4	889	**912**	48	11	2284	**2344**
Pleasant Valley East	69	7	1119	**1196**	178	18	2877	**3073**
Upton Lake	49	3	238	**290**	126	6	612	**745**
Wappingers Falls	14	3	1474	**1491**	37	7	3789	**3833**
Willow Brook	8	1	129	**137**	19	3	331	**353**
Overall Watershed	**526**	**90**	**16009**	**16626**	**1352**	**232**	**41144**	**42728**

Analysis of the orthoimagery of the watershed shows approximately 347 houses within 50 feet of the stream shorelines and 1785 houses between 50 and 250 feet of the stream shorelines that rely on septic systems. Within 50 feet of the stream shorelines, 100% of the septic systems were categorized as short-circuiting. Between 50 and 250 feet, 10% of the septic systems were categorized as short-circuiting, and 5% were categorized as ponding systems, and 85% were categorized as normal systems. To convert the estimated number of septic systems to population served, an average household size of 2.57 people per dwelling was used based on the circa 2018 USCB census estimate for the number of persons per household in New York State. An example analysis for Willow Broook subwatershed is shown in the figure to the right.



Appendix F

Summary of Point Sources in Wappinger Creek Watershed

Summary of Point Sources in Wappinger Creek Watershed								
Facility Name	**NPDES ID**	**ADDRESS**	**Subwatershed**	**Type**	**Treatment**	**Residents Served**	**Phosphorus Monitoring**	**Phosphorus Permit Limits**
Fleetwood Manor SD WWTP	NY0021601	FLEETWOOD DRIVE, WAPPINGERS FALLS, NY 12590	Wappingers Falls	POTW	Secondary	345	No	None
Midpoint Pk - Royal Ridge	NY0035637	ROYAL RIDGE DEVELOPMENT, WAPPINGERS FALLS, NY 12590	Dutchess County Airport	POTW	Secondary	405	No	None
Millbrook STP	NY0025429	39 NORTH AVE, MILLBROOK, NY 12545	East Branch Wappinger Creek	POTW	Advanced	1329	Yes	None
Noxon Knolls STP	NY0026085	SIMONE DRIVE, POUGHKEEPSIE, NY 12603	Dutchess County Airport	POTW	Advanced	160	No	None
Poughkeepsie Corp Center	NY0218723	350 DUTCHESS TURNPIKE, POUGHKEEPSIE, NY 12603	Direct Drainge to Wappinger Creek	Non-POTW	N/A	N/A	No	None
Stratford Farms	NY0218944	BOWER RD, POUGHKEEPSIE, NY 12603	Direct Drainge to Wappinger Creek	Non-POTW	N/A	N/A	No	None
Titusville WWTP	NY0264989	OVERLOOK ROAD, LAGRANGEVILLE, NY 12540	Direct Drainge to Wappinger Creek	Non-POTW	N/A	N/A	Yes	0.5 mg/L (Monthly Average)
Valley Dale STP	NY0077593	68 FOREST VALLEY RD, PLEASANT VALLEY, NY 12569	Pleasant Valley East	POTW	Advanced	800	No	None
Wildwood SD	NY0037117	NEW HACKENSACK RD, WAPPINGERS FALLS, NY 12590	Direct Drainge to Wappinger Creek	POTW	Advanced	925	No	None
Brookside Meadows	NY0268119	10100 BROOKSIDE RD, PLEASANT VALLEY, NY 12569	Great Spring Creek	Non-POTW	N/A	N/A	No	None
Ennis Mobile Home Park	NY0218952	ROUTE 44, PLEASANT VALLEY, NY 12569	Direct Drainge to Wappinger Creek	Non-POTW	N/A	N/A	No	None
Montclair Townhouses	NY0086550	20 MISK LN AND RT 9D, WAPPINGERS FALLS, NY 12590	Wappingers Falls	Non-POTW	N/A	N/A	No	None
United Parcel DC	NY0149489	41 FIREMENS WAY, POUGHKEEPSIE, NY 12603	Overlook Road	Non-POTW	N/A	N/A	No	None
Village Crest WW	NY1303232	510 MALONEY RD & ST RTE 376, POUGHKEEPSIE, NY 12603	Direct Drainge to Wappinger Creek	Non-POTW	N/A	N/A	No	None
Woodhill Green Condos	NY0034240	1668 U.S. 9, WAPPINGERS FALLS, NY 12590	Direct Drainge to Wappinger Creek	Non-POTW	N/A	N/A	No	None
Titusville Corporate Park	NY0149420	TITUSVILLE ROAD, LAGRANGE, NY 12603	Overlook Road	Non-POTW	N/A	N/A	No	None

Summary of Flows and Phosphorus Loading from Point Sources in Wappinger Creek Watershed

	Fleetwood Manor SD WWTP	Midpoint Pk - Royal Ridge	Millbrook STP	Noxon Knolls STP	Poughkeepsie Corp Center	Stratford Farms	Titusville WWTP	Valley Dale STP	Wildwood SD	Brookside Meadows	Ennis Mobile Home Park	Montclair Townhouses	United Parcel DC	Village Crest WW	Woodhill Green Condos	Titusville Corporate Park	Total
Flow																	
	Flow (MGD)	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**	**Flow (MGD)**
Jan	0.045	0.092	0.193	0.015	0.0023	0.014	0.305	0.023	0.090	0.0410	0.0339	0.0373	0.00056	0.0410	0.0235	0.0515	**1.008**
Feb	0.045	0.098	0.200	0.018	0.0026	0.015	0.323	0.027	0.101	0.0390	0.0339	0.0332	0.00065	0.0400	0.0220	0.0515	**1.049**
Mar	0.071	0.118	0.236	0.021	0.0028	0.013	0.387	0.040	0.132	0.0380	0.0339	0.0318	0.00055	0.0410	0.0210	0.0515	**1.238**
Apr	0.054	0.099	0.198	0.017	0.0027	0.013	0.343	0.028	0.102	0.0405	0.0339	0.0313	0.00092	0.0345	0.0250	0.0515	**1.074**
May	0.039	0.084	0.175	0.017	0.0029	0.013	0.323	0.024	0.090	0.0395	0.0339	0.0330	0.00073	0.0360	0.0230	0.0515	**0.985**
Jun	0.037	0.075	0.174	0.016	0.0028	0.013	0.299	0.026	0.078	0.0460	0.0339	0.0356	0.00069	0.0325	0.0220	0.0515	**0.943**
Jul	0.032	0.066	0.147	0.014	0.0025	0.015	0.271	0.018	0.061	0.0410	0.0339	0.0322	0.00051	0.0295	0.0230	0.0515	**0.837**
Aug	0.034	0.070	0.143	0.015	0.0026	0.015	0.28	0.019	0.067	0.0415	0.0339	0.0329	0.00039	0.0295	0.0240	0.0515	**0.861**
Sep	0.032	0.067	0.149	0.016	0.0029	0.014	0.266	0.021	0.080	0.0455	0.0339	0.0306	0.00068	0.0295	0.0226	0.0515	**0.862**
Oct	0.032	0.072	0.156	0.014	0.0026	0.013	0.282	0.022	0.080	0.0425	0.0339	0.0324	0.00052	0.0290	0.0230	0.0515	**0.886**
Nov	0.025	0.073	0.148	0.014	0.0024	0.013	0.265	0.021	0.075	0.0430	0.0339	0.0323	0.00026	0.0305	0.0235	0.0515	**0.852**
Dec	0.049	0.091	0.188	0.016	0.0023	0.014	0.327	0.024	0.093	0.0420	0.0339	0.0348	0.00024	0.0335	0.0225	0.0515	**1.022**
Phosporous																	
	Kg	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**	**Kg**
Jan	15.91	32.35	70.98	5.42	0.81	4.87	4.94	8.11	31.61	14.43	11.93	13.11	0.20	14.43	8.27	18.13	**255.5**
Feb	14.44	31.10	62.12	5.56	0.82	4.66	6.20	8.60	32.01	12.40	10.78	10.56	0.21	12.72	7.00	16.38	**235.6**
Mar	24.82	41.44	70.84	7.29	0.98	4.73	5.77	14.16	46.33	13.38	11.93	11.18	0.19	14.43	7.39	18.13	**293.0**
Apr	18.50	33.56	63.86	5.86	0.91	4.53	5.71	9.69	34.58	13.80	11.55	10.65	0.31	11.75	8.52	17.55	**251.3**
May	13.69	29.47	70.19	5.88	1.03	4.58	4.62	8.56	31.58	13.91	11.93	11.62	0.26	12.67	8.10	18.13	**246.2**
Jun	12.64	25.59	76.12	5.31	0.96	4.48	4.11	8.87	26.69	15.67	11.55	12.13	0.23	11.07	7.50	17.55	**240.5**
Jul	11.12	23.31	66.70	4.89	0.88	5.14	6.46	6.32	21.55	14.43	11.93	11.34	0.18	10.39	8.10	18.13	**220.9**
Aug	12.08	24.61	64.91	5.35	0.90	5.33	6.64	6.85	23.69	14.61	11.93	11.58	0.14	10.39	8.45	18.13	**225.6**
Sep	10.94	22.72	79.40	5.28	0.98	4.77	6.40	7.08	27.29	15.50	11.55	10.43	0.23	10.05	7.71	17.55	**237.9**
Oct	11.27	25.24	84.41	4.96	0.93	4.58	8.44	7.81	28.09	14.96	11.93	11.41	0.18	10.21	8.10	18.13	**250.7**
Nov	8.52	24.79	66.87	4.62	0.82	4.46	5.27	7.32	25.55	14.65	11.55	10.99	0.09	10.39	8.01	17.55	**221.4**
Dec	17.23	31.88	74.09	5.63	0.82	4.99	4.09	8.43	32.82	14.79	11.93	12.23	0.08	11.79	7.92	18.13	**256.9**
Total (kg)	171.15	346.05	850.50	66.07	10.84	57.11	68.63	101.80	361.79	172.53	140.52	137.23	2.31	140.30	95.05	213.47	**2935.34**
Total (lb)	377.32	762.90	1875.03	145.65	23.90	125.90	151.31	224.43	797.62	380.36	309.79	302.53	5.08	309.31	209.54	470.62	**6471.31**

Estimated monthly flow and total phosphorus concentration data was obtained from Discharge Monitoring Reports (DMRs) for facilities that monitor phosphorus. For facilities with no phosphorus monitoring, a concentration of 3 mg/L was used to calculate loads for modeling purposes.

Appendix G

Summary of Farm Animals in Wappinger Creek Watershed

Summary of Farm Animal Counts by Subwatershed

	Overall	Subwatersheds												
Horse Farms	**Watershed**	**CSC**	**DDW**	**DCA**	**EBWC**	**GSC**	**GMC**	**HLC**	**LWC**	**OLR**	**PVE**	**ULC**	**WF**	**WB**
Area (ac)	3046	27	1115	110	582	438	122	43	390	8	2	152	3	54
lb Animals	1523065	13430	557535	55008	290817	219219	61229	21415	194872	4076	1002	76238	1368	26854
# Horses	**1269**	**11**	**465**	**46**	**242**	**183**	**51**	**18**	**162**	**3**	**1**	**64**	**1**	**22**
Dairy Cow Farms	**Watershed**	**CSC**	**DDW**	**DCA**	**EBWC**	**GSC**	**GMC**	**HLC**	**LWC**	**OLR**	**PVE**	**ULC**	**WF**	**WB**
Area (ac)	930	0	176	0	25	89	32	18	149	33	308	0	0	101
lb Animals	465139	0	87818	0	12537	44566	15923	8905	74501	16485	153960	0	0	50444
# Dairy Cows	**332**	**0**	**63**	**0**	**9**	**32**	**11**	**6**	**53**	**12**	**110**	**0**	**0**	**36**
Beef Cow Farms	**Watershed**	**CSC**	**DDW**	**DCA**	**EBWC**	**GSC**	**GMC**	**HLC**	**LWC**	**OLR**	**PVE**	**ULC**	**WF**	**WB**
Area (ac)	2699	0	472	0	1179	171	73	262	276	0	0	41	10	214
lb Animals	1349504	0	235945	0	589273	85727	36591	131207	138162	0	0	20716	4910	106973
# Beef Cows	**964**	**0**	**169**	**0**	**421**	**61**	**26**	**94**	**99**	**0**	**0**	**15**	**4**	**76**
Sheep Farms	**Watershed**	**CSC**	**DDW**	**DCA**	**EBWC**	**GSC**	**GMC**	**HLC**	**LWC**	**OLR**	**PVE**	**ULC**	**WF**	**WB**
Area (ac)	542	27	100	0	78	125	13	39	81	26	1	11	0	41
lb Animals	270966	13625	49773	0	38830	62426	6539	19297	40739	13224	529	5329	0	20656
# Sheep	**1806**	**91**	**332**	**0**	**259**	**416**	**44**	**129**	**272**	**88**	**4**	**36**	**0**	**138**
Totals	**Watershed**	**CSC**	**DDW**	**DCA**	**EBWC**	**GSC**	**GMC**	**HLC**	**LWC**	**OLR**	**PVE**	**ULC**	**WF**	**WB**
Area (ac)	7217	54	1862	110	1863	824	241	362	897	68	311	205	13	410
lb Animals	3608674	27055	931071	55008	931457	411938	120281	180825	448274	33785	155491	102283	6278	204927
# Animals	**4372**	**102**	**1028**	**46**	**931**	**692**	**132**	**247**	**586**	**103**	**114**	**114**	**5**	**273**

CSC	Cold Spring Creek
DDW	Direct Drainage to Wappinger Creek
DCA	Dutchess County Airport
EBWC	East Branch Wappinger Creek
GSC	Great Spring Creek
GMC	Grist Mill Creek
HLC	Hunns Lake Creek
LWC	Little Wappinger Creek
OLR	Overlook Road
PVE	Pleasant Valley East
ULC	Upton Lake Creek
WF	Wappingers Falls
WB	Willow Brook

The number of animals were calculated based on the optimum stocking rates of different livestock based on available forage. GIS based farm parcel data was obtained from Cornell Cooperative Extension Dutchess County and the basic stocking capacity was extrapolated based on weight (500 pounds of grazing animal/acre of pasture land). Depending on breed the following weights were used:

1 mature cow = 1400 pounds
1 mature horse = 1200 pounds
1 mature goat/sheep = 150 pounds

Appendix H

2017-2018 Watershed Sampling Data

MS -1 (West Main Street Bridge) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
9/12/2017	0.39	0.2	1.7	50	51	9	<4.0	0.74	<1.0	<1.0	7.60 @ 19.4 °C	
11/20/2017	0.41	0.1	7	10	70	6.7	<4.0	2.4	<1.0	<1.0	7.85 @ 19.7 °C	
3/6/2018	0.69	0.027	3.2	20	1008	13	<4.0	2.8	<0.50	0.69	7.67 @ 21.4 °C	
4/3/2018	0.41	0.010	1.9	10	775	12	<3.0	2.7	<0.50	<0.50	7.92 @ 17.4 °C	
5/1/2018	0.34	0.01	3.4	30	611	10	<3.0	2.7	<0.50	<1.0	7.99 @ 19.6 °C	
6/5/2018	0.4	0.051	4.8	390	262	7	<4.0	3	0.83	1.2	7.82 @ 18.1 °C	Storm Event
7/24/2018	0.34	0.054	3.7	120	148	12	<3.0	1.9	0.55	0.9	7.57 @ 21.8 °C	Storm Event
8/15/2018	0.38	0.075	9.4	1000	414	15	<3.0	5.7	0.62	<1.0	7.97 @ 20.5 °C	Storm Event
9/27/2018	0.3	0.07	21	1600	1574	8.5	<3.0	13	<0.50	<1.0	7.91 @ 18.4 °C	Storm Event
10/31/2018	0.44	0.028	7.2	550	480	8	<3.0	2.4	<0.50	<1.0	7.76 @ 19.5 °C	
11/28/2018	0.49	0.020	6.0	270	1278	11	<4.0	3.1	<0.50	<1.0	7.84 @ 20.4 °C	Storm Event

MS -2 (Albany Post Road bridge) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
9/12/2017	0.49	0.29	9.6	60	48	8.8	<4.0	0.8	<1.0	<1.0	7.85 @ 19.7 °C	
11/20/2017	0.39	0.22	16	80	54	6.3	<4.0	6.4	1.1	1.5	N/A	
3/6/2018	0.69	0.054	2.4	30	955	14	<4.0	3.3	<0.50	0.69	7.76 @ 21.2 °C	
4/3/2018	0.41	0.010	1.1	40	679	12	<3.0	2.1	<0.50	<0.50	7.93 @ 17.3 °C	
5/1/2018	0.34	0.01	3.3	190	567	11	<3.0	1.5	<0.50	<1.0	8.04 @ 20.1 °C	
6/5/2018	0.42	0.081	3.6	490	235	8.7	<4.0	2.8	<0.50	<1.0	7.84 @ 17.7 °C	Storm Event
7/24/2018	0.46	0.081	7.2	440	114	6.7	<3.0	3.3	<0.50	<0.50	7.87 @ 22.0 °C	Storm Event
8/15/2018	0.43	0.085	5	890	357	15	<3.0	3.8	<0.50	<1.0	8.22 @ 20.0 °C	Storm Event
9/27/2018	0.29	0.096	33	2419	1511	5.4	<3.0	19	<0.50	<1.0	7.74 @ 19.4 °C	Storm Event
10/31/2018	0.45	0.025	1.6	41	412	7.7	<3.0	0.65	<0.50	<1.0	7.84 @ 18.4 °C	
11/28/2018	0.51	0.025	6.4	210	1196	8.0	<4.0	4.6	<0.50	<1.0	7.74 @ 19.4 °C	Storm Event

MS -3 (Dutchess County Airport) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
9/12/2017	0.49	0.28	4	60	34	9.8	<4.0	0.53	<1.0	<1.0	7.99 @ 20 °C	
11/20/2017	0.35	0.1	3.9	80	46	8.8	<4.0	1.8	<1.0	<1.0	N/A	
3/6/2018	0.66	0.029	2.8	20	911	13	<4.0	3.1	<0.50	0.66	7.75 @ 21 °C	
4/3/2018	0.41	0.010	3.8	4	564	13	<3.0	2.5	<0.50	<0.50	7.91 @ 17.6 °C	
5/1/2018	0.32	0.01	5.4	N/A	478	12	<3.0	1.1	<0.50	<1.0	8.12 @ 19.7 °C	
6/5/2018	0.41	0.05	5.2	370	182	9.1	<4.0	3.1	0.57	<1.0	7.89 @ 17.1 °C	Storm Event
7/24/2018	0.44	0.05	3.6	240	89	8.9	<3.0	3.6	<0.50	<0.50	8.20 @ 20.6 °C	Storm Event
8/15/2018	0.41	0.089	28	370	311	16	<3.0	30	<0.50	<1.0	8.22 @ 20.1 °C	Storm Event
9/27/2018	0.27	0.17	40	1300	1450	8.3	<3.0	28	<0.50	<1.0	7.77 @ 19.6 °C	Storm Event
10/31/2018	0.4	0.021	1.7	43	357	8.6	<3.0	0.77	<0.50	<1.0	7.89 @ 18.5 °C	
11/28/2018	0.47	0.022	5.8	160	1145	9.9	<4.0	2.9	<0.50	<1.0	7.74 @ 19.0 °C	Storm Event

MS -4 (USGS Gauging Station (01372500)) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
9/12/2017	0.48	0.1	1.3	130	33	9.9	<4.0	0.62	<1.0	<1.0	7.99 @ 19.2 °C	
11/20/2017	0.3	0.1	1	40	49	7.6	<4.0	0.87	<1.0	<1.0	N/A	
3/6/2018	0.62	0.043	4	10	807	13	<4.0	3.5	<0.50	0.62	7.78 @ 21.1 °C	
4/3/2018	0.39	0.010	2.8	80	527	12	<3.0	2.6	<0.50	<0.50	7.88 @ 18.0 °C	
5/1/2018	0.29	0.01	5	10	456	12	<3.0	0.92	0.92	1.1	8.11 @ 19.8 °C	
6/5/2018	0.4	0.049	8	370	176	8.9	<4.0	1.6	<0.50	<1.0	7.85 @ 16.8 °C	Storm Event
7/24/2018	0.38	0.044	2.6	350	74	9.2	<3.0	3.1	<0.50	<0.50	8.19 @ 20.6 °C	Storm Event
8/15/2018	0.37	0.085	11	200	248	17	<3.0	4.2	<0.50	<1.0	8.19 @ 19.0 °C	Storm Event
9/27/2018	0.25	0.21	41	2419	1370	7.1	<3.0	30	0.64	<1.0	7.68 @ 18.9 °C	Storm Event
10/31/2018	0.38	0.017	1.7	67	330	12	<3.0	0.65	<0.50	<1.0	7.87 @ 18.1 °C	
11/28/2018	0.46	0.031	5.8	74	1080	11	<4.0	4.2	<0.50	<1.0	7.73 @ 18.8 °C	Storm Event

MS -5 (State Route 55) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
9/12/2017	N/A	N/A	N/A	N/A	29	N/A	N/A	N/A	N/A	N/A	N/A	
11/20/2017	N/A	N/A	N/A	N/A	42	N/A	N/A	N/A	N/A	N/A	N/A	
3/6/2018	0.55	0.024	1.9	40	601	14	<4.0	2.4	<0.50	0.76	7.86 @ 21.3 °C	
4/3/2018	0.41	0.010	2.4	10	443	13	<3.0	2.4	<0.50	<0.50	7.87 @ 18.5 °C	
5/1/2018	0.33	0.01	3.3	40	412	11	<3.0	0.95	<0.50	<1.0	8.04 @ 19.8 °C	
6/5/2018	0.39	0.047	4.3	410	154	8.9	<4.0	2.7	0.73	1.1	7.83 @ 16.9 °C	Storm Event
7/24/2018	0.34	0.054	2.8	300	78	13	<3.0	2.9	<0.50	<0.50	8.15 @ 19.6 °C	Storm Event
8/15/2018	0.39	0.085	13	490	220	18	<3.0	17	<0.50	<1.0	8.09 @ 19.0 °C	Storm Event
9/27/2018	0.25	0.16	38	2419	1180	6.7	<3.0	28	<0.50	<1.0	7.71 @ 19.0 °C	Storm Event
10/31/2018	0.37	0.023	1.7	42	285	10	<3.0	0.82	<0.50	<1.0	7.84 @ 18.0 °C	
11/28/2018	0.48	0.01	5.2	260	1044	9.6	<4.0	4.6	<0.50	<1.0	7.71 @ 18.7 °C	Storm Event

MS -6 (Dutchess Turnpike) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
10/20/2017	0.31	0.1	2.2	50	27	5.4	<4.0	0.71	<1.0	<1.0	N/A	
11/20/2017	0.35	0.1	1.6	10	40	8	<4.0	0.88	<1.0	<1.0	N/A	
3/6/2018	0.55	0.024	1.7	10	498	14	<4.0	1.1	<0.50	0.55	7.85 @ 21.4 °C	
4/3/2018	0.35	0.010	1.7	10	363	13	<3.0	2.7	<0.50	<0.50	7.87 @ 18.6 °C	
5/1/2018	0.27	0.01	3.0	30	320	11	<3.0	0.88	<0.50	<1.0	8.01 @ 19.9 °C	
6/5/2018	0.32	0.048	4.6	490	129	9	<4.0	3.6	0.73	1	7.85 @ 16.8 °C	Storm Event
7/24/2018	0.32	0.061	5.6	240	55	11	<3.0	3.6	<0.50	<0.50	8.23 @ 19.3 °C	Storm Event
8/15/2018	0.28	0.083	8.4	330	185	9.6	<3.0	5.3	<0.50	<1.0	8.23 @ 19.2 °C	Storm Event
9/27/2018	0.19	0.16	31.0	2400	1112	6.6	<3.0	21	<0.50	<1.0	7.59 @ 19.2 °C	Storm Event
10/31/2018	0.33	0.018	2.1	54	260	10	<3.0	0.76	<0.50	<1.0	7.86 @ 17.9 °C	
11/28/2018	0.39	0.029	4.4	110	887	7.8	<4.0	2.9	<0.50	<1.0	7.70 @ 18.9 °C	Storm Event

MS -7 (Creek Road at Camp Nooteeming) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
10/20/2017	0.36	0.1	2	50	25	4.1	<4.0	0.62	<1.0	1	N/A	
11/21/2017	0.33	0.1	1.3	130	35	7.2	<4.0	0.9	<1.0	<1.0	N/A	
3/6/2018	0.51	0.020	2.3	10	343	14	<4.0	2.1	<0.50	0.51	7.86 @ 21.4 °C	
4/3/2018	0.36	0.010	2.3	40	211	12	<3.0	2.1	<0.50	<0.50	7.86 @ 18.7 °C	
5/1/2018	0.28	0.01	2.6	30	185	11	<3.0	0.91	<0.50	<1.0	8.00 @ 20.2 °C	
6/5/2018	0.34	0.046	4.4	310	118	8.9	<4.0	2.3	<0.50	<1.0	7.73 @ 17.0 °C	Storm Event
7/24/2018	0.32	0.042	4	320	49	9.3	<3.0	1.9	<0.50	<0.50	8.12 @ 17.8 °C	Storm Event
8/15/2018	0.24	0.076	19	2420	159	13	<3.0	6.8	0.74	<1.0	8.17 @ 19.9 °C	Storm Event
9/27/2018	0.17	0.16	29	2419	820	7.6	<3.0	20	<0.50	<1.0	7.52 @ 19.1 °C	Storm Event
10/31/2018	0.35	0.018	1.7	49	175	7.9	<3.0	0.83	<0.50	<1.0	7.83 @ 17.0 °C	
11/28/2018	0.38	0.01	4.2	61	792	7.6	<4.0	4.2	<0.50	<1.0	7.78 @ 17.8 °C	Storm Event

MS -8 (Cold Spring Road at Community of McIntyre) - Mainstream Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
10/31/2017	0.12	0.1	2.2	280	17	8.3	<4.0	1.8	1.2	1.3	N/A	
11/21/2017	0.24	0.1	14	150	22	5.6	<4.0	6.3	<1.0	<1.0	N/A	
3/6/2018	0.36	0.027	4.4	10	61	14	<4.0	1.5	<0.50	<0.50	7.91 @ 21.4 °C	
4/3/2018	0.27	0.066	3.2	30	54	12	<3.0	4.1	<0.50	<0.50	7.85 @ 18.1 °C	
5/1/2018	0.17	0.021	4.6	70	42	9.8	<3.0	1.0	<0.50	<1.0	8.08 @ 21.0 °C	
6/5/2018	0.19	0.078	6.3	180	51	7.5	<4.0	3.3	<0.50	<1.0	7.74 @ 18.0 °C	Storm Event
7/24/2018	0.2	0.078	4.3	410	31	12	<3.0	5.3	<0.50	<0.50	8.17 @ 15.5 °C	Storm Event
8/15/2018	0.2	0.098	5.6	1200	57	14	<3.0	2.9	<0.50	<1.0	8.31 @ 21.9 °C	Storm Event
9/27/2018	0.16	0.086	13	820	134	6.8	<3.0	4.2	<0.50	<1.0	7.53 @ 19.7 °C	Storm Event
10/31/2018	0.28	0.017	1.6	21	39	9.1	<3.0	0.76	<0.50	<1.0	7.75 @ 17.3 °C	
11/28/2018	0.34	0.01	2.0	83	116	10	<4.0	0.55	<0.50	<1.0	7.77 @ 16.9 °C	Storm Event

TR-1 (Dutchess County Airport Tributary at New Hackensack Road) - Tributary Sample												
Date	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms	Discharge	DO	BOD	Turbidity	TKN as N	Total N	pH	Notes
	mg/L	mg/L	mg/L	CFU per 100 ML	CFS	mg/L	mg/L	NTU	mg/L	mg/L		
9/12/2017	0.41	0.3	2.2	110	6	8.6	<4.0	1.5	<1.0	<1.0	7.69 @ 19.3 °C	
11/20/2017	0.51	0.1	1.9	90	5	6.9	<4.0	2.6	<1.0	<1.0	N/A	
3/6/2018	0.85	0.031	5.2	30	20	14	<4.0	5.1	<0.50	0.85	7.93 @ 21.2 °C	
4/3/2018	0.48	0.010	2.3	70	17	12	<3.0	3.0	0.54	1.0	7.79 @ 17.0 °C	
5/1/2018	0.28	0.01	2.2	100	15	11	<3.0	2.0	<0.50	<1.0	8.00 @ 19.6 °C	
6/5/2018	0.3	0.081	3.6	550	11	9	<4.0	4.0	0.61	<1.0	7.90 @ 17.4 °C	Storm Event
7/24/2018	0.24	0.1	8.3	480	10	8.2	<3.0	6.0	<0.50	<0.50	7.92 @ 20.9 °C	Storm Event
8/15/2018	0.34	0.39	14	650	7	8.6	<3.0	5.4	<0.50	<1.0	8.21 @ 19.3 °C	Storm Event
9/27/2018	0.42	0.15	11	2419	38	8.4	<3.0	14.0	<0.50	<1.0	7.87 @ 19.9 °C	Storm Event
10/31/2018	0.45	0.054	1.6	84	9	9.6	<3.0	1.3	<0.50	<1.0	7.78 @ 17.5 °C	
11/28/2018	0.60	0.018	4.3	130	33	7.8	<4.0	2.8	<0.50	<1.0	7.80 @ 19.8 °C	Storm Event

TR-2 (Pleasant Valley East Tributary at Highway 44) - Tributary Sample												
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**	**DO**	**BOD**	**Turbidity**	**TKN as N**	**Total N**	**pH**	**Notes**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**	**mg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**		
11/3/2017	0.2	0.1	14	40	21	6.8	<4.0	5.7	<1.0	<1.0	N/A	
11/21/2017	0.29	2.5	140	50	28	7.3	7.3	63	2.9	3.2	N/A	
3/6/2018	0.70	0.029	1.6	10	138	13	<4.0	1.6	<0.50	0.70	7.73 @ 21 °C	
4/3/2018	0.27	0.010	1.3	30	106	12	<3.0	2.4	<0.50	<0.50	7.73 @ 16.7 °C	
5/1/2018	0.24	0.01	3.0	40	95	11	<3.0	1.7	<0.50	<1.0	7.96 @ 19.4 °C	
6/5/2018	0.26	0.096	4.3	230	55	8.9	<4.0	2.4	<0.50	<1.0	7.80 @ 17.1 °C	Storm Event
7/24/2018	0.22	0.11	5.0	310	38	9.1	<3.0	2.8	<0.50	<0.50	7.97 @ 22.5 °C	Storm Event
8/15/2018	0.34	0.14	4.6	490	60	20	<3.0	4	<0.50	<1.0	8.13 @ 20.1 °C	Storm Event
9/27/2018	0.33	0.14	4.4	2419	214	7.8	<3.0	3	<0.50	<1.0	7.81 @ 19.2 °C	Storm Event
10/31/2018	0.28	0.044	1.8	57	82	8.2	<3.0	1.3	<0.50	<1.0	7.69 @ 17.8 °C	
11/28/2018	0.55	0.028	3.3	120	200	8.0	<4.0	3.5	<0.50	<1.0	7.59 @ 18.6 °C	Storm Event

TR-3 (Great Spring Creek Tributary at Wigsten Road) - Tributary Sample												
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**	**DO**	**BOD**	**Turbidity**	**TKN as N**	**Total N**	**pH**	**Notes**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**	**mg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**		
10/31/2017	0.54	0.14	2.2	440	3	5.9	<4.0	1.5	1.1	1.6	N/A	
11/21/2017	0.85	0.23	5.2	90	4		<4.0	16	<1.0	<1.0	N/A	
3/6/2018	0.40	0.027	1.3	10	20	15	<4.0	1.7	<0.50	<0.50	7.79 @ 21.1 °C	
4/3/2018	0.29	0.010	1.1	20	12	12	<3.0	1.7	<0.50	<0.50	7.52 @ 16.7 °C	
5/1/2018	0.15	0.01	2.7	10	11	9.6	<3.0	1.4	<0.50	<1.0	7.86 @ 19.0 °C	
6/5/2018	0.41	0.09	5	270	7	7.5	<4.0	2.8	<0.50	<1.0	7.77 @ 17.4 °C	Storm Event
7/24/2018	0.72	0.15	7.3	430	6	7.9	<3.0	3.7	<0.50	<0.50	7.81 @ 21.0 °C	Storm Event
8/15/2018	0.40	0.13	7.2	690	10	15	<3.0	9.2	0.56	<1.0	7.91 @ 20.0 °C	Storm Event
9/27/2018	0.21	0.11	2.8	410	42	6.4	<3.0	1.8	<0.50	<1.0	7.38 @ 17.8 °C	Storm Event
10/31/2018	0.23	0.046	1.7	93	10	10	<3.0	0.7	<0.50	<1.0	7.38 @ 17.3 °C	
11/28/2018	0.37	0.011	16	290	37	9.2	<4.0	3.9	<0.50	<1.0	7.61 @ 16.5 °C	Storm Event

TR-4 (Little Wappinger Creek Tributary at Salt Point) - Tributary Sample												
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**	**DO**	**BOD**	**Turbidity**	**TKN as N**	**Total N**	**pH**	**Notes**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**	**mg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**		
10/31/2017	0.082	0.1	2	480	22	5.4	<4.0	2.2	<1.0	<1.0	N/A	
11/21/2017	0.05	0.1	9.2	80	28	5.7	<4.0	1.4	<1.0	<1.0	N/A	
3/6/2018	0.26	0.015	1.6	10	166	14	<4.0	0.72	<0.50	<0.50	7.78 @ 21.3 °C	
4/3/2018	0.16	0.010	1.0	10	119	12	<3.0	2.1	<0.50	<0.50	7.67 @ 17.1 °C	
5/1/2018	0.11	0.01	2.2	40	118	11	<3.0	1.6	<0.50	<1.0	7.88 @ 18.9 °C	
6/5/2018	0.1	0.036	3.2	100	55	9.1	<4.0	1.8	<0.50	<1.0	7.84 @ 17.8 °C	Storm Event
7/24/2018	0.13	0.044	4	100	34	10	<3.0	1.7	<0.50	<0.50	7.88 @ 19.5 °C	Storm Event
8/15/2018	0.085	0.049	2	390	60	9.6	<3.0	2.6	<0.50	<1.0	8.10 @ 20.1 °C	Storm Event
9/27/2018	0.13	0.09	32	2419	214	7	<3.0	20	<0.50	<1.0	7.39 @ 18.4 °C	Storm Event
10/31/2018	0.14	0.028	4.6	44	71	9.4	<3.0	3	<0.50	<1.0	7.57 @ 18.6 °C	
11/28/2018	0.19	0.01	2.5	72	171	8.2	<4.0	3.5	<0.50	<1.0	7.55 @ 17.4 °C	Storm Event

TR-5 (East Branch of Wappinger Creek Tributaryat Hibernia Road) - Tributary Sample												
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**	**DO**	**BOD**	**Turbidity**	**TKN as N**	**Total N**	**pH**	**Notes**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**	**mg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**		
11/3/2017	0.32	0.1	3	170	12	9.8	<4.0	0.93	<1.0	<1.0	N/A	Not Sampled
11/21/2017	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Sampled
3/6/2018	0.61	0.024	1.3	40	85	14	<4.0	2.5	<0.50	0.61	7.86 @ 21.4 °C	
4/3/2018	0.43	0.010	2.7	150	58	13	<3.0	3.3	<0.50	<0.50	7.79 @ 17.6 °C	
5/1/2018	0.39	0.01	4.2	90	60	11	<3.0	1.6	<0.50	<1.0	7.96 @ 18.7 °C	
6/5/2018	0.28	0.054	2.4	690	32	9.2	<4.0	2.9	<0.50	<1.0	7.85 @ 18.1 °C	Storm Event
7/24/2018	0.33	0.075	7.4	400	18	14	<3.0	1.9	<0.50	<0.50	8.25 @ 21.1 °C	Storm Event
8/15/2018	0.27	0.07	10	250	68	17	<3.0	3.8	<0.50	<1.0	8.14 @ 19.8 °C	Storm Event
9/27/2018	0.33	0.056	8.8	340	127	7.1	<3.0	4.7	<0.50	<1.0	7.81 @ 19.3 °C	Storm Event
10/31/2018	0.43	0.034	1.7	48	45	6.7	<3.0	0.8	<0.50	<1.0	7.77 @ 17.5 °C	
11/28/2018	0.54	0.012	5.6	230	120	9.4	<4.0	3.5	<0.50	<1.0	7.77 @ 16.6 °C	Storm Event

TR-6 (Willow Brook Tributary at Point Turnpike) - Tributary Sample												
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**	**DO**	**BOD**	**Turbidity**	**TKN as N**	**Total N**	**pH**	**Notes**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**	**mg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**		
11/3/2017	0.21	0.1	2.3	20	5	5.4	<4.0	0.66	<1.0	<1.0	N/A	
11/21/2017	0.21	0.1	2.1	10	7	8.4	<4.0	15	<1.0	<1.0	N/A	
3/6/2018	0.65	0.023	1.5	10	37	13	<4.0	0.86	<0.50	0.65	7.79 @ 21.5 °C	
4/3/2018	0.30	0.010	10	10	35	13	<3.0	1.5	0.52	0.85	7.78 @ 17.2 °C	
5/1/2018	0.22	0.051	2.6	30	22	12	<3.0	1.3	<0.50	<1.0	7.85 @ 18.7 °C	
6/5/2018	0.39	0.05	2.4	260	18	10	<4.0	1.0	<0.50	<1.0	7.78 @ 18.6 °C	Storm Event
7/24/2018	0.33	0.047	16	470	9	8.1	<3.0	3.0	<0.50	<0.50	8.02 @ 19.2 °C	Storm Event
8/15/2018	0.22	0.063	8	1100	17	6.1	<3.0	2.5	<0.50	<1.0	8.08 @ 21.0 °C	Storm Event
9/27/2018	0.25	0.079	8	870	58	7.4	<3.0	7.4	<0.50	<1.0	7.61 @ 18.9 °C	Storm Event
10/31/2018	0.47	0.035	1.6	19	21	15	<3.0	0.6	<0.50	<1.0	7.67 @ 17.9 °C	
11/28/2018	0.44	0.01	2.0	100	55	11	<4.0	2.3	<0.50	<1.0	7.66 @ 16.8 °C	Storm Event

TR-7 (Hunns Lake Creek Tributary at Route 82A) - Tributary Sample												
Date	**Nitrate-Nitrite as N**	**Total P**	**TSS**	**Fecal Coliforms**	**Discharge**	**DO**	**BOD**	**Turbidity**	**TKN as N**	**Total N**	**pH**	**Notes**
	mg/L	**mg/L**	**mg/L**	**CFU per 100 ML**	**CFS**	**mg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**		
11/3/2017	0.4	0.1	2.4	27	3	6.5	<4.0	0.71	<1.0	<1.0	N/A	
11/21/2017	0.54	0.1	12	30	4		<4.0	110	<1.0	<1.0	N/A	
3/6/2018	1.00	0.015	1.6	30	30	13	<4.0	1.5	<0.50	1.0	7.85 @ 21.6 °C	
4/3/2018	0.85	0.010	7.1	50	29	11	<3.0	3.3	<0.50	<0.50	8.04 @ 17.1 °C	
5/1/2018	0.75	0.01	3.0	60	19	11	<3.0	0.99	<0.50	<1.0	8.14 @ 18.8 °C	
6/5/2018	0.65	0.023	2.9	240	15	10	<4.0	2.0	<0.50	<1.0	8.06 @ 19.0 °C	Storm Event
7/24/2018	0.63	0.01	3.8	130	11	8.8	<3.0	1.4	<0.50	<0.50	8.34 @ 20.1 °C	Storm Event
8/15/2018	0.50	0.045	6.4	110	19	7.3	<3.0	1.1	<0.50	<1.0	8.45 @ 20.8 °C	Storm Event
9/27/2018	0.61	0.038	7.6	410	52	9.8	<3.0	4.4	<0.50	<1.0	8.11 @ 19.1 °C	Storm Event
10/31/2018	0.69	0.01	1.7	31	19	11	<3.0	0.4	<0.50	<1.0	8.06 @ 18.8 °C	
11/28/2018	0.70	0.01	2.2	190	48	6.5	<4.0	3.4	<0.50	<1.0	8.09 @ 18.1 °C	Storm Event

Appendix I

Quality Assurance Project Plan for Water Quality Testing Program

Quality Assurance Project Plan

December 3, 2019

Version 4.0

Matt Alexander – Project Manager
Village of Wappingers Falls
845-297-8773
mayor@wappingersfallsny.gov

Title and Approval Page

Wappinger Creek and Water Quality Modeling Project to support development of Nine Element Plan

Model Quality Assurance Project Plan

December 3, 2019
Revision 4.0

Matt Alexander — Project Manager
Village of Wappingers Falls
Date: 12-3-19

John Szarowski — Contractor Project Manager
KC Engineering and Land Surveying PC
Date: 12.3.19

Ryan Stratton — Contractor QC Manager
KC Engineering and Land Surveying PC
Date: 12-3-19

RoseAnn Garry — Quality Assurance Officer
NYS Department of Environmental Conservation
Bureau of Water Assessment and Management
Date: 12 04 19

Abstract: This document details a quality assurance plan to guide the successful implementation of the Wappingers Creek Watershed Revitalization project. We propose to model pollutant loads, particularly phosphorus loads originating in the Wappinger Creek Watershed from various sources using a hydrologic model. The expected outcomes of the development of this model is a management tool capable of evaluating different strategies to reduce pollutant loads in the watershed.

CONTENTS

1. Project management

1.1. Distribution List

The following individuals must receive a copy of the approved QAPP in order to complete their role in this project.

Name: Mayor Matt Alexander
Title: Project Manager
Organization: Wappinger Creek Watershed Intermunicipal Council
Contact Information: 2582 South Ave, Wappingers Falls, NY, 12590, 845-297-8773, mayor@wappingersfallsny.gov
Document Type: Electronic

Name: John Szarowski
Title: Contractor Project Manager
Organization: KC Engineering and Land Surveying PC
Contact Information: 2142 NY-302, Circleville, NY, 10919, 845-673-3199, jszarowski@kcepc.com
Document Type: Electronic

Name: Barbara Kendall
Title: Waterfront Revitalization Program Supervisor
Organization: NYS Department of State
Contact Information: 99 Washington Ave, Albany, NY, 12231, 518-473-8928, barbara.kendall@dos.ny.gov
Document Type: Electronic

Name: Ryan Stratton
Title: Contractor QC Manager
Organization: KC Engineering
Contact Information: 2142 NY-302, Circleville, NY, 10919, 845-228-3894, rstratton@kcepc.com
Document Type: Electronic

Name: Sean Carroll
Title: Public Outreach Officer
Organization: Cornell Cooperative Extension Dutchess County
Contact Information: 2715 US-44, Millbrook, NY, 12545, 845-677-8223 x147, smc427@cornell.edu
Document Type: Electronic

Name: Vijay Kumar Eppakayala
Title: Modeling Team Lead
Organization: KC Engineering and Land Surveying PC
Contact Information: 2142 NY-302, Circleville, NY, 10919, 845-673-3204, veppakayala@kcepc.com
Document Type: Electronic

1.2. Project Organization

Project Manager (Matt Alexander) will be the responsible official for overseeing the overall project and budget, as well as tasking contractors with work required to complete projects. He/she will communicate project needs to the contractor's project manager.

Contractor Project Manager (John Szarowski) will have overall responsibility for assigning appropriate personnel to complete the tasks included in this plan. He/she will ensure that the project budget is adhered to. He/she will communicate with the Project Manager on work accomplished in this plan and any problems or deviations that need to be resolved.

QA/QC Manager will be responsible for reviewing and approving and maintaining the QA Project Plan. He/she may provide technical input.

Division of Water Quality Assurance Officer will be responsible for final approval of all quality assurance documents and verifying that the major quality assurance elements are included and addressed in the quality assurance project plan.

1.3. Problem Definition/Background

Contained entirely within Dutchess County, the Wappinger Creek watershed spans 211 square miles and is one of the five major tributaries that feed into the lower Hudson River (Findlay *et al.,* 2010). The watershed encompasses large portions of the Town of Pine Plains, the Town of Milan, the Town of Clinton, the Town of Stanford, the Town of Washington, the Village of Millbrook, the Town of Pleasant Valley, the Town of LaGrange, the Town of Poughkeepsie, the Town of Wappinger, the Village of Wappingers Falls, and small portions of the Town of Hyde Park and the Town of Fishkill (Findlay *et al.,* 2010).

Historically, this watershed has been the lifeblood of these communities, supplying, water, recreation, electrical power, and flood storage. At present, the watershed requires revitalization. Recent observations of Wappinger Creek found the watershed to be overloaded with phosphorus and plugged with silt (Cadmus Group, 2009). These pollutants are deteriorating water quality and have reduced the lake's capacity for flood storage. Wappinger Lake is on the 2016 303(d) list of impaired waterbodies, which require development of a total maximum daily load (TMDL) and is a restoration target for pollutant reduction (NYSDEC, 2016. *2016 section 303(d) list of impaired waters requiring a TMDL/ other strategy*). Since Wappinger Lake outlets into the Hudson River, and acts as a sink for substances that travel downstream, it is an indicator of water quality issues in the greater watershed.

The NYSDEC Division of Water, Bureau of Water Resource Management oversees the development of strategies to restore and protect the waters of New York State. This bureau's responsibilities include the development of water-quality based effluent limits, participating in watershed management groups, and water quality restoration strategies such as Total Maximum Daily Loads (TMDL). Phosphorus has long been recognized as a critical nutrient controlling the growth of phytoplankton in rivers and streams. Although there are currently no numerical water quality standards established for phosphorus the NYSDEC does have numeric guidance values for phosphorus which will assist in setting expectations of pollutant loads.

Computer modeling techniques will be used to estimate water quality conditions in Wappinger Creek using, streamflow data, land use classifications, and point source concentration data from WWTPs to develop a defensible justification, in the form of a watershed pollutant load assessment, for better watershed management practices and phosphorus load reduction that will result in improved water quality conditions in the watershed.

Presently the following segments of the Wappinger Creek are listed on the 303(d) list:
303(d) Part 1 – Requiring a TMDL
Segment #1305-0001 – phosphorus and silt/sediment

303(d) Part 3b – TMDL Deferred - Verification of Pollutant/Sources needed
Segment #1201-0094 – floatables, copper, pathogen, and low dissolved oxygen

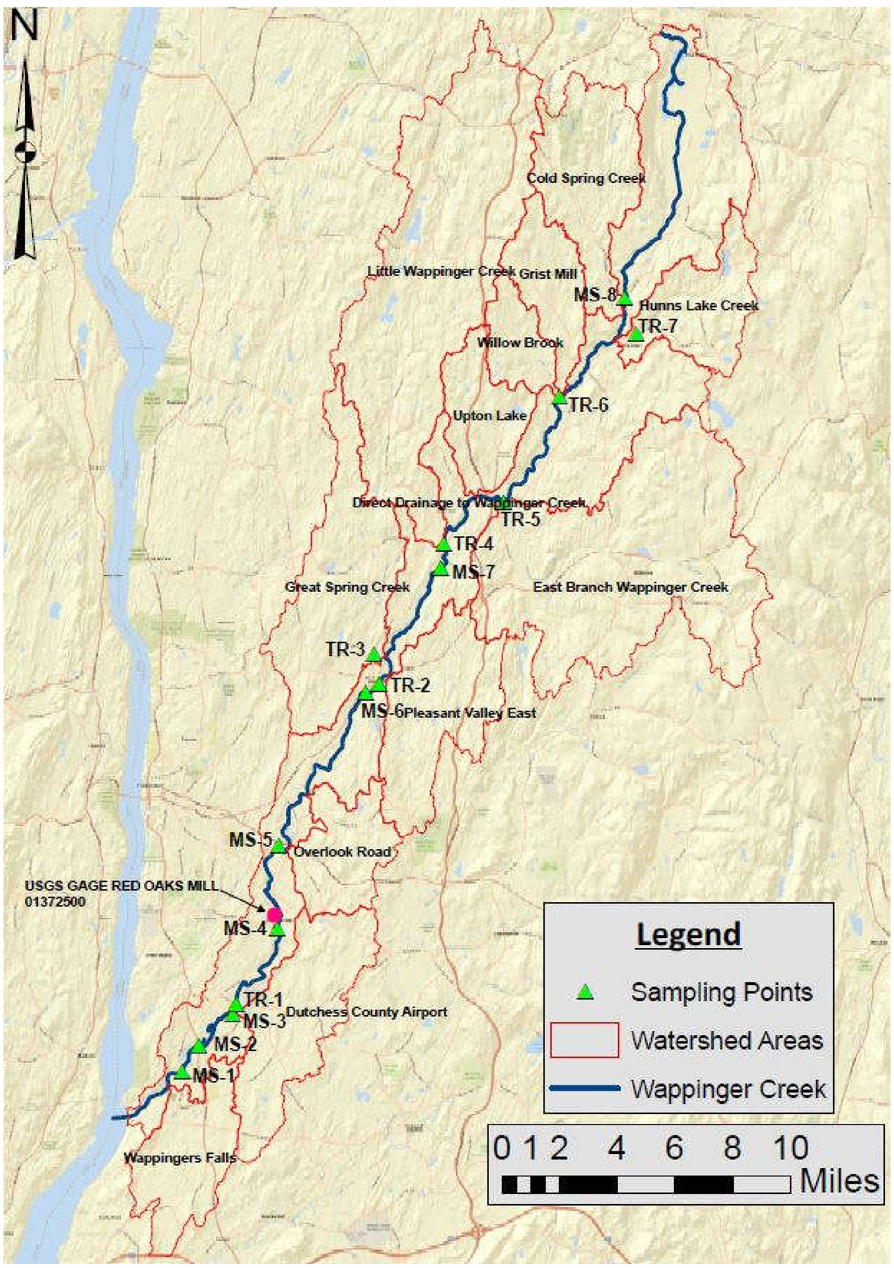


Figure 1. Map of USGS stream gages and sampling locations along the Wappinger Creek, New York

Development of pollutant loads for Wappinger Creek is a multistep process and requires determining potential sources of the contaminants and quantifying the loads of contaminants entering the waterway. The primary steps in this process include the development of hydrologic simulation models to estimate the flow volumes and contaminant concentrations along the creek to simulate current conditions. Finally, the calibrated models will be used to help in the development of pollutant loads.

The model will be created using the GWLF_E (Generalized Watershed Loading Function) component of Mapshed. A GIS based watershed modeling software developed at Penn State. Versions for New England/New York are available and the software has been used for 20 years to do TMDL modeling based on federal EPA guidelines.

1.4. Project/Tasks and Schedule

KC Engineering and Land Surveying PC will use MapShed-GWLF_E, a GIS-based watershed modeling tool that uses hydrology, land cover, soils, topography, weather, pollutant discharges, and other critical environmental data to model sediment and nutrient transport within a watershed to develop the hydrologic simulation model of the Wappinger Creek watershed from the creek's headwaters to its confluence with the Hudson River, to assist in management of nutrients, specifically Phosphorus in the Wappinger Creek watershed. The project schedule is as listed in Table 1.

Table 1. Tasks and Schedule

Task	Projected Completion Date
DEC Approval of Modeling QAPP	December 2, 2019
Input Data compilation and processing	December 9, 2019
Development of Mapshed Model	December 13, 2019
Model Calibration and Validation	December 18, 2019
Development of base model	December 23, 2019
Model scenarios	January 6, 2020
Finalize model	January 10, 2020

1.5. Special Training Requirements/Certification

The Project Manager will ensure that all individuals involved in the project receive a copy of the QAPP, are knowledgeable in their respective fields related to their work on this project and adhere to the procedures outline within the QAPP.

Vijay Eppakayala, the modeling team lead, possesses a B.S. in Chemical Engineering, a M.S. in Environmental Engineering, and a PhD in Civil Engineering. Furthermore, he has worked on a variety of projects relating to hydraulic modeling and water quality.

1.6. Documents and Records

KC Engineering will be responsible for maintaining project documentation and records. A dedicated electronic project folder will be used to store all project materials and data, which will be located on KC's server with frequent data backups. Any hardcopy paperwork will be scanned and filed in the project folder, along with any important correspondence.

KC Engineering and Land Surveying PC will deliver a final report and calibrated model to NYSDEC. The model input data, output data, parameters and coefficients, will be archived with the final model. The NYSDEC will maintain a copy of the final version of the Quality Assurance Project Plan on their computer system.

Any revisions made to this report will result in an electronic reissue of the report to the entire project distribution list. This will be done by the QAPP/DUAR Preparer (Ryan Stratton).

2. Modeling Goals and Objectives

The primary objective of this project is to build tools that can help communities within the watershed prepare guidelines to improve the water quality of the Wappinger Creek watershed. The expected long-term outcomes are development of an overall watershed management plan, and implementation of BMPs to reduce phosphorus loading to Wappinger Creek.

In general, the modeling goals include the development of a predictive model of pollutant loading by source type. The modeling system developed will then be used to evaluate the effectiveness of pollutant management scenarios on Wappinger Creek watershed phosphorus levels, and to compare the level of effectiveness of different management options with conceptual cost estimates.

2.1. Modeling Objectives

The specific objectives of the proposed modeling effort for the Wappinger Creek watershed management are as follows:

Develop a hydrologic model of the Wappinger Creek watershed from its headwaters, near Pine Plains, to its mouth, near New Hamburg, NY, utilizing best available data of the watershed to quantify pollutant loads and their sources.

Estimate effects of various pollutant management scenarios on Wappinger Creek watershed phosphorus levels.

3. Modeling Approach and Selection

Modeling is an essential component of the Wappinger Creek Watershed Revitalization Study. Modeling is proposed to evaluate to what extent phosphorus conditions in the watershed are due to various human-related inputs.

3.1. Modeling Approach

In theory, modeling should be an iterative approach that involves initial conceptualization and implementation based on management information needs and available resources followed by testing and model refinement. However, the application of models as an aid in management decision making typically requires a more finite project timeline. Ideally, modeling and management decision making would be a coupled iterative process that allows for additional data collection, model testing, model refinement, and re-evaluation of model results and management decisions based on them.

A relatively finite timeline will be achieved through the following steps:

- Develop new models or select existing models for project application
- Review of model data needs
- Compilation and review of existing data required for model
- Identification of data gaps or additional data needs
- Additional data collection and incorporation of additional data into model
- Selection of periods for model calibration
- Model setup
- Model calibration and testing
- Identification and implementation of possible model refinements
- Final testing and calibration of individual models

3.2. Modeling Selection

The work described in this QAPP does not involve creating new simulation modeling software. Rather, it involves developing and applying existing models—MapShed, GWLF_E.

The most important criteria for selecting the Mapshed-GWLF_E modeling framework for this project include:

- The framework uses algorithms and solution techniques that are appropriate for the intended application.
- Peer review of model theory and past applications has occurred.
- Technical documentation is available.
- Active development of the framework is ongoing and technical support is available.

In addition to these key criteria, other considerations that were beneficial include the following:

- Successful past applications in the State of New York have occurred.
- Graphical user interface (GUI) utilities that facilitate model setup, execution, and input and output management and analysis.
- The model has also been endorsed by the U.S. EPA as a good “mid-level” model that contains algorithms for simulating most of the key mechanisms controlling nutrient and sediment changes within a watershed.
- Ease of use and reliance on input datasets that are less complex than those required by other watershed-oriented water quality models such as SWAT, SWMM and HSPF.

- MapShed has enhanced capabilities, such as improved simulation of pollutant transport processes in urban settings, improved assessment of the effects of BMPs on pollutant load reduction, and the inclusion of streambank erosion, agricultural tile drainage routines.
- Team members responsible for modeling and reviewing tasks are familiar with the selected model(s).

3.3. MapShed-GWLF-E Model

The core watershed simulation model used in MapShed (GWLF-E) is based on the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker (1987). The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loads from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads and allows for the inclusion of point source discharge data. It is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads based on the daily water balance accumulated to monthly values.

GWLF is considered to be a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios, but each area is assumed to be homogenous in regard to various “landscape” attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but simply aggregates the loads from each source area into a watershed total; in other words, there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

For execution, the GWLF model requires three separate input files containing transport-, nutrient-, and weather-related data. Transport-related data define the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. Nutrient data specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (weather.dat) file contains daily average temperature and total precipitation values for each year simulated.

GWLF had previously been calibrated for the Northeastern U.S. in general and New York specifically. The GWLF model was calibrated and validated for the northeast (Evans et al., 2007). GWLF requires that calibration watersheds have long-term flow and water quality data. For the northeast model, watershed simulations were performed for twenty-two (22) watersheds throughout New York and New England for the period 1997-2004. Flow data was obtained directly from the water resource database maintained by the U.S. Geological Survey (USGS). Water quality data was obtained from the New York and New England State agencies. These data sets included in-stream concentrations of nitrogen, phosphorus, and sediment based on periodic sampling.

4. Wappinger Creek Watershed Water Quality Model Setup

Development of the MapShed-GWLF_E model will consist of two steps:

- Development of input files required for the model.
- Calibration and Validation Analysis.

4.1. Model Inputs

In MapShed, there are two data entry phases. The first phase, called MapShed, is when GIS layers and weather data are entered using the GIS interface. The second phase, called GWLF-E, is when additional data can be entered by typing numbers directly into a series of data entry screens. A summary of the input data is provided below:

Weather data (temperature and precipitation)

The weather data in the GWLF_E model includes daily temperature and precipitation values that are obtained from climate station records compiled by the National Weather Service. The GWLF_E model assumes an April-March "weather year" similar in concept to the "hydrologic year" used by the U.S. Geological Survey that begins on October 1 and ends on September 30. In the weather file, a line is required to specify the number of days in each month, and subsequent lines are used to record the average daily temperature (in degrees C) and the total amount of precipitation (in centimeters).

Within MapShed, weather data files are automatically prepared using daily climate data for weather stations contained in ".csv-formatted" Excel files. In constructing the weather data for a given watershed, MapShed uses data from nearby weather stations. If one or more stations are located within the basin polygon, the mean daily values for temperature and precipitation are used. For the Wappinger Creek watershed, the daily mean values of Dutchess County Airport weather station are used.

Basins

This layer is used to depict the boundary of one or more basins in which modeling is to be performed. Typically, these features are digitized from topographic maps or created "free-hand" using some type of base map or image. For this project, the Wappinger Creek watershed basin was digitized from the Wappinger Creek watershed GIS layer provided by Dutchess County Office of Central and Information Services (OCIS).

Streams

This layer contains the stream segments for the watershed of interest. For this model, this data was downloaded from the MapShed website at Penn State for the New York/ New England region.

Groundwater Nitrogen

To estimate nitrogen loads to streams, GWLF-E requires an estimate of the "area-weighted" concentration of nitrogen in groundwater. This is used to calculate the subsurface component of the load delivered to streams. The initial estimate of this concentration is made based on the groundwater nitrogen grid using spatial relationships between nitrogen concentration and rock type and land use/cover type. For this model, this data was downloaded from the MapShed website at Penn State for the New York/ New England region.

Soil Phosphorus

Within MapShed, a "soil P" grid is used to estimate the sediment P value for GWLF-E. This grid can either represent "soil test" P or total P. Soil P is reported in mg/kg and is an estimate measured by a standard land test such as Bray, Olsen or Mehlich. Total P is an estimate of the concentration of total P in the soil (both organic and inorganic, and dissolved and solid). One approach to creating a total P grid is to re-code an existing soil type map using empirical relationships between soil texture and phosphorus concentration based on soil sampling. For this model, this data was downloaded from the MapShed website at Penn State for the New York/ New England region.

Land Use/Cover

To properly estimate hydrology and nutrient loads within a watershed, the areal extent of various "source areas" (i.e., sub-units of land defined by different land use/cover types) is required. With MapShed, the extent of different source areas is computed using a digital land use/cover layer. Currently, seventeen (17) different land use types can be handled by the GWLF-E model. For this model, this data was downloaded from the MapShed website at Penn State for the New York/ New England region.

Soils

The soils layer is used to hold information pertaining to various soils-related properties. For this model, this data was downloaded from the MapShed website at Penn State for the New York/ New England region.

Topography

The topography layer is used to calculate land-slope related data for use within Mapshed. For the northeast model, both 100-meter and 30-meter digital elevation data sets were created. For the Wappinger Creek watershed, 30-meter digital elevation model (DEM) dataset downloaded from the MapShed website at Penn State for the New York/ New England region is used.

Table 2: GIS Level Input Parameters

Data Layer	Short Description	File Type	Required	Notes and Source
Weather Stations	Weather station locations	Point	Yes	Source: File created using Dutchess County Airport weather station
Weather Directory	Weather station directory	CSV	Yes	Source: MapShed and csv file created for Dutchess County Airport
Point Sources	Point source discharge locations	Point	No	Point source data was manually entered using GWLF-E
Basins	Basin boundary used for modeling	Polygon	Yes	Source: Dutchess County OCIS
Streams	Map of stream network	Line	Yes	Source: MapShed
Counties	County boundaries	Polygon	No	Source: MapShed

Septic Systems	Septic systems number and types	Polygon	No	Septic system population data was manually entered in GWLF-E
Soils	Contains various soil related data	Polygon	Yes	Source: MapShed
Physiographic Provinces	Contains hydrologic parameter data	Polygon	No	Source: MapShed
Urban Areas	Map of urban area boundaries	Polygon	No	This data layer was not used for this modeling effort
Land Use/ Cover	Map of land use/ cover	Grid	Yes	Source: MapShed
DEM	Elevation grid	Grid	Yes	Source: MapShed
Groundwater-N	Background estimate of N in mg/l	Grid	No	Source: MapShed
Soil-P	Estimate of Soil-P in mg/kg of Total P	Grid	No	Source: MapShed

Input Parameters for the GWLF-E Portion of MapShed

The GWLF-E component of MapShed starts with the .gsm file generated from the GIS portion of the model. This file consists of a large number of input parameters dealing with soil character, hydrology, weather patterns, nutrient transport, animal and human populations, and agricultural practices, which were calculated for each specific watershed based on the GIS data inputs described above.

Point Sources

In GWLF-E, point source loads are specified by the user and are simply added to the nonpoint source loads calculated by the model. Since point source discharge information is oftentimes difficult to obtain, this task is facilitated in MapShed through the use of a "point source" layer that contains information on estimated monthly loads of nitrogen and phosphorus from major industrial and municipal wastewater treatment plants. For the Wappinger Creek watershed, total phosphorus loads are determined using actual reported data from discharge monitoring reports. For facilities with no monitored phosphorus data, a concentration of 3mg/L is used to estimate the phosphorus loading.

Septic System Populations

In GWLF-E, information on the number of persons served by septic systems is used to calculate nutrient loads from such systems. With MapShed, this information has historically been derived using a census tract layer and is normally based on recent U.S. Census Bureau data or other locally-produced population data . The GWLF-E model can accept information on the populations served by different septic systems such as normally functioning systems confirm to recommended construction and operational procedures (normal systems), malfunctioning systems that discharge to underlying water tables and groundwater (short-circuited systems), and malfunctioning systems that deliver waste to surface waters (ponding systems). In the case of Wappinger Creek watershed, The number of dwellings relying on septic systems are estimated based on a GIS analysis of orthoimagery to account for proximity of septic systems to surface waters in the watershed. Greater attention was given to the dwellings that are located within 250 feet of the surface waters.

Animal Data

GWLF-E gives users the ability to more directly simulate loads from farm animals, as well as to estimate pathogen loads from these and other sources. Data in this file can be viewed and edited using the "animal/pathogen" form which is accessed by clicking on the Edit Animal Data button. The basic input to this form includes information on animal populations by type, which can be either loaded automatically via the use of an "AFOs" shapefile or typed directly into the form. The remainder of this form contains information that is either provided by default (e.g., nutrient and pathogen loading rates) or is calculated automatically using input animal populations and user-edited settings (e.g., time spent in grazing areas and streams, loss rates, etc.). In the case of Wappinger Creek watershed, the number of farm animals are entered directly based on the amount of pasture land available for animal grazing. The animal stocking capacity is assumed to be 500 pounds of grazing animal per acre.

BMP data (rural and urban land BMPs)

Within GWLF-E, a wide range of BMPs are theoretically available for use in rural (primarily agricultural) and urban areas. In simulating the implementation of these BMPs with GWLF-E, the user is required to specify the extent to which they are to be implemented within a given area (e.g., % of area to which a BMP is applied, % of total animal population treated, length of stream buffered or fenced, etc.). Based on this information, pollutant load calculations are then made using the reduction coefficients associated with each BMP type. For the Wappinger Creek watershed, nine different BMPs (cover crops, conservation tillage, strip cropping, conservation plan, nutrient management, grazing land management, animal waste management systems, vegetated buffer strips and stream fencing) are applied based on the input gathered from Cornell Cooperative Extension of Dutchess County and Dutchess County Soil & Water Conservation District.

4.2. Model Calibration and Validation

Once the model setup is completed, the model will be calibrated through comparison with observed data collected in Wappinger Creek watershed. The term calibration is defined as the process of adjusting the model parameters within physically defensible ranges until the resulting predictions give the best possible match with observed data. Calibration tunes the models to represent conditions appropriate to the waterbody and watershed being studied. However, calibration alone is not sufficient to evaluate the predictive capability of the model or to determine whether the model developed via calibration contains a valid representation of cause and effect relationships. To help determine the adequacy of the calibration and to evaluate the uncertainty associated with the calibration, the model is subjected to a corroboration step. In the corroboration step, the model performance is assessed on a set of data separate from that used in calibration.

The Wappinger Creek watershed model will be calibrated and validated through a hydrologic calibration. The model will not be calibrated for water quality components (Phosphorus) due to the unavailability of continuous water quality data. The calibration will be done by changing evapotranspiration coefficient for different months and groundwater recession rate. Both calibration and evaluation of the model will rely on a combination of quantitative statistics for goodness-of-fit of predicted and observed stream flow data.

After the model is adequately calibrated, the quality of the calibration will be evaluated through corroboration tests on separate data. This process is often referred to as model validation, defined as, "subsequent testing of a pre-calibrated model to additional field data, usually under different external conditions, to further examine the model's ability to predict future conditions". Its purpose is to ensure that the calibrated model properly assesses all the variables and conditions that can affect model results and demonstrate the ability to predict field observations for periods separate from the calibration effort. That helps to ensure that the model of the system is robust, and that the quality of the calibration is not an artifact of over-fitting to a specific set of observations, which can occur because of the persistence of the effects of high-precipitation events on water storage in the model.

The model will be run for the years 2009 to 2018. The result will be calibrated for the years 2009 to 2018. For validation 2014 to 2018 were taken. The calibration will be done by changing evapotranspiration coefficient for different months and groundwater recession rate. The agreement of the observed streamflow with the model output will be tested using a qualitative graphical comparison and set of basic statistical methods, including the root mean square error standard deviation ratio (RSR), the coefficient of determination, and the Nash-Sutcliffe efficiency (NSE) methods.

RMSE-observations standard deviation ratio (RSR): RMSE is one of the commonly used error index statistics. RSR is calculated as the ratio of the RMSE and standard deviation of measured data. RSR incorporates the benefits of error index statistics and includes a scaling/normalization factor, so that the resulting statistic and reported values can apply to various constituents. RSR varies from the optimal value of 0, which indicates zero RMSE or residual variation and therefore perfect model simulation, to a large positive value. The lower RSR, the lower the RMSE, and the better the model simulation performance.

Coefficient of Determination (R^2): Coefficient of determination describes the proportion of the variance in measured data explained by the model. R^2 ranges from 0 to 1, with higher values indicating less error variance, and typically values greater than 0.5 are considered acceptable.

Nash-Sutcliffe efficiency (NSE): The Nash-Sutcliffe efficiency (NSE) is a normalized statistic that determines the relative magnitude of the residual variance ("noise") compared to the measured data variance ("information"). NSE ranges between $-\infty$ and 1.0 (1 inclusive), with NSE = 1 being the optimal value. Values between 0.0 and 1.0 are generally viewed as acceptable levels of performance, whereas values ≤ 0.0 indicates that the mean observed value is a better predictor than the simulated value, which indicates unacceptable performance.

4.3. Numeric Guidance for Acceptance of Model Calibration

The intended uses of the model focus on the effectiveness and cost-effectiveness of different implementation strategies. As such, the ability of the models to represent the relative contributions of different source areas and the relative performance of different management measures is of greatest importance, while obtaining a precise estimate of loading time series is of less direct interest. Ideally, the models should attain tight calibration to observed data.

In light of these uses of the models, it is most informative to specify performance target ranges of precision that characterize the model results as satisfactory or unsatisfactory. In general, hydrologic model performance can be evaluated as satisfactory if NSE > 0.50 and RSR ≤ 0.70 (Moriasi *etal.*, 2007), and the model can assume a strong role in evaluating management options.

5. Evaluation of Model Scenarios

After the model is calibrated and validated, the model will be used to evaluate pollutant loads in Wappinger Creek watershed from 2009 and 2018. Several scenarios will be simulated with primary focus on various phosphorus management strategies. An existing condition (base) scenario will be simulated with known influences on watershed (point sources, septic systems, farm animals, BMP application). Scenario results will be evaluated both as predicted patterns for that scenario and as differences between the base case and any particular scenario.

6. Model Output Assessment and Usability

The model developed for the project will be used to assess a series of study questions, as summarized in Section 2.1, associated with the project goals and objectives. The calibrated model will be provided to the QA officer for review. If a model does not meet acceptance criteria, the QC officer will first direct efforts to bring the model into compliance. If, after such efforts, the model still fails to meet acceptance criteria, KC Engineering and Land Surveying PC, will conduct a thorough exposition of the problem and potential corrective actions.

MapShed is an aggregate distributed/lumped parameter watershed model that generates loading estimates for the surface water pollutants of phosphorus, nitrogen, total dissolved solids, and fecal coliform bacteria. The model is distributed in that it allows multiple land use/cover scenarios. However, loads originating from the watershed are lumped by land use category, and spatial routing of nutrient and sediment loads within each watershed is not available. For example, all farmland is lumped together and defined by one set of parameter values, and all forested land is lumped together and defined by a different set of parameter values. The model does not account for active forest operations within forested areas. Other factors that affect the nutrient balance of a watershed such as livestock numbers and practices, soil and groundwater nutrient loads, point-sources, and septic systems are also lumped together, with each group treated as a unique source. The GWLF-E model on which MapShed is based is a watershed loading model. Like other models of this type, another limitation is that it does not perform in-stream routing. This functionality provides for in-stream attenuation as a given pollutant such as nitrogen or phosphorus moves down- stream.

As with any model, the results obtained with MapShed - GWLF-E are directly related to the quality of the input provided. If the input is poor, then the simulated output based on the data can be expected to be poor as well. Generally speaking, data quality is usually related to “inherent” data accuracy (how accurately are local conditions reported or represented) and the “appropriateness” of the data used.

Not all watershed simulation models produce output in the same format. The type and format of the output from a given model has a direct effect on the manner in which subsequent calibration work is performed. Many water quality models, for example, produce estimates of flow and constituent concentrations over relatively short time frames that can be directly compared against available in-stream flow and concentration data. MAPSHED, on the other hand, produces estimates of flow and loads that are accumulated over longer time periods. In the case of MAPSHED, load estimates (rather than concentrations) are calculated daily and then reported on a monthly basis for each year of the simulation period. For calibration purposes, this requires that simulated loads be compared against "observed" loads compiled for the same time period.

Since continuous load estimates based on daily observations are rarely available (given the high cost of in-stream sampling,) such loads are normally "estimated" using another procedure. Such procedures are typically based on the assumption that fluctuations in concentration or load are primarily dependent on varying flow conditions and do not typically consider the effects of rainfall intensity, which can have a significant influence on observed loads (particularly for sediment and phosphorus) in a watershed. A relatively simple "rating curve" approach based on a "load/flow" relationship is used for MAPSHED. Since daily estimates of load are essentially based on limited stream flow and concentration data, this procedure is subject to error, and it is possible that "observed" loads for any month may be slightly higher or lower than "actual" loads, thereby further complicating comparisons between simulated and "observed" data.

The potentials sources of model error identified and described above are not specific to MapShed, but are typical of most modeling approaches (e.g., problems with weather data, lack of available map data, etc.) and therefore would not be rectified by use of a different model. Based on the results of the Northeast MAPSHED Model, KC Engineering feels that the finetuned MAPSHED Model for New York, when calibrated, will be able to simulate sediment and nutrient loads for different time periods.

6.1. Reconciliation with User Requirements

The primary product created during the Wappinger Creek watershed project will be a calibrated watershed model of the Wappinger Creek watershed from the creek's headwaters to its confluence with the Hudson River to assess pollutant loads originating from various sources. This project seeks to identify the sources and quantify the amount of phosphorus and nitrogen entering the waters in the watershed. Furthermore, through modeling and water quality data collection, the goal of this project is the development of an understanding of pollutant sources and loads and identify feasible strategies for phosphorus management in Wappinger Creek watershed and provide recommendations to implement those strategies via policy, regulation or programmatic actions, as a comprehensive watershed plan.

This information will be communicated initially through draft and final watershed reports, including, but not limited to, reports containing recommendations to decision makers that update the Wappinger Creek Watershed Management Plan.

The modeling results are intended to serve as guidance for watershed load assessment and subsequent watershed management to meet pollutant reduction goals.

The calibrated watershed model data and simulation scenarios will be sent to NYSDEC for review. Any simulations of future scenarios will have several caveats attached to them and correspondingly large confidence bands. The scenarios may include upgrades to WWTPs, even though it is unclear if funding would be available for applying these upgrades if point source concentrations seem to have a major impact on the water-quality of the Wappinger Creek.

7. References

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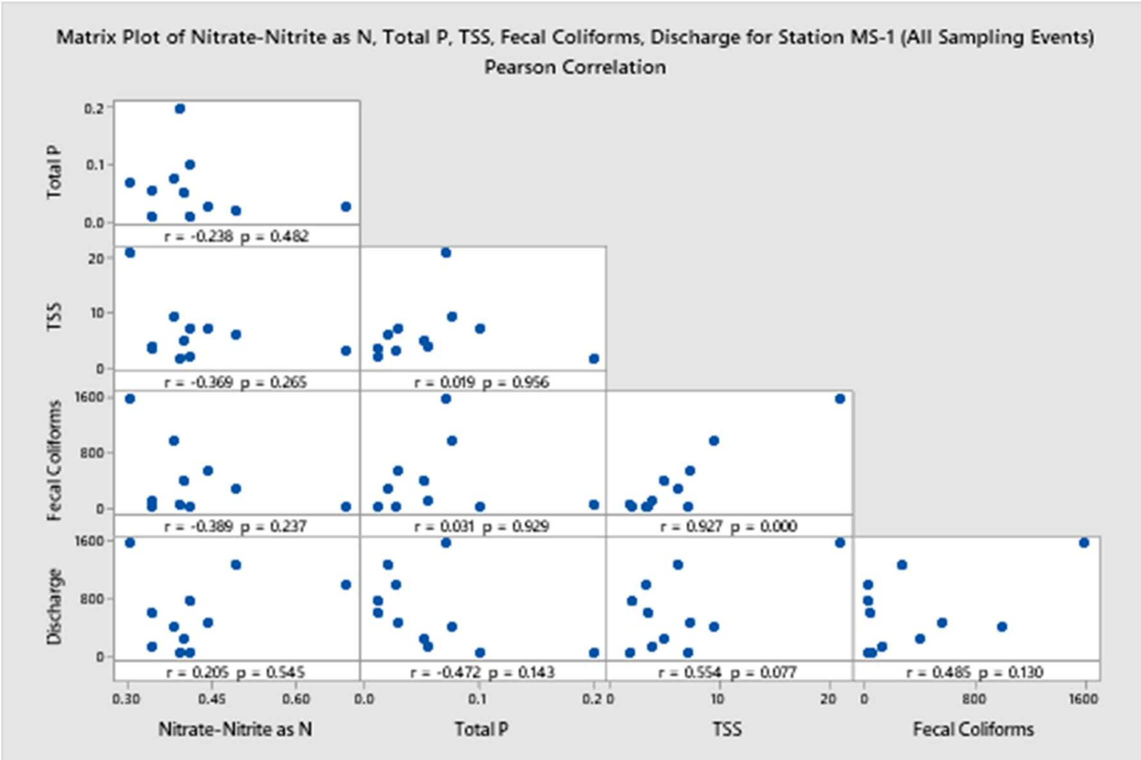
Moriasi, D. N.; Arnold, J. G.; Van Liew, M. W.; Bingner, R. L.; Harmel, R. D.; Veith, T. L. (2007). "Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations. *Transactions of the ASABE.* 50 (3): 885–900.

Appendix J

Pearson Correlation Analyses



Method

Correlation type	Pearson
Rows used	11

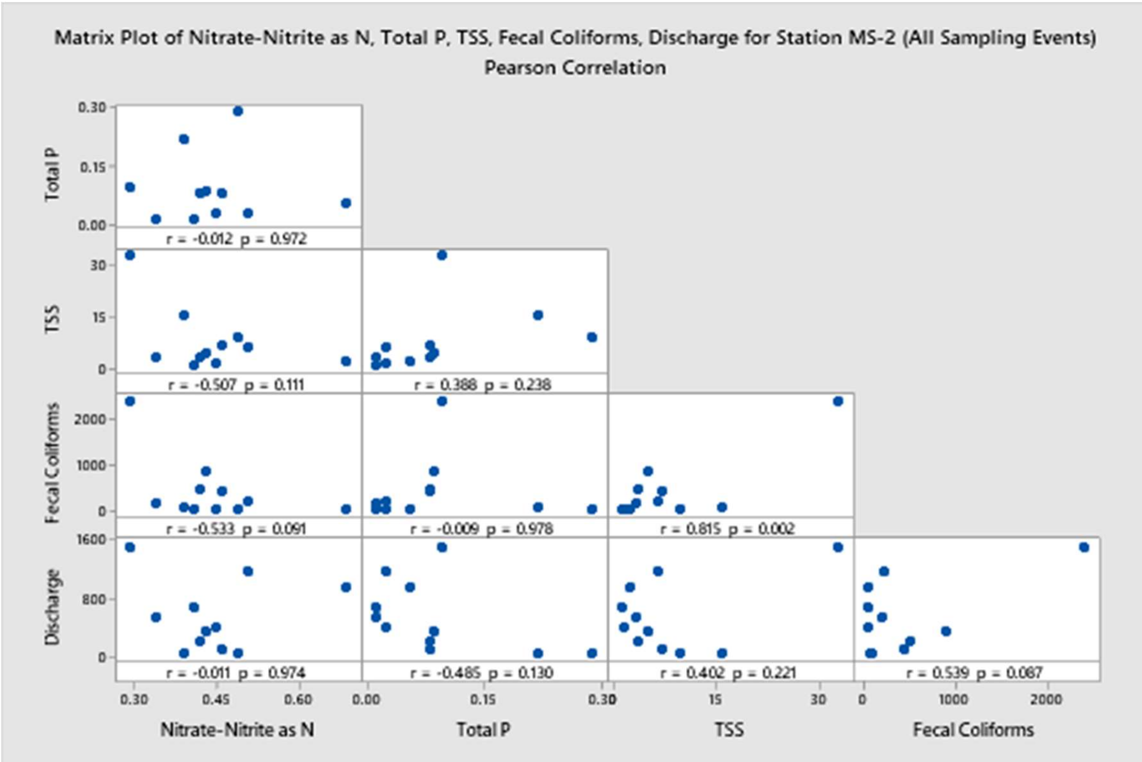
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.238			
TSS	-0.369	0.019		
Fecal Coliforms	-0.389	0.031	0.927	
Discharge	0.205	-0.472	0.554	0.485

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.238	(-0.733, 0.422)	0.482
TSS	Nitrate-Nitrite as N	-0.369	(-0.793, 0.297)	0.265
Fecal Coliforms	Nitrate-Nitrite as N	-0.389	(-0.802, 0.275)	0.237
Discharge	Nitrate-Nitrite as N	0.205	(-0.450, 0.717)	0.545
TSS	Total P	0.019	(-0.588, 0.612)	0.956
Fecal Coliforms	Total P	0.031	(-0.580, 0.619)	0.929
Discharge	Total P	-0.472	(-0.835, 0.179)	0.143
Fecal Coliforms	TSS	0.927	(0.736, 0.981)	0.000
Discharge	TSS	0.554	(-0.069, 0.866)	0.077
Discharge	Fecal Coliforms	0.485	(-0.161, 0.841)	0.130



Method

Correlation type	Pearson
Rows used	11

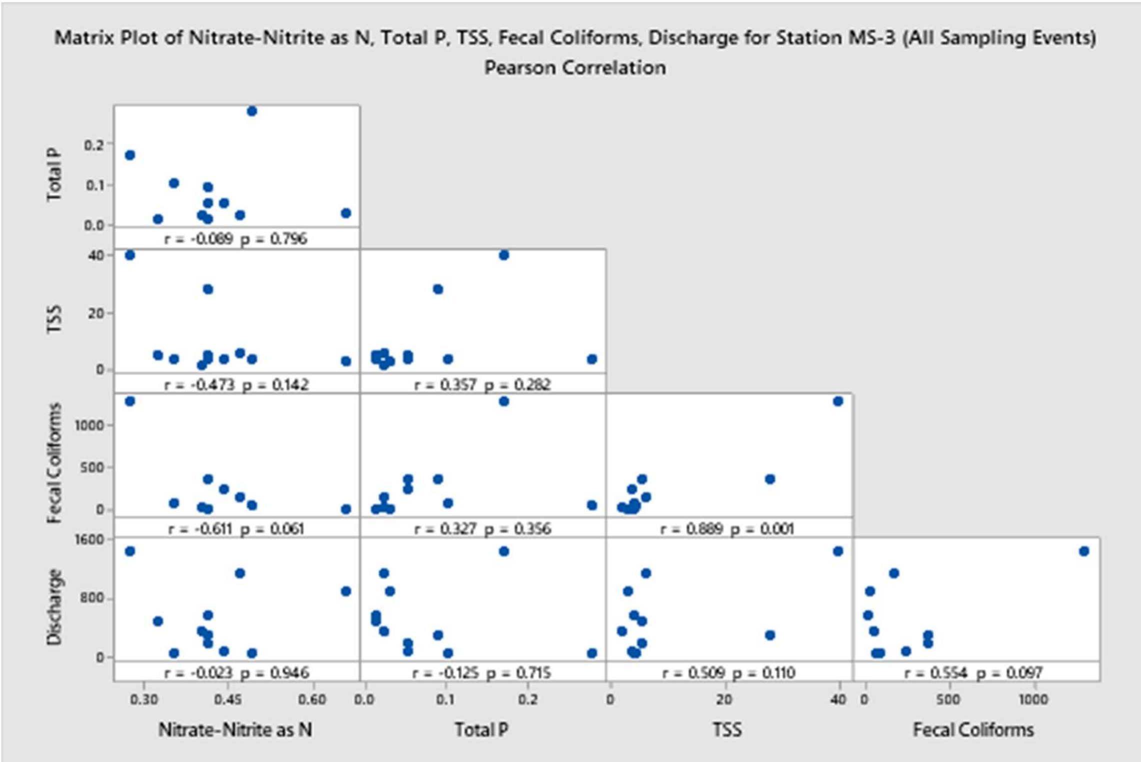
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.012			
TSS	-0.507	0.388		
Fecal Coliforms	-0.533	-0.009	0.815	
Discharge	-0.011	-0.485	0.402	0.539

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.012	(-0.607, 0.592)	0.972
TSS	Nitrate-Nitrite as N	-0.507	(-0.849, 0.133)	0.111
Fecal Coliforms	Nitrate-Nitrite as N	-0.533	(-0.858, 0.098)	0.091
Discharge	Nitrate-Nitrite as N	-0.011	(-0.607, 0.593)	0.974
TSS	Total P	0.388	(-0.276, 0.801)	0.238
Fecal Coliforms	Total P	-0.009	(-0.606, 0.594)	0.978
Discharge	Total P	-0.485	(-0.840, 0.162)	0.130
Fecal Coliforms	TSS	0.815	(0.420, 0.950)	0.002
Discharge	TSS	0.402	(-0.261, 0.807)	0.221
Discharge	Fecal Coliforms	0.539	(-0.090, 0.861)	0.087



Method

Correlation type	Pearson
Rows used	11

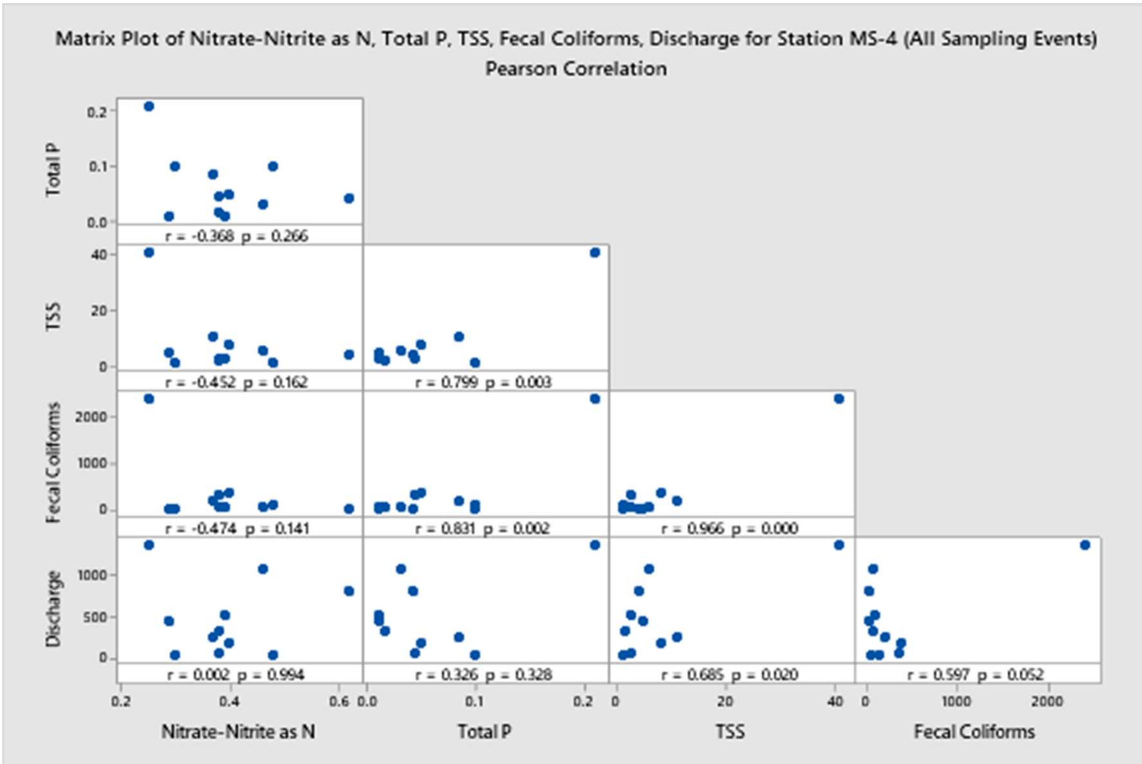
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.089			
TSS	-0.473	0.357		
Fecal Coliforms	-0.611	0.327	0.889	
Discharge	-0.023	-0.125	0.509	0.554

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.089	(-0.654, 0.540)	0.796
TSS	Nitrate-Nitrite as N	-0.473	(-0.836, 0.178)	0.142
Fecal Coliforms	Nitrate-Nitrite as N	-0.611	(-0.896, 0.031)	0.061
Discharge	Nitrate-Nitrite as N	-0.023	(-0.615, 0.585)	0.946
TSS	Total P	0.357	(-0.309, 0.788)	0.282
Fecal Coliforms	Total P	0.327	(-0.381, 0.793)	0.356
Discharge	Total P	-0.125	(-0.674, 0.514)	0.715
Fecal Coliforms	TSS	0.889	(0.588, 0.974)	0.001
Discharge	TSS	0.509	(-0.130, 0.850)	0.110
Discharge	Fecal Coliforms	0.554	(-0.116, 0.878)	0.097



Method

Correlation type	Pearson
Rows used	11

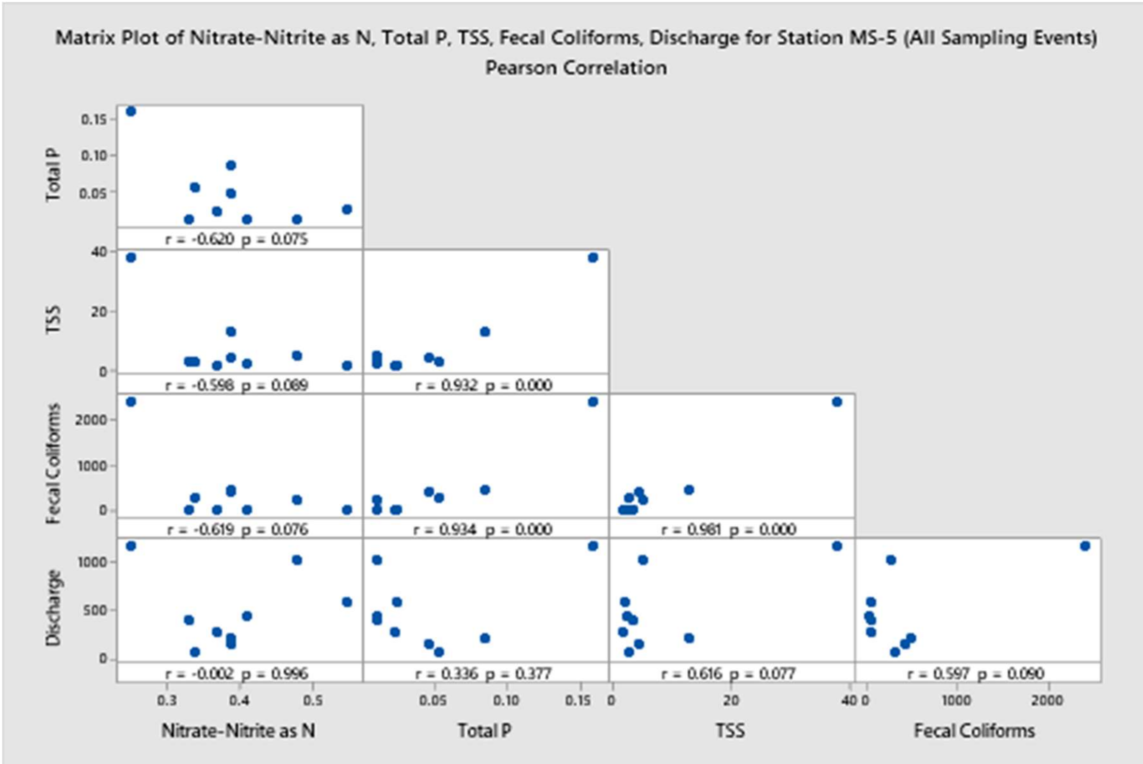
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.368			
TSS	-0.452	0.799		
Fecal Coliforms	-0.474	0.831	0.966	
Discharge	0.002	0.326	0.685	0.597

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.368	(-0.793, 0.298)	0.266
TSS	Nitrate-Nitrite as N	-0.452	(-0.828, 0.202)	0.162
Fecal Coliforms	Nitrate-Nitrite as N	-0.474	(-0.836, 0.176)	0.141
Discharge	Nitrate-Nitrite as N	0.002	(-0.598, 0.601)	0.994
TSS	Total P	0.799	(0.383, 0.946)	0.003
Fecal Coliforms	Total P	0.831	(0.460, 0.955)	0.002
Discharge	Total P	0.326	(-0.341, 0.774)	0.328
Fecal Coliforms	TSS	0.966	(0.869, 0.991)	0.000
Discharge	TSS	0.685	(0.145, 0.911)	0.020
Discharge	Fecal Coliforms	0.597	(-0.004, 0.881)	0.052



Method

Correlation type	Pearson
Rows used	9

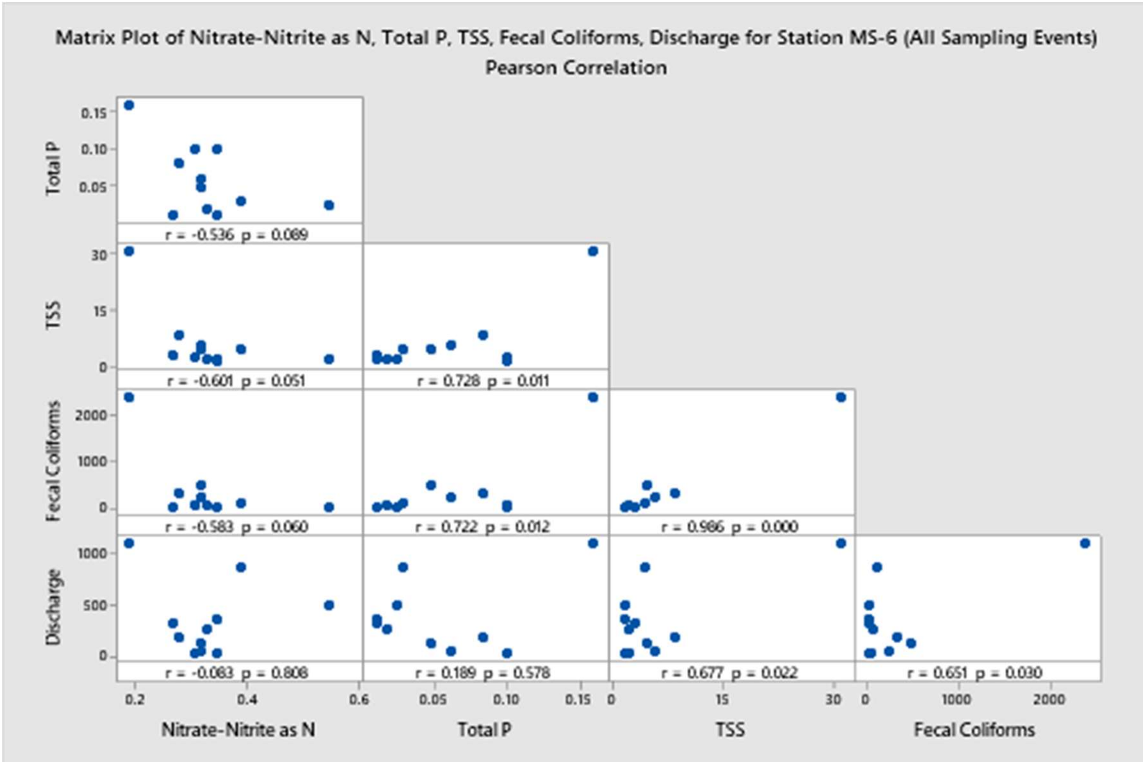
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.620			
TSS	-0.598	0.932		
Fecal Coliforms	-0.619	0.934	0.981	
Discharge	-0.002	0.336	0.616	0.597

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.620	(-0.910, 0.075)	0.075
TSS	Nitrate-Nitrite as N	-0.598	(-0.903, 0.110)	0.089
Fecal Coliforms	Nitrate-Nitrite as N	-0.619	(-0.909, 0.077)	0.076
Discharge	Nitrate-Nitrite as N	-0.002	(-0.665, 0.663)	0.996
TSS	Total P	0.932	(0.702, 0.986)	0.000
Fecal Coliforms	Total P	0.934	(0.712, 0.986)	0.000
Discharge	Total P	0.336	(-0.423, 0.817)	0.377
Fecal Coliforms	TSS	0.981	(0.911, 0.996)	0.000
Discharge	TSS	0.616	(-0.082, 0.908)	0.077
Discharge	Fecal Coliforms	0.597	(-0.111, 0.903)	0.090



Method

Correlation type	Pearson
Rows used	11

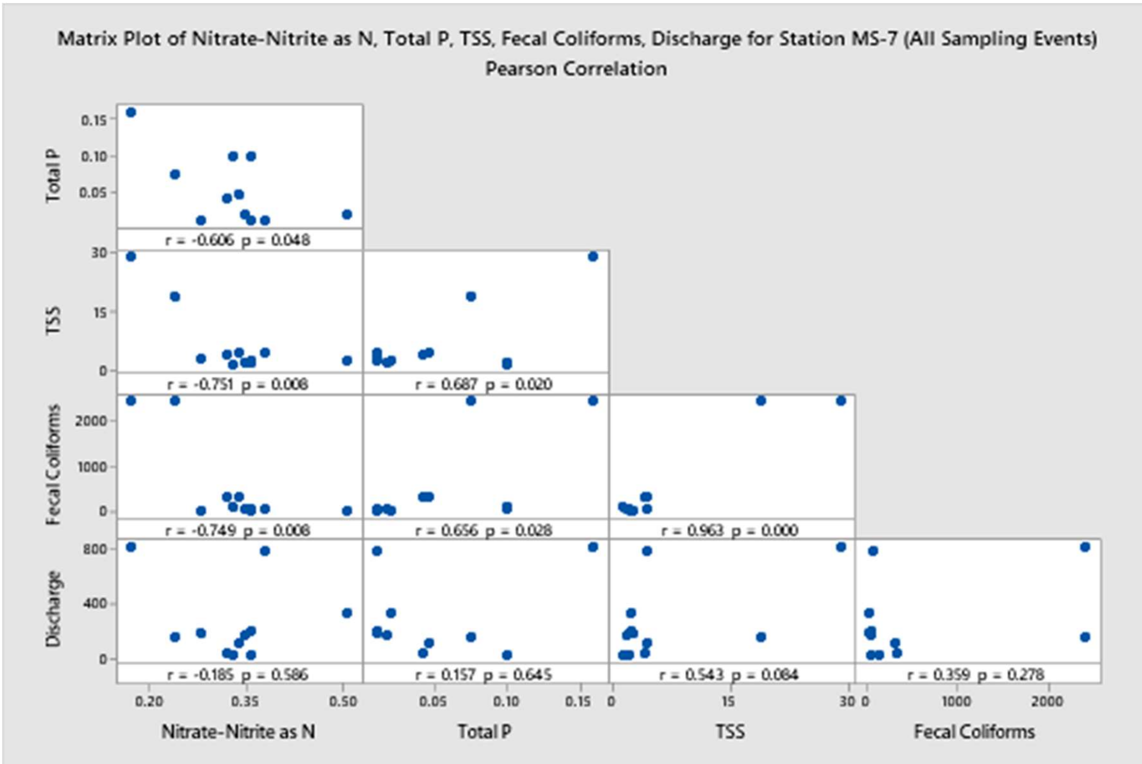
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.536			
TSS	-0.601	0.728		
Fecal Coliforms	-0.583	0.722	0.986	
Discharge	-0.083	0.189	0.677	0.651

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.536	(-0.859, 0.095)	0.089
TSS	Nitrate-Nitrite as N	-0.601	(-0.883, -0.001)	0.051
Fecal Coliforms	Nitrate-Nitrite as N	-0.583	(-0.876, 0.026)	0.060
Discharge	Nitrate-Nitrite as N	-0.083	(-0.651, 0.544)	0.808
TSS	Total P	0.728	(0.228, 0.924)	0.011
Fecal Coliforms	Total P	0.722	(0.215, 0.922)	0.012
Discharge	Total P	0.189	(-0.463, 0.709)	0.578
Fecal Coliforms	TSS	0.986	(0.946, 0.997)	0.000
Discharge	TSS	0.677	(0.130, 0.908)	0.022
Discharge	Fecal Coliforms	0.651	(0.083, 0.899)	0.030



Method

Correlation type	Pearson
Rows used	11

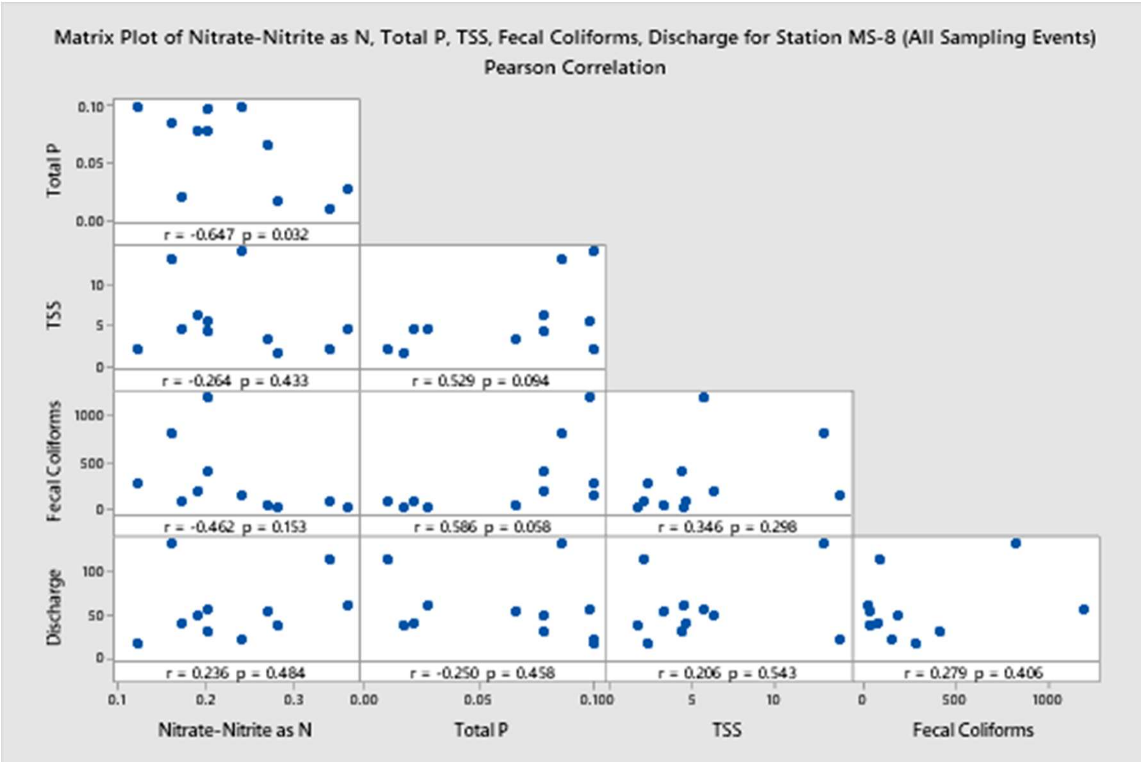
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.606			
TSS	-0.751	0.687		
Fecal Coliforms	-0.749	0.656	0.963	
Discharge	-0.185	0.157	0.543	0.359

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.606	(-0.884, -0.010)	0.048
TSS	Nitrate-Nitrite as N	-0.751	(-0.931, -0.275)	0.008
Fecal Coliforms	Nitrate-Nitrite as N	-0.749	(-0.931, -0.270)	0.008
Discharge	Nitrate-Nitrite as N	-0.185	(-0.706, 0.467)	0.586
TSS	Total P	0.687	(0.148, 0.911)	0.020
Fecal Coliforms	Total P	0.656	(0.093, 0.901)	0.028
Discharge	Total P	0.157	(-0.489, 0.692)	0.645
Fecal Coliforms	TSS	0.963	(0.861, 0.991)	0.000
Discharge	TSS	0.543	(-0.085, 0.862)	0.084
Discharge	Fecal Coliforms	0.359	(-0.307, 0.789)	0.278



Method

Correlation type	Pearson
Rows used	11

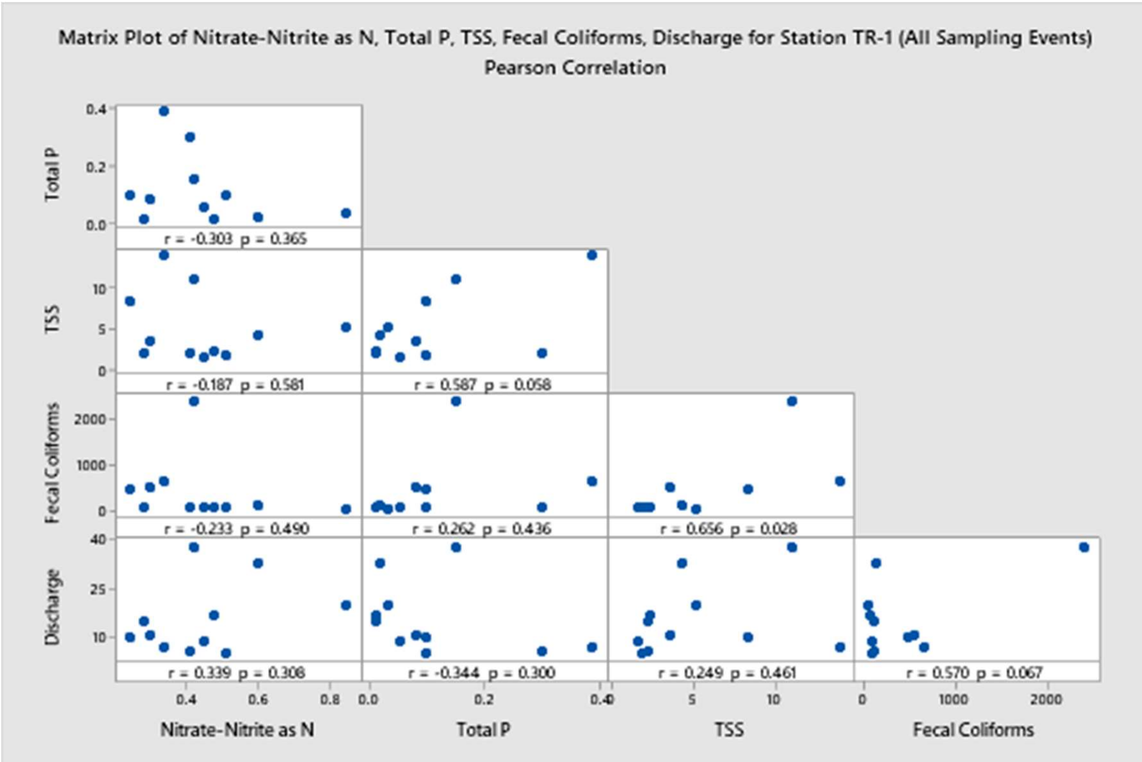
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.647			
TSS	-0.264	0.529		
Fecal Coliforms	-0.462	0.586	0.346	
Discharge	0.236	-0.250	0.206	0.279

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.647	(-0.898, -0.076)	0.032
TSS	Nitrate-Nitrite as N	-0.264	(-0.746, 0.399)	0.433
Fecal Coliforms	Nitrate-Nitrite as N	-0.462	(-0.831, 0.191)	0.153
Discharge	Nitrate-Nitrite as N	0.236	(-0.424, 0.732)	0.484
TSS	Total P	0.529	(-0.104, 0.857)	0.094
Fecal Coliforms	Total P	0.586	(-0.022, 0.877)	0.058
Discharge	Total P	-0.250	(-0.739, 0.411)	0.458
Fecal Coliforms	TSS	0.346	(-0.321, 0.783)	0.298
Discharge	TSS	0.206	(-0.449, 0.717)	0.543
Discharge	Fecal Coliforms	0.279	(-0.385, 0.753)	0.406



Method

Correlation type	Pearson
Rows used	11

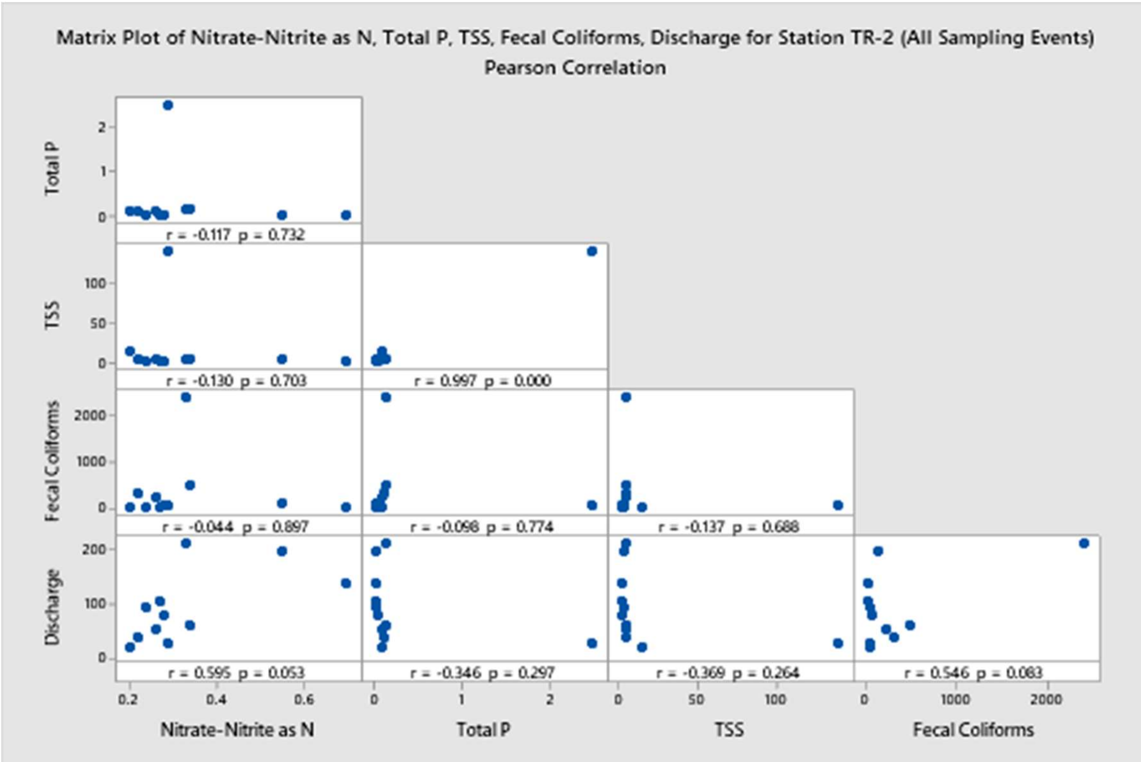
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.303			
TSS	-0.187	0.587		
Fecal Coliforms	-0.233	0.262	0.656	
Discharge	0.339	-0.344	0.249	0.570

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.303	(-0.764, 0.363)	0.365
TSS	Nitrate-Nitrite as N	-0.187	(-0.708, 0.465)	0.581
Fecal Coliforms	Nitrate-Nitrite as N	-0.233	(-0.731, 0.426)	0.490
Discharge	Nitrate-Nitrite as N	0.339	(-0.327, 0.780)	0.308
TSS	Total P	0.587	(-0.020, 0.878)	0.058
Fecal Coliforms	Total P	0.262	(-0.400, 0.745)	0.436
Discharge	Total P	-0.344	(-0.783, 0.322)	0.300
Fecal Coliforms	TSS	0.656	(0.092, 0.901)	0.028
Discharge	TSS	0.249	(-0.413, 0.738)	0.461
Discharge	Fecal Coliforms	0.570	(-0.045, 0.872)	0.067



Method

Correlation type	Pearson
Rows used	11

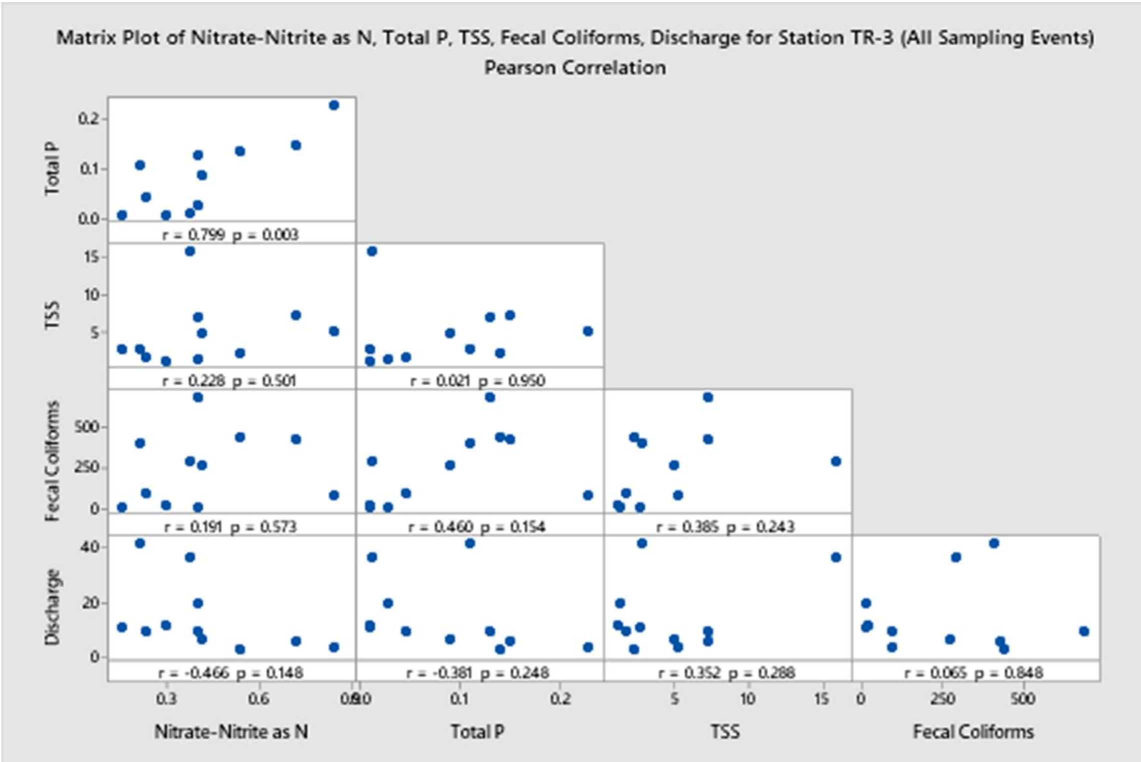
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.117			
TSS	-0.130	0.997		
Fecal Coliforms	-0.044	-0.098	-0.137	
Discharge	0.595	-0.346	-0.369	0.546

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.117	(-0.670, 0.519)	0.732
TSS	Nitrate-Nitrite as N	-0.130	(-0.677, 0.510)	0.703
Fecal Coliforms	Nitrate-Nitrite as N	-0.044	(-0.628, 0.571)	0.897
Discharge	Nitrate-Nitrite as N	0.595	(-0.007, 0.881)	0.053
TSS	Total P	0.997	(0.988, 0.999)	0.000
Fecal Coliforms	Total P	-0.098	(-0.659, 0.533)	0.774
Discharge	Total P	-0.346	(-0.783, 0.321)	0.297
Fecal Coliforms	TSS	-0.137	(-0.681, 0.504)	0.688
Discharge	TSS	-0.369	(-0.793, 0.297)	0.264
Discharge	Fecal Coliforms	0.546	(-0.081, 0.863)	0.083



Method

Correlation type	Pearson
Rows used	11

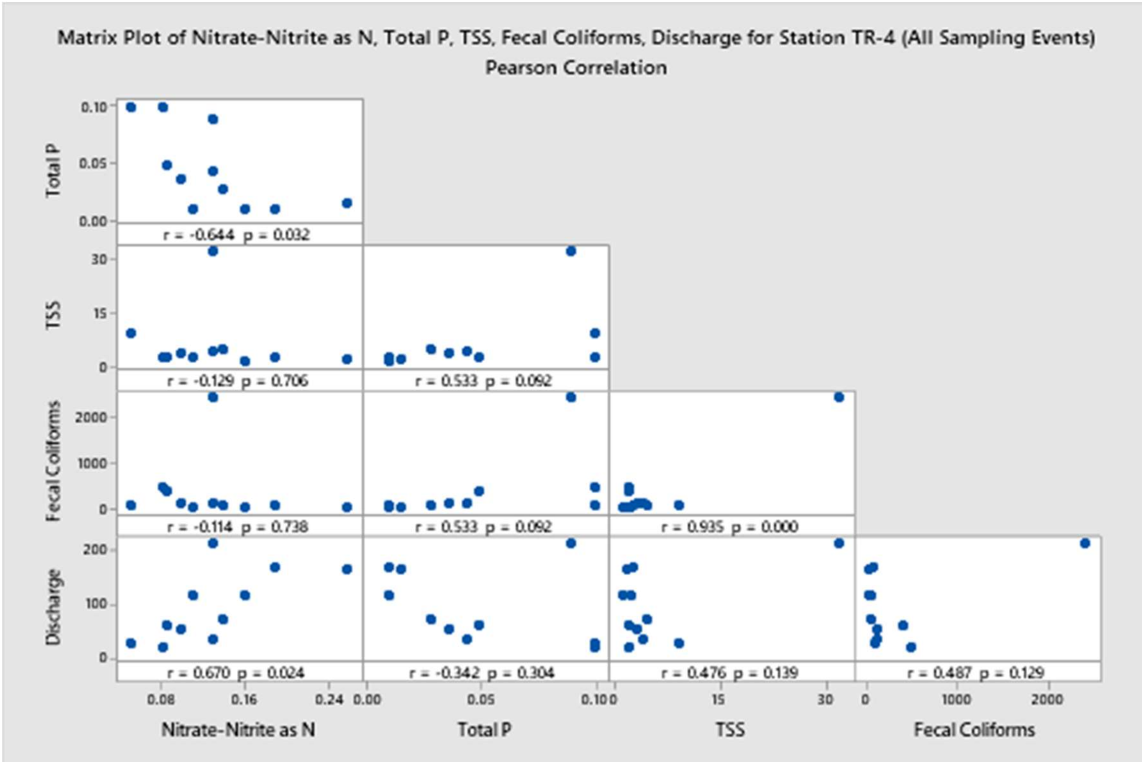
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	0.799			
TSS	0.228	0.021		
Fecal Coliforms	0.191	0.460	0.385	
Discharge	-0.466	-0.381	0.352	0.065

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	0.799	(0.384, 0.946)	0.003
TSS	Nitrate-Nitrite as N	0.228	(-0.431, 0.728)	0.501
Fecal Coliforms	Nitrate-Nitrite as N	0.191	(-0.462, 0.710)	0.573
Discharge	Nitrate-Nitrite as N	-0.466	(-0.833, 0.186)	0.148
TSS	Total P	0.021	(-0.586, 0.613)	0.950
Fecal Coliforms	Total P	0.460	(-0.193, 0.831)	0.154
Discharge	Total P	-0.381	(-0.798, 0.284)	0.248
Fecal Coliforms	TSS	0.385	(-0.280, 0.800)	0.243
Discharge	TSS	0.352	(-0.314, 0.786)	0.288
Discharge	Fecal Coliforms	0.065	(-0.556, 0.640)	0.848



Method

Correlation type	Pearson
Rows used	11

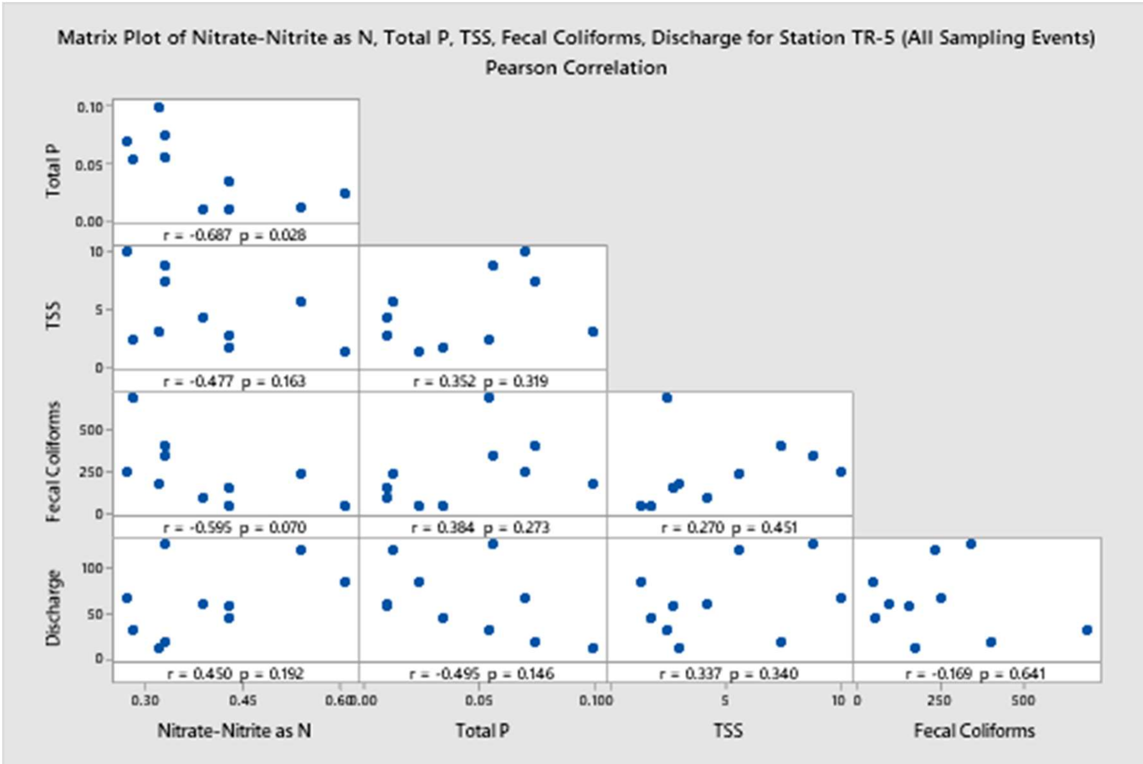
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.644			
TSS	-0.129	0.533		
Fecal Coliforms	-0.114	0.533	0.935	
Discharge	0.670	-0.342	0.476	0.487

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.644	(-0.897, -0.072)	0.032
TSS	Nitrate-Nitrite as N	-0.129	(-0.676, 0.510)	0.706
Fecal Coliforms	Nitrate-Nitrite as N	-0.114	(-0.668, 0.521)	0.738
Discharge	Nitrate-Nitrite as N	0.670	(0.117, 0.906)	0.024
TSS	Total P	0.533	(-0.099, 0.858)	0.092
Fecal Coliforms	Total P	0.533	(-0.099, 0.858)	0.092
Discharge	Total P	-0.342	(-0.781, 0.325)	0.304
Fecal Coliforms	TSS	0.935	(0.763, 0.983)	0.000
Discharge	TSS	0.476	(-0.174, 0.837)	0.139
Discharge	Fecal Coliforms	0.487	(-0.160, 0.841)	0.129



Method

Correlation type	Pearson
Rows used	11

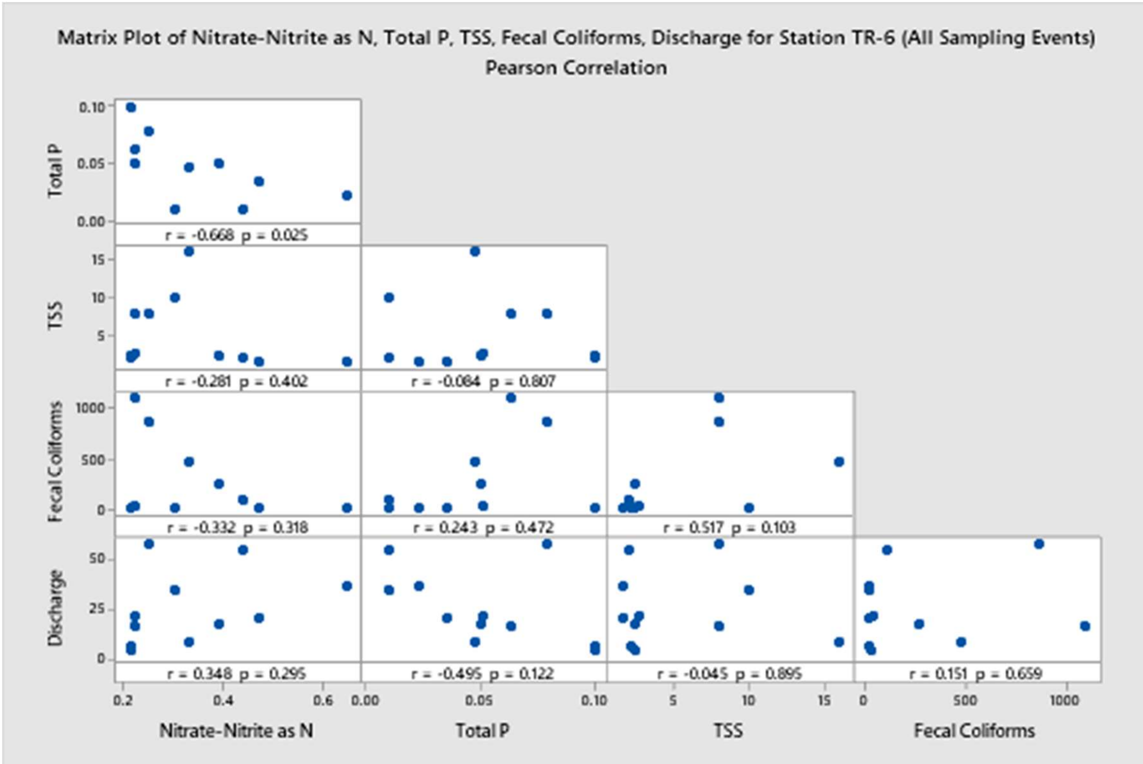
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.687			
TSS	-0.477	0.352		
Fecal Coliforms	-0.595	0.384	0.270	
Discharge	0.450	-0.495	0.337	-0.169

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.687	(-0.919, -0.101)	0.028
TSS	Nitrate-Nitrite as N	-0.477	(-0.851, 0.218)	0.163
Fecal Coliforms	Nitrate-Nitrite as N	-0.595	(-0.891, 0.056)	0.070
Discharge	Nitrate-Nitrite as N	0.450	(-0.251, 0.841)	0.192
TSS	Total P	0.352	(-0.357, 0.803)	0.319
Fecal Coliforms	Total P	0.384	(-0.324, 0.816)	0.273
Discharge	Total P	-0.495	(-0.857, 0.195)	0.146
Fecal Coliforms	TSS	0.270	(-0.434, 0.769)	0.451
Discharge	TSS	0.337	(-0.371, 0.798)	0.340
Discharge	Fecal Coliforms	-0.169	(-0.722, 0.516)	0.641



Method

Correlation type	Pearson
Rows used	11

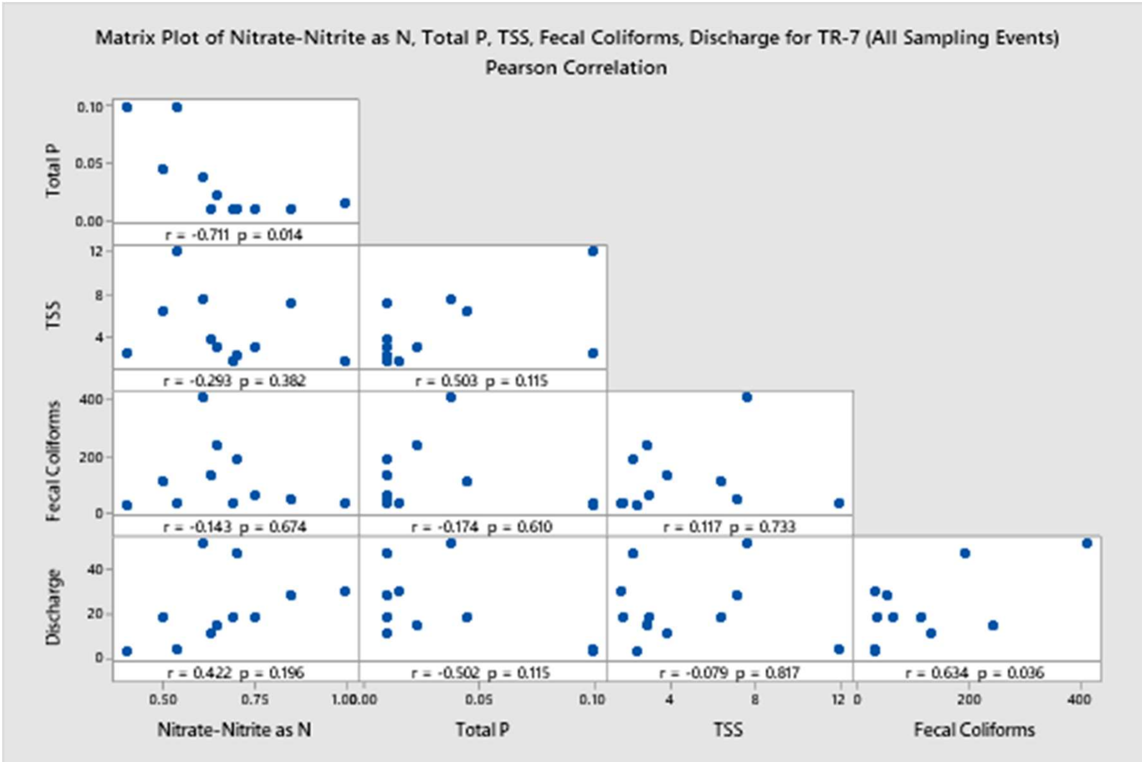
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.668			
TSS	-0.281	-0.084		
Fecal Coliforms	-0.332	0.243	0.517	
Discharge	0.348	-0.495	-0.045	0.151

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.668	(-0.905, -0.113)	0.025
TSS	Nitrate-Nitrite as N	-0.281	(-0.754, 0.383)	0.402
Fecal Coliforms	Nitrate-Nitrite as N	-0.332	(-0.777, 0.334)	0.318
Discharge	Nitrate-Nitrite as N	0.348	(-0.319, 0.784)	0.295
TSS	Total P	-0.084	(-0.651, 0.543)	0.807
Fecal Coliforms	Total P	0.243	(-0.418, 0.735)	0.472
Discharge	Total P	-0.495	(-0.844, 0.150)	0.122
Fecal Coliforms	TSS	0.517	(-0.120, 0.852)	0.103
Discharge	TSS	-0.045	(-0.628, 0.570)	0.895
Discharge	Fecal Coliforms	0.151	(-0.494, 0.688)	0.659



Method

Correlation type	Pearson
Rows used	11

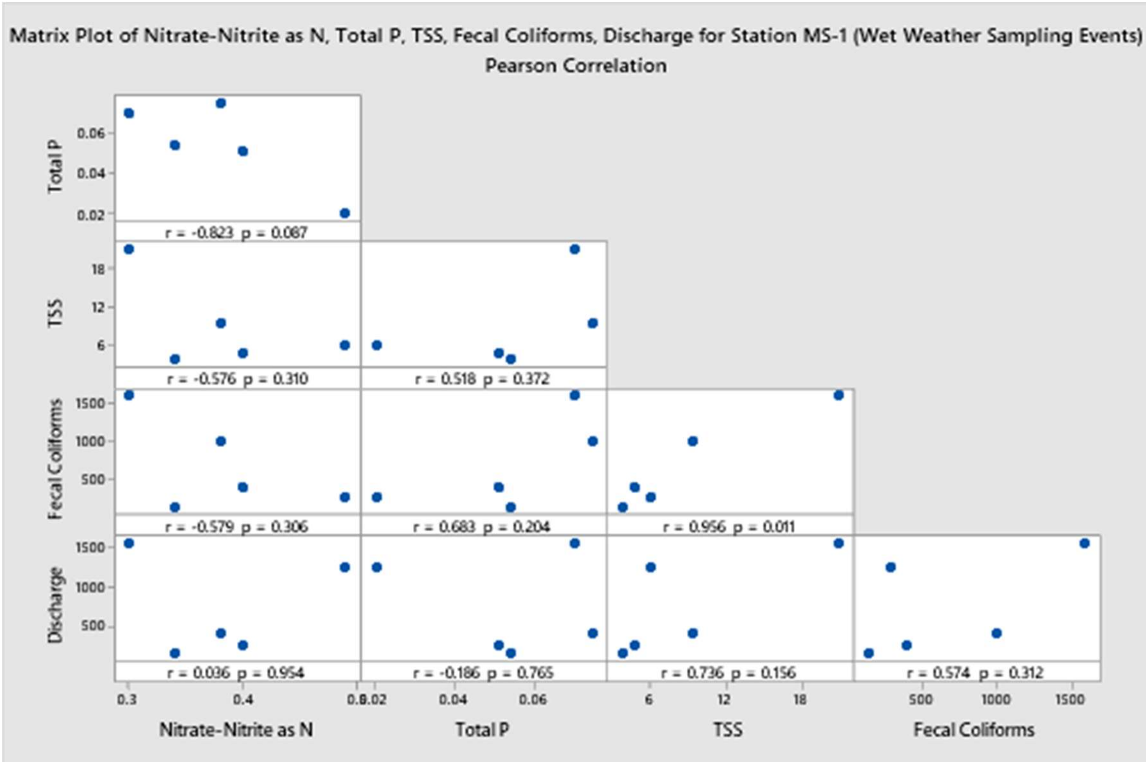
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.711			
TSS	-0.293	0.503		
Fecal Coliforms	-0.143	-0.174	0.117	
Discharge	0.422	-0.502	-0.079	0.634

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.711	(-0.919, -0.194)	0.014
TSS	Nitrate-Nitrite as N	-0.293	(-0.759, 0.372)	0.382
Fecal Coliforms	Nitrate-Nitrite as N	-0.143	(-0.684, 0.499)	0.674
Discharge	Nitrate-Nitrite as N	0.422	(-0.238, 0.815)	0.196
TSS	Total P	0.503	(-0.139, 0.847)	0.115
Fecal Coliforms	Total P	-0.174	(-0.701, 0.476)	0.610
Discharge	Total P	-0.502	(-0.847, 0.140)	0.115
Fecal Coliforms	TSS	0.117	(-0.520, 0.670)	0.733
Discharge	TSS	-0.079	(-0.648, 0.547)	0.817
Discharge	Fecal Coliforms	0.634	(0.056, 0.894)	0.036



Method

Correlation type	Pearson
Rows used	5

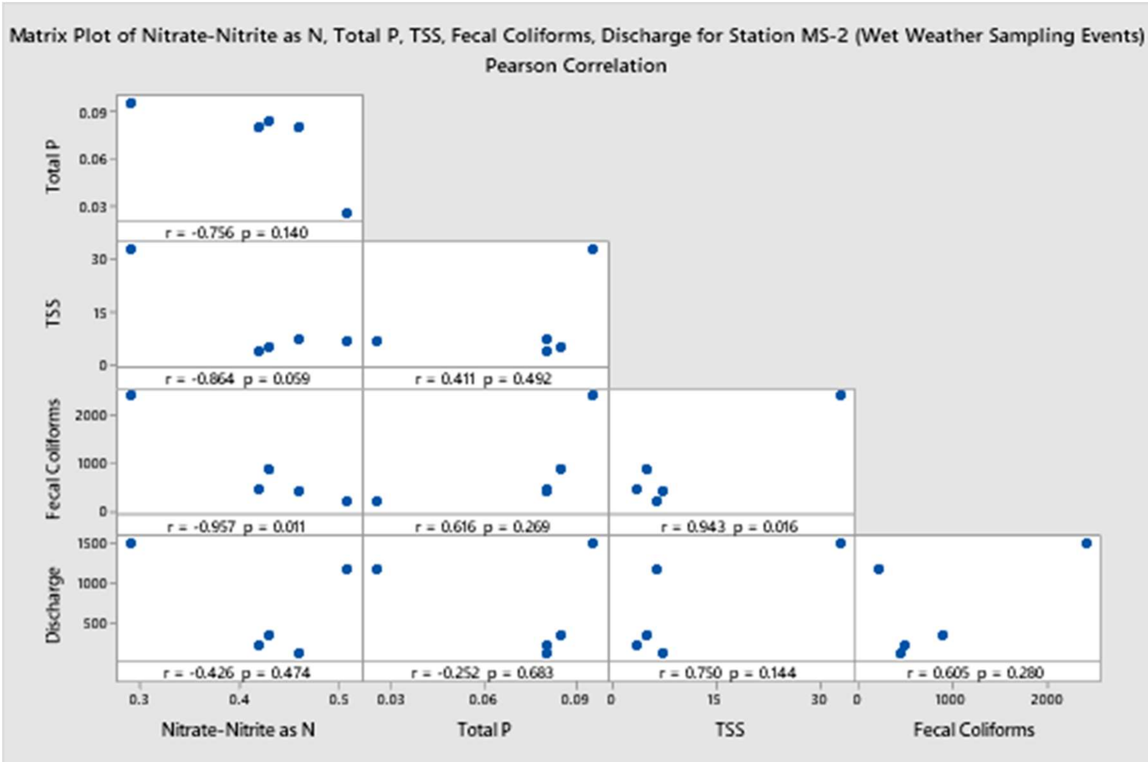
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.823			
TSS	-0.576	0.518		
Fecal Coliforms	-0.579	0.683	0.956	
Discharge	0.036	-0.186	0.736	0.574

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.823	(-0.988, 0.217)	0.087
TSS	Nitrate-Nitrite as N	-0.576	(-0.967, 0.623)	0.310
Fecal Coliforms	Nitrate-Nitrite as N	-0.579	(-0.967, 0.620)	0.306
Discharge	Nitrate-Nitrite as N	0.036	(-0.874, 0.890)	0.954
TSS	Total P	0.518	(-0.671, 0.961)	0.372
Fecal Coliforms	Total P	0.683	(-0.502, 0.977)	0.204
Discharge	Total P	-0.186	(-0.918, 0.833)	0.765
Fecal Coliforms	TSS	0.956	(0.467, 0.997)	0.011
Discharge	TSS	0.736	(-0.418, 0.981)	0.156
Discharge	Fecal Coliforms	0.574	(-0.625, 0.967)	0.312



Method

Correlation type	Pearson
Rows used	5

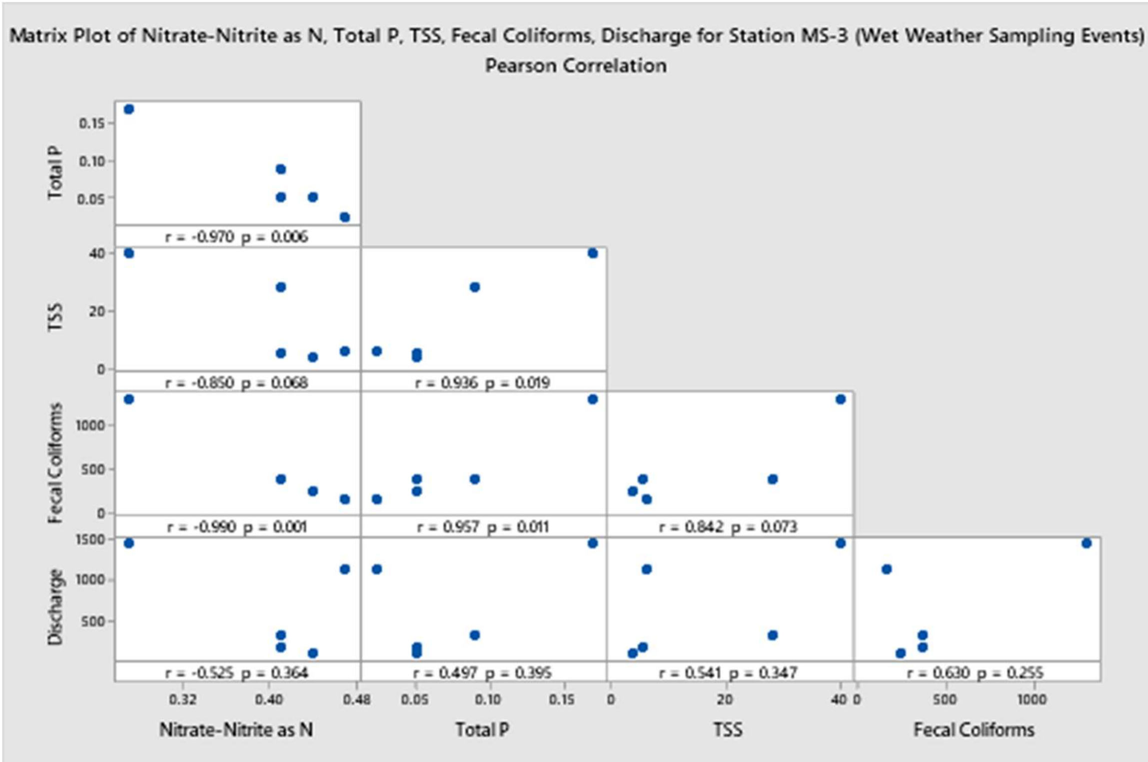
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.756			
TSS	-0.864	0.411		
Fecal Coliforms	-0.957	0.616	0.943	
Discharge	-0.426	-0.252	0.750	0.605

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.756	(-0.983, 0.380)	0.140
TSS	Nitrate-Nitrite as N	-0.864	(-0.991, 0.077)	0.059
Fecal Coliforms	Nitrate-Nitrite as N	-0.957	(-0.997, -0.479)	0.011
Discharge	Nitrate-Nitrite as N	-0.426	(-0.951, 0.731)	0.474
TSS	Total P	0.411	(-0.740, 0.949)	0.492
Fecal Coliforms	Total P	0.616	(-0.583, 0.971)	0.269
Discharge	Total P	-0.252	(-0.928, 0.811)	0.683
Fecal Coliforms	TSS	0.943	(0.362, 0.996)	0.016
Discharge	TSS	0.750	(-0.391, 0.982)	0.144
Discharge	Fecal Coliforms	0.605	(-0.595, 0.970)	0.280



Method

Correlation type	Pearson
Rows used	5

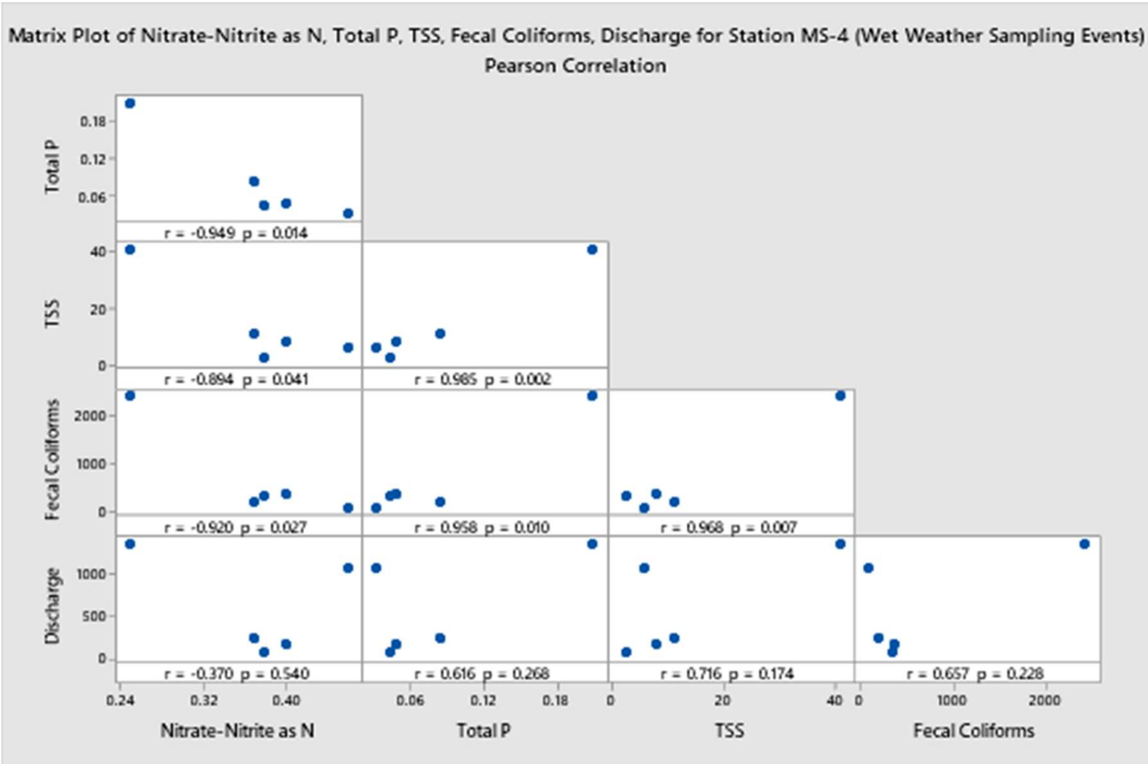
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.970			
TSS	-0.850	0.936		
Fecal Coliforms	-0.990	0.957	0.842	
Discharge	-0.525	0.497	0.541	0.630

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.970	(-0.998, -0.610)	0.006
TSS	Nitrate-Nitrite as N	-0.850	(-0.990, 0.128)	0.068
Fecal Coliforms	Nitrate-Nitrite as N	-0.990	(-0.999, -0.858)	0.001
Discharge	Nitrate-Nitrite as N	-0.525	(-0.962, 0.665)	0.364
TSS	Total P	0.936	(0.309, 0.996)	0.019
Fecal Coliforms	Total P	0.957	(0.480, 0.997)	0.011
Discharge	Total P	0.497	(-0.686, 0.959)	0.395
Fecal Coliforms	TSS	0.842	(-0.156, 0.989)	0.073
Discharge	TSS	0.541	(-0.653, 0.963)	0.347
Discharge	Fecal Coliforms	0.630	(-0.568, 0.972)	0.255



Method

Correlation type	Pearson
Rows used	5

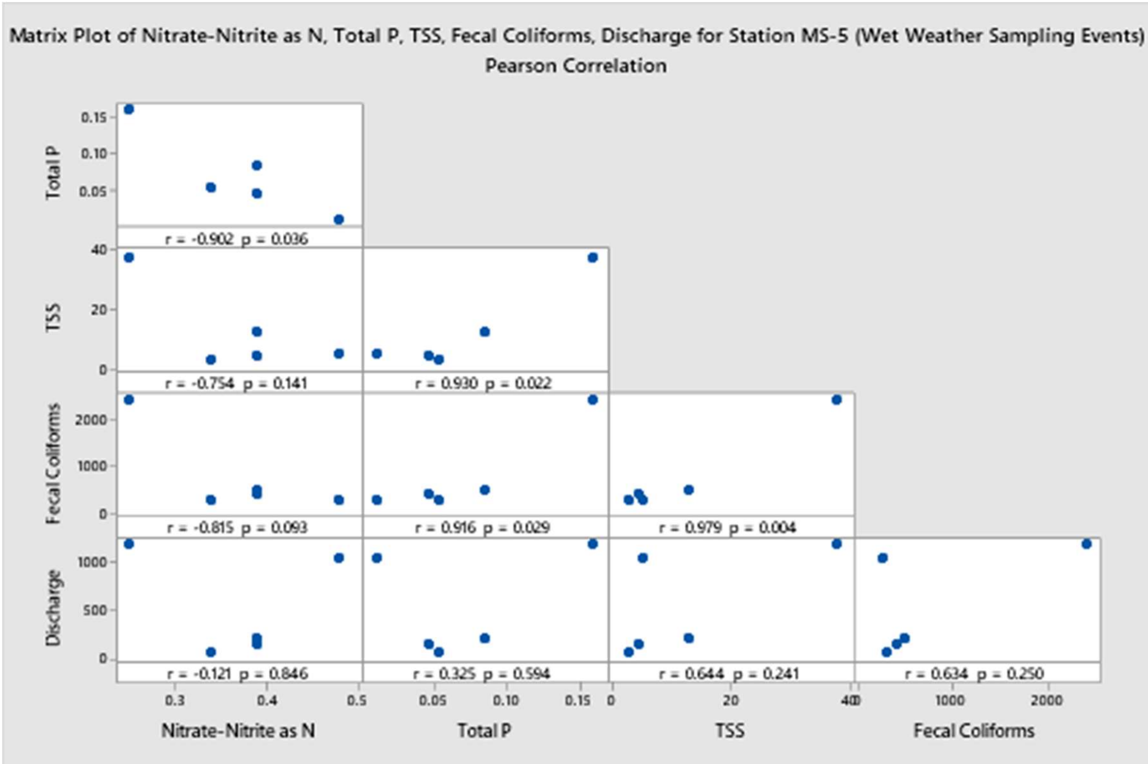
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.949			
TSS	-0.894	0.985		
Fecal Coliforms	-0.920	0.958	0.968	
Discharge	-0.370	0.616	0.716	0.657

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.949	(-0.997, -0.414)	0.014
TSS	Nitrate-Nitrite as N	-0.894	(-0.993, -0.056)	0.041
Fecal Coliforms	Nitrate-Nitrite as N	-0.920	(-0.995, -0.202)	0.027
Discharge	Nitrate-Nitrite as N	-0.370	(-0.944, 0.761)	0.540
TSS	Total P	0.985	(0.780, 0.999)	0.002
Fecal Coliforms	Total P	0.958	(0.488, 0.997)	0.010
Discharge	Total P	0.616	(-0.583, 0.971)	0.268
Fecal Coliforms	TSS	0.968	(0.586, 0.998)	0.007
Discharge	TSS	0.716	(-0.451, 0.980)	0.174
Discharge	Fecal Coliforms	0.657	(-0.536, 0.974)	0.228



Method

Correlation type	Pearson
Rows used	5

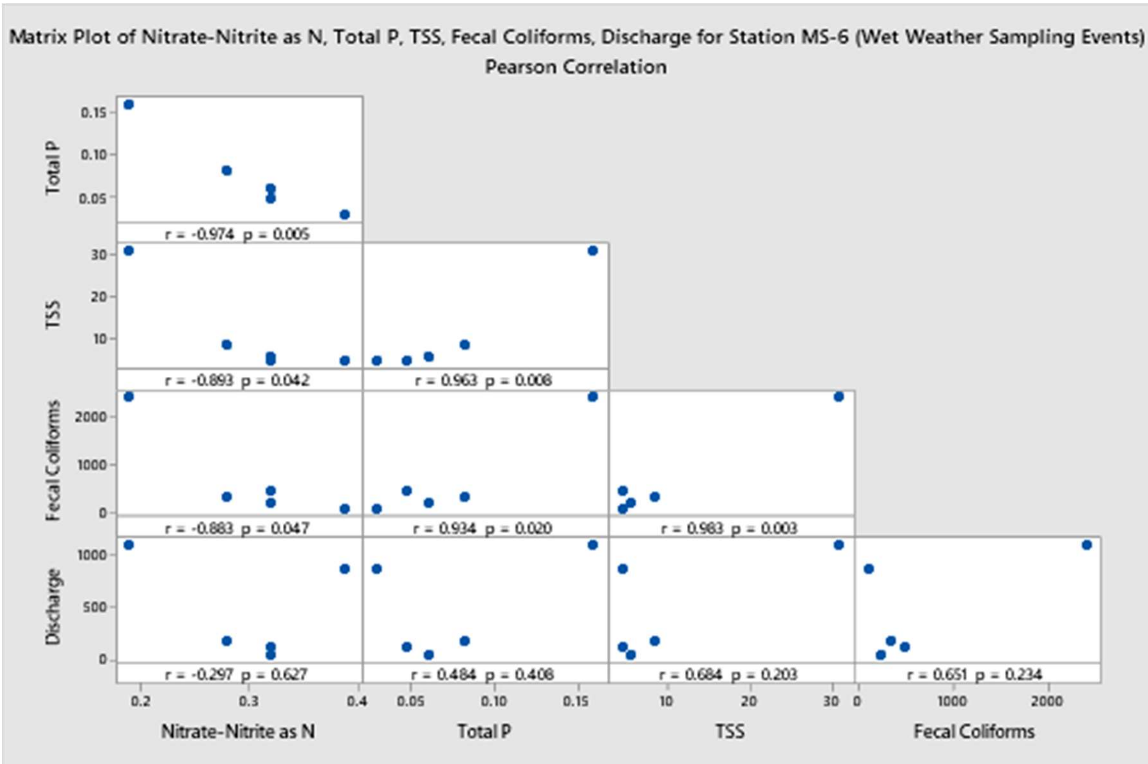
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.902			
TSS	-0.754	0.930		
Fecal Coliforms	-0.815	0.916	0.979	
Discharge	-0.121	0.325	0.644	0.634

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.902	(-0.994, -0.099)	0.036
TSS	Nitrate-Nitrite as N	-0.754	(-0.983, 0.382)	0.141
Fecal Coliforms	Nitrate-Nitrite as N	-0.815	(-0.987, 0.239)	0.093
Discharge	Nitrate-Nitrite as N	-0.121	(-0.907, 0.852)	0.846
TSS	Total P	0.930	(0.267, 0.995)	0.022
Fecal Coliforms	Total P	0.916	(0.175, 0.995)	0.029
Discharge	Total P	0.325	(-0.781, 0.938)	0.594
Fecal Coliforms	TSS	0.979	(0.706, 0.999)	0.004
Discharge	TSS	0.644	(-0.551, 0.973)	0.241
Discharge	Fecal Coliforms	0.634	(-0.563, 0.972)	0.250



Method

Correlation type	Pearson
Rows used	5

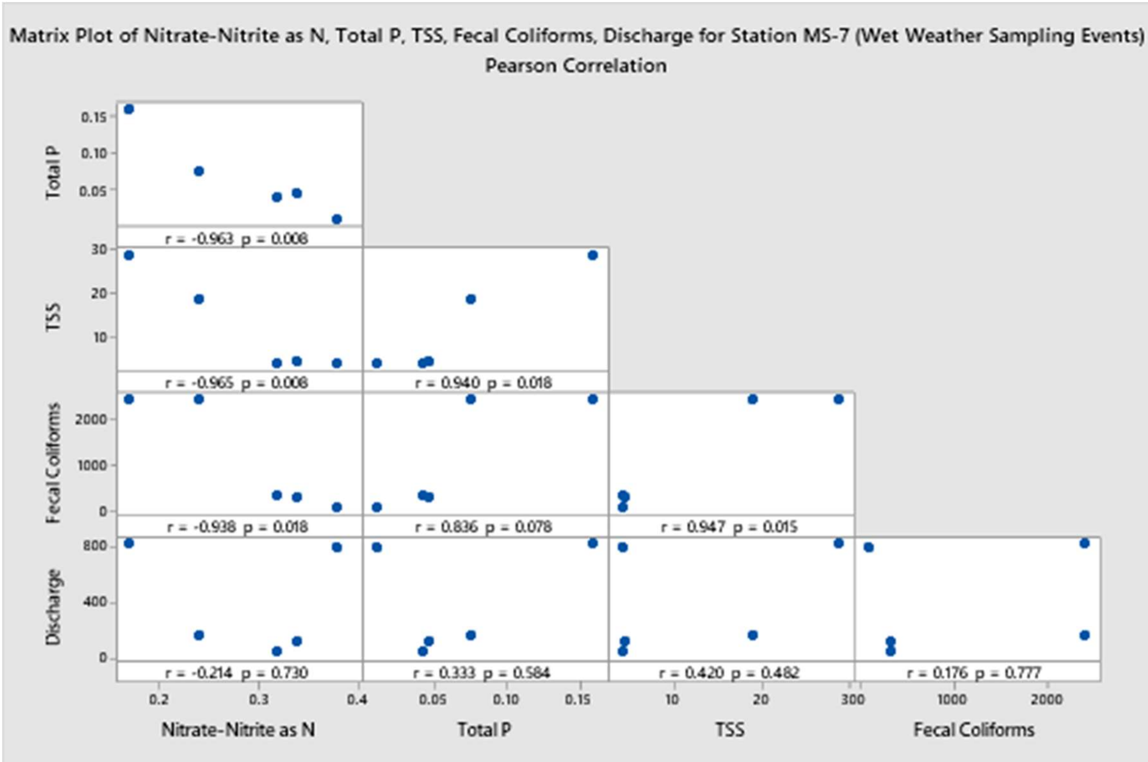
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.974			
TSS	-0.893	0.963		
Fecal Coliforms	-0.883	0.934	0.983	
Discharge	-0.297	0.484	0.684	0.651

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.974	(-0.998, -0.647)	0.005
TSS	Nitrate-Nitrite as N	-0.893	(-0.993, -0.048)	0.042
Fecal Coliforms	Nitrate-Nitrite as N	-0.883	(-0.992, -0.003)	0.047
Discharge	Nitrate-Nitrite as N	-0.297	(-0.934, 0.793)	0.627
TSS	Total P	0.963	(0.540, 0.998)	0.008
Fecal Coliforms	Total P	0.934	(0.291, 0.996)	0.020
Discharge	Total P	0.484	(-0.695, 0.957)	0.408
Fecal Coliforms	TSS	0.983	(0.754, 0.999)	0.003
Discharge	TSS	0.684	(-0.500, 0.977)	0.203
Discharge	Fecal Coliforms	0.651	(-0.543, 0.974)	0.234



Method

Correlation type	Pearson
Rows used	5

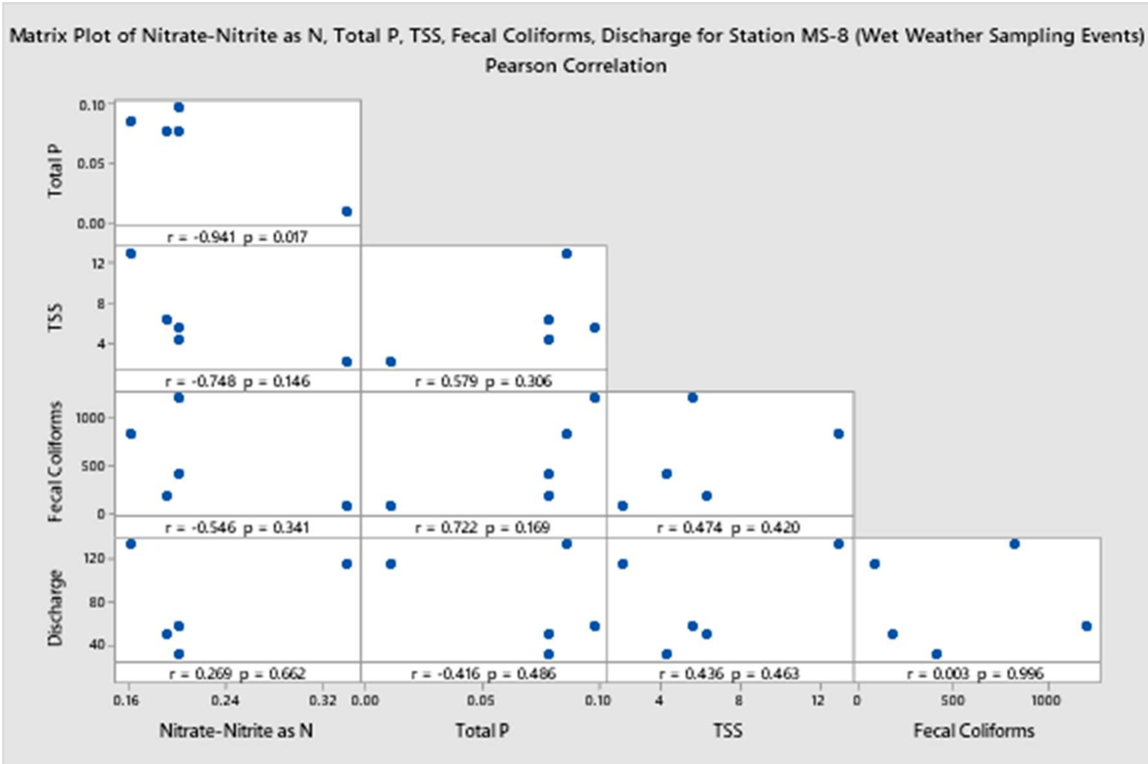
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.963			
TSS	-0.965	0.940		
Fecal Coliforms	-0.938	0.836	0.947	
Discharge	-0.214	0.333	0.420	0.176

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.963	(-0.998, -0.539)	0.008
TSS	Nitrate-Nitrite as N	-0.965	(-0.998, -0.561)	0.008
Fecal Coliforms	Nitrate-Nitrite as N	-0.938	(-0.996, -0.327)	0.018
Discharge	Nitrate-Nitrite as N	-0.214	(-0.922, 0.824)	0.730
TSS	Total P	0.940	(0.335, 0.996)	0.018
Fecal Coliforms	Total P	0.836	(-0.176, 0.989)	0.078
Discharge	Total P	0.333	(-0.778, 0.939)	0.584
Fecal Coliforms	TSS	0.947	(0.394, 0.997)	0.015
Discharge	TSS	0.420	(-0.735, 0.950)	0.482
Discharge	Fecal Coliforms	0.176	(-0.836, 0.916)	0.777



Method

Correlation type	Pearson
Rows used	5

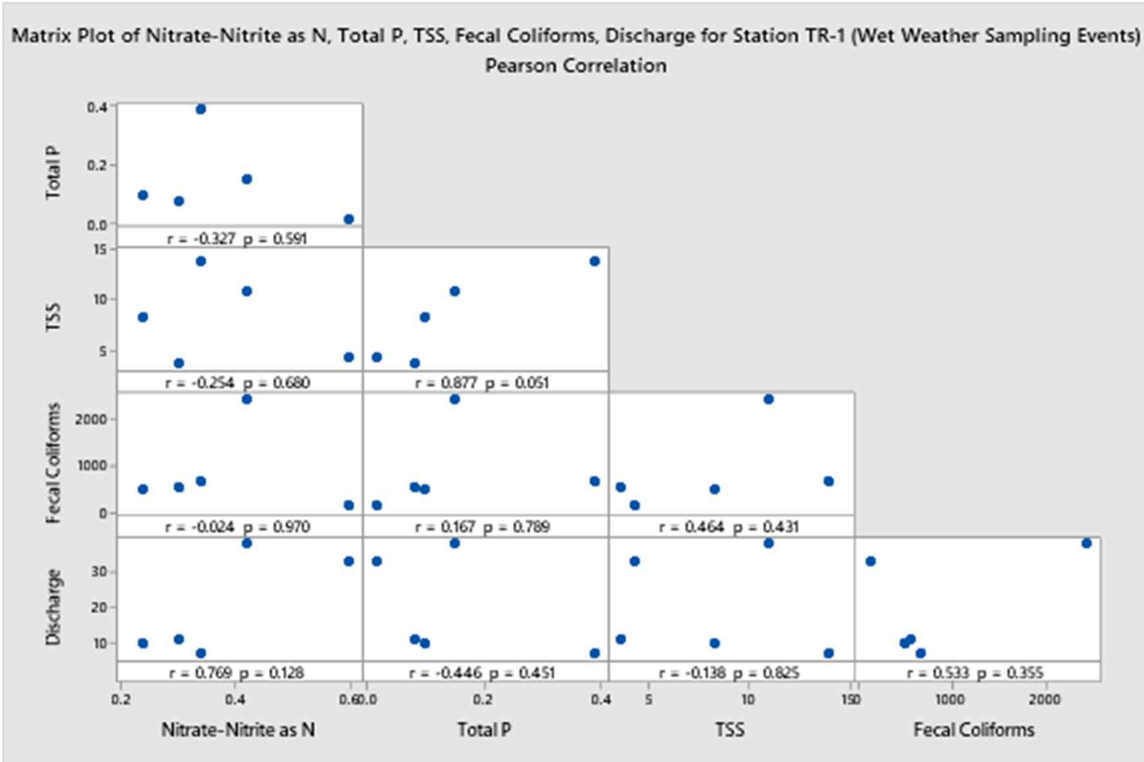
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.941			
TSS	-0.748	0.579		
Fecal Coliforms	-0.546	0.722	0.474	
Discharge	0.269	-0.416	0.436	0.003

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.941	(-0.996, -0.350)	0.017
TSS	Nitrate-Nitrite as N	-0.748	(-0.982, 0.394)	0.146
Fecal Coliforms	Nitrate-Nitrite as N	-0.546	(-0.964, 0.649)	0.341
Discharge	Nitrate-Nitrite as N	0.269	(-0.804, 0.930)	0.662
TSS	Total P	0.579	(-0.620, 0.967)	0.306
Fecal Coliforms	Total P	0.722	(-0.442, 0.980)	0.169
Discharge	Total P	-0.416	(-0.950, 0.737)	0.486
Fecal Coliforms	TSS	0.474	(-0.702, 0.956)	0.420
Discharge	TSS	0.436	(-0.725, 0.952)	0.463
Discharge	Fecal Coliforms	0.003	(-0.882, 0.883)	0.996



Method

Correlation type	Pearson
Rows used	5

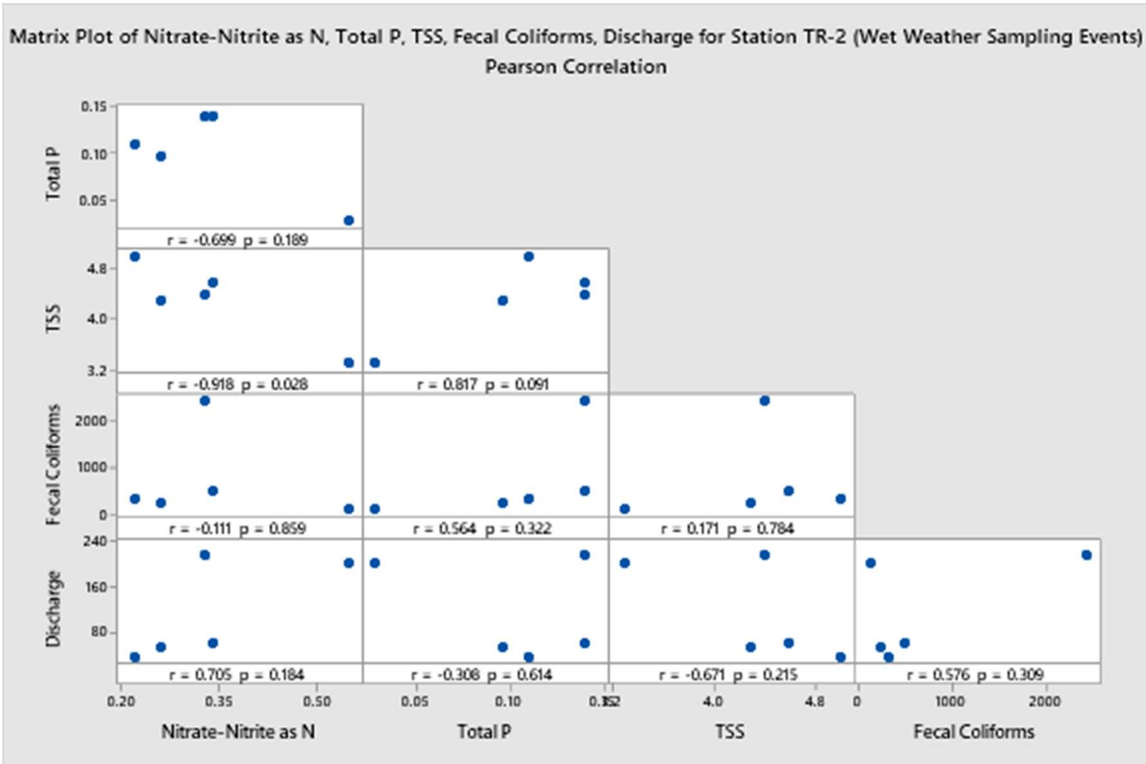
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.327			
TSS	-0.254	0.877		
Fecal Coliforms	-0.024	0.167	0.464	
Discharge	0.769	-0.446	-0.138	0.533

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.327	(-0.938, 0.780)	0.591
TSS	Nitrate-Nitrite as N	-0.254	(-0.928, 0.810)	0.680
Fecal Coliforms	Nitrate-Nitrite as N	-0.024	(-0.887, 0.877)	0.970
Discharge	Nitrate-Nitrite as N	0.769	(-0.352, 0.984)	0.128
TSS	Total P	0.877	(-0.023, 0.992)	0.051
Fecal Coliforms	Total P	0.167	(-0.839, 0.914)	0.789
Discharge	Total P	-0.446	(-0.953, 0.719)	0.451
Fecal Coliforms	TSS	0.464	(-0.708, 0.955)	0.431
Discharge	TSS	-0.138	(-0.909, 0.848)	0.825
Discharge	Fecal Coliforms	0.533	(-0.659, 0.963)	0.355



Method

Correlation type	Pearson
Rows used	5

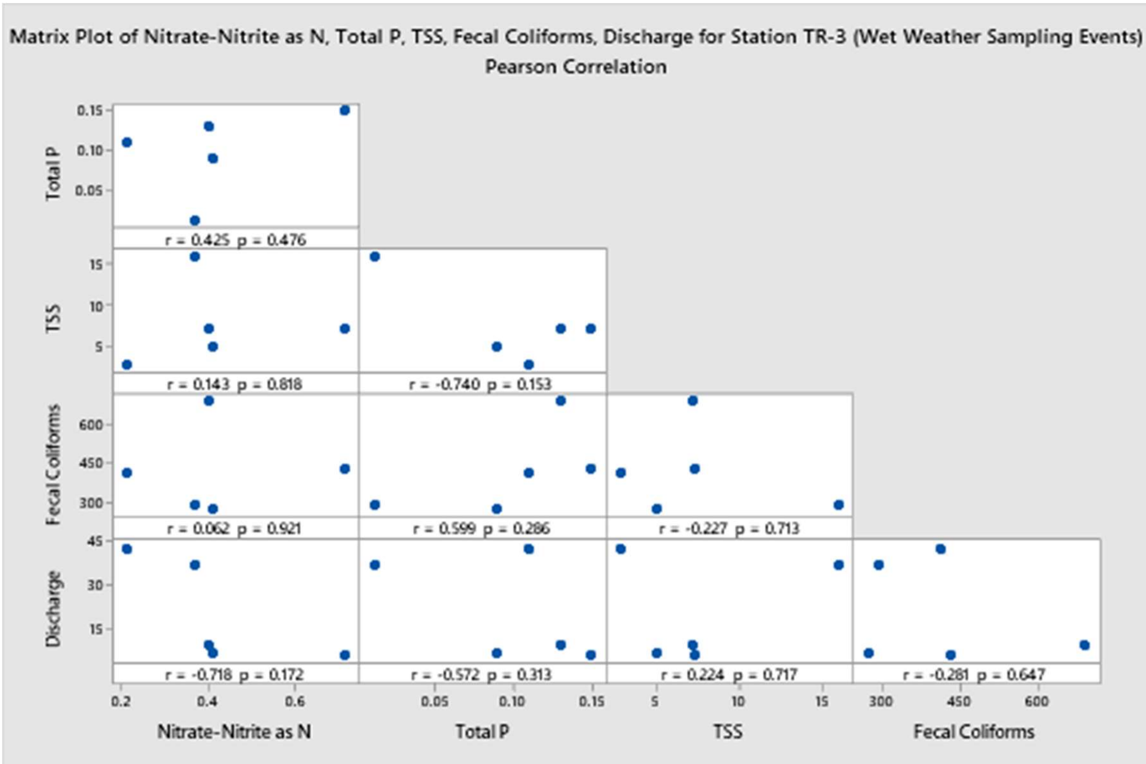
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.699			
TSS	-0.918	0.817		
Fecal Coliforms	-0.111	0.564	0.171	
Discharge	0.705	-0.308	-0.671	0.576

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.699	(-0.978, 0.478)	0.189
TSS	Nitrate-Nitrite as N	-0.918	(-0.995, -0.189)	0.028
Fecal Coliforms	Nitrate-Nitrite as N	-0.111	(-0.905, 0.855)	0.859
Discharge	Nitrate-Nitrite as N	0.705	(-0.469, 0.979)	0.184
TSS	Total P	0.817	(-0.233, 0.987)	0.091
Fecal Coliforms	Total P	0.564	(-0.633, 0.966)	0.322
Discharge	Total P	-0.308	(-0.936, 0.789)	0.614
Fecal Coliforms	TSS	0.171	(-0.838, 0.915)	0.784
Discharge	TSS	-0.671	(-0.976, 0.518)	0.215
Discharge	Fecal Coliforms	0.576	(-0.623, 0.967)	0.309



Method

Correlation type	Pearson
Rows used	5

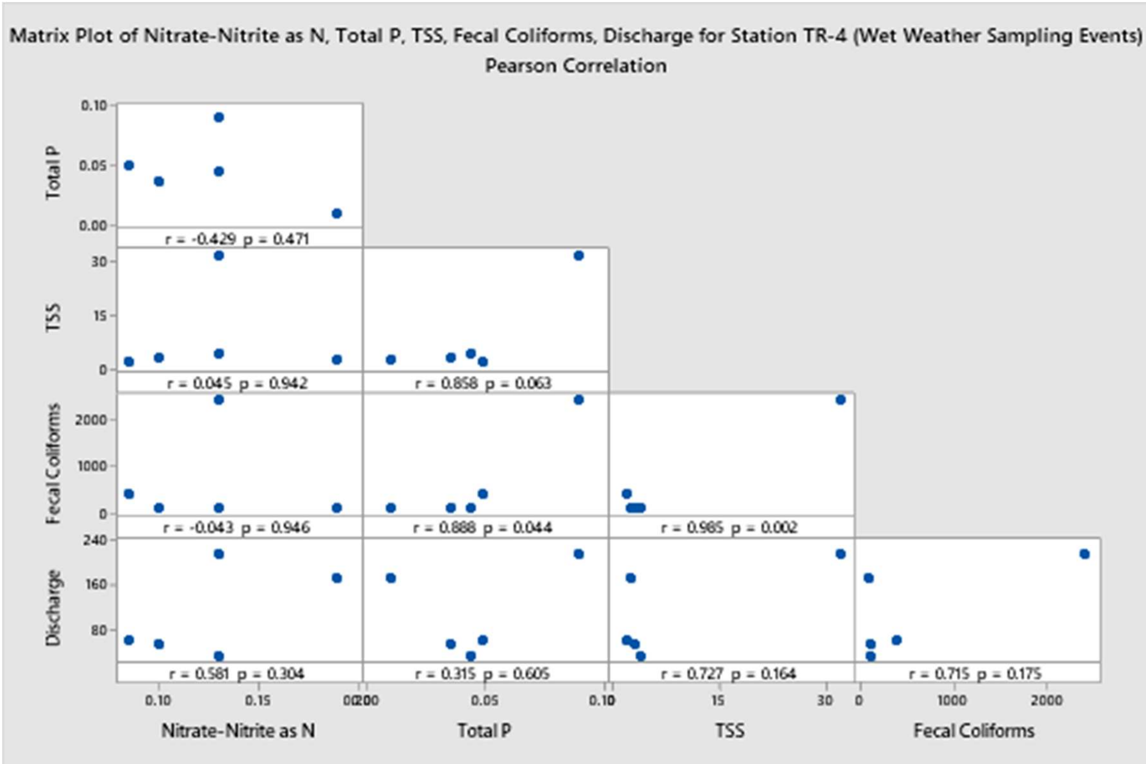
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	0.425			
TSS	0.143	-0.740		
Fecal Coliforms	0.062	0.599	-0.227	
Discharge	-0.718	-0.572	0.224	-0.281

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	0.425	(-0.732, 0.951)	0.476
TSS	Nitrate-Nitrite as N	0.143	(-0.846, 0.910)	0.818
Fecal Coliforms	Nitrate-Nitrite as N	0.062	(-0.868, 0.895)	0.921
Discharge	Nitrate-Nitrite as N	-0.718	(-0.980, 0.449)	0.172
TSS	Total P	-0.740	(-0.981, 0.410)	0.153
Fecal Coliforms	Total P	0.599	(-0.601, 0.969)	0.286
Discharge	Total P	-0.572	(-0.967, 0.626)	0.313
Fecal Coliforms	TSS	-0.227	(-0.924, 0.819)	0.713
Discharge	TSS	0.224	(-0.820, 0.924)	0.717
Discharge	Fecal Coliforms	-0.281	(-0.932, 0.799)	0.647



Method

Correlation type	Pearson
Rows used	5

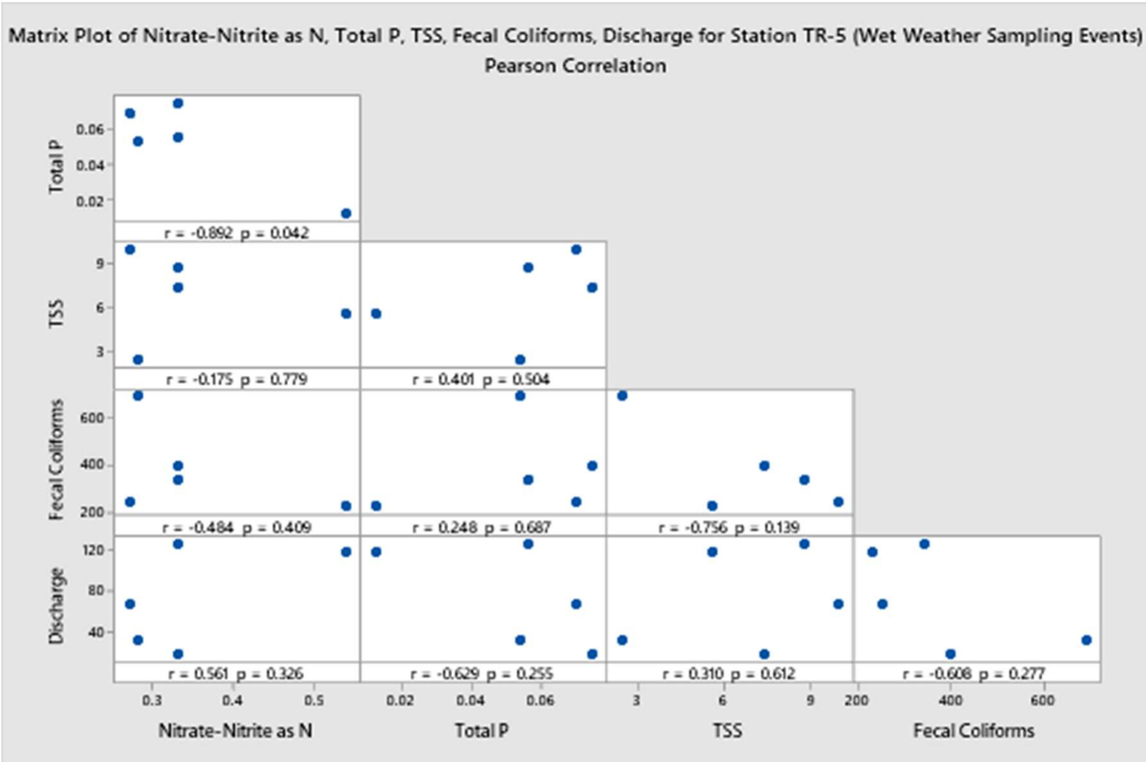
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.429			
TSS	0.045	0.858		
Fecal Coliforms	-0.043	0.888	0.985	
Discharge	0.581	0.315	0.727	0.715

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.429	(-0.951, 0.729)	0.471
TSS	Nitrate-Nitrite as N	0.045	(-0.872, 0.892)	0.942
Fecal Coliforms	Nitrate-Nitrite as N	-0.043	(-0.891, 0.872)	0.946
Discharge	Nitrate-Nitrite as N	0.581	(-0.618, 0.967)	0.304
TSS	Total P	0.858	(-0.100, 0.990)	0.063
Fecal Coliforms	Total P	0.888	(0.029, 0.993)	0.044
Discharge	Total P	0.315	(-0.785, 0.937)	0.605
Fecal Coliforms	TSS	0.985	(0.788, 0.999)	0.002
Discharge	TSS	0.727	(-0.433, 0.980)	0.164
Discharge	Fecal Coliforms	0.715	(-0.454, 0.979)	0.175



Method

Correlation type	Pearson
Rows used	5

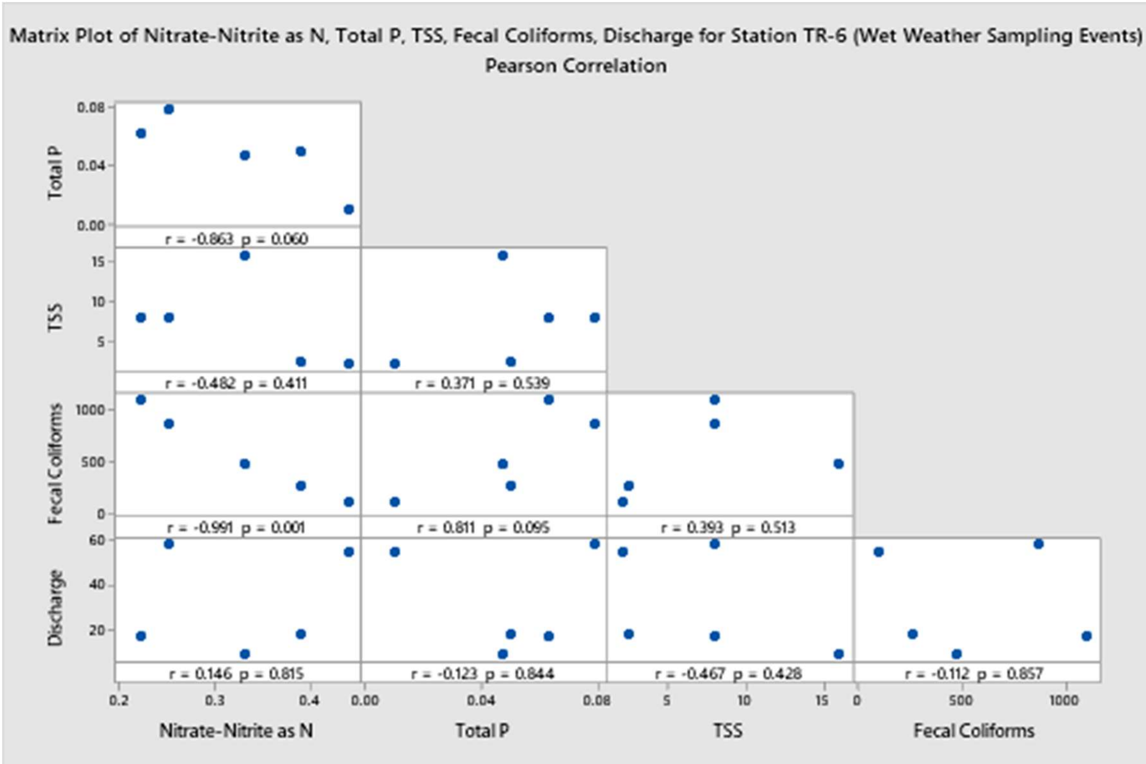
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.892			
TSS	-0.175	0.401		
Fecal Coliforms	-0.484	0.248	-0.756	
Discharge	0.561	-0.629	0.310	-0.608

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.892	(-0.993, -0.046)	0.042
TSS	Nitrate-Nitrite as N	-0.175	(-0.916, 0.837)	0.779
Fecal Coliforms	Nitrate-Nitrite as N	-0.484	(-0.957, 0.695)	0.409
Discharge	Nitrate-Nitrite as N	0.561	(-0.636, 0.965)	0.326
TSS	Total P	0.401	(-0.745, 0.948)	0.504
Fecal Coliforms	Total P	0.248	(-0.812, 0.927)	0.687
Discharge	Total P	-0.629	(-0.972, 0.569)	0.255
Fecal Coliforms	TSS	-0.756	(-0.983, 0.378)	0.139
Discharge	TSS	0.310	(-0.788, 0.936)	0.612
Discharge	Fecal Coliforms	-0.608	(-0.970, 0.592)	0.277



Method

Correlation type	Pearson
Rows used	5

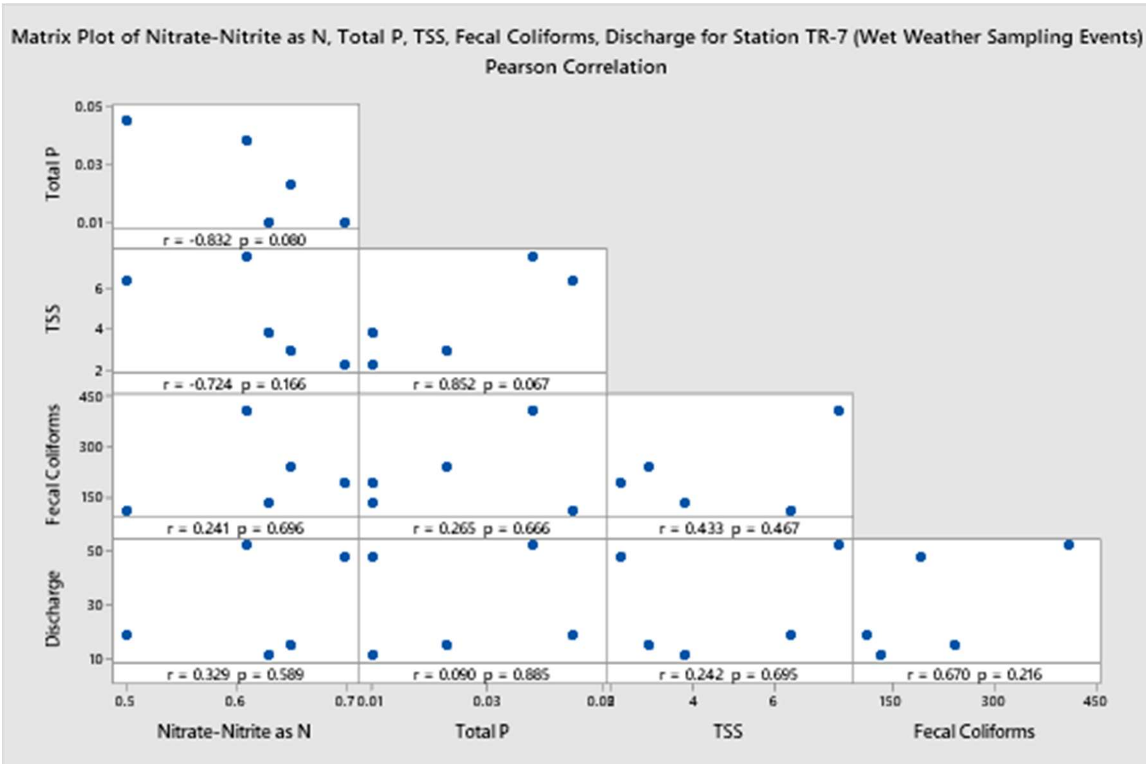
ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.863			
TSS	-0.482	0.371		
Fecal Coliforms	-0.991	0.811	0.393	
Discharge	0.146	-0.123	-0.467	-0.112

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.863	(-0.991, 0.082)	0.060
TSS	Nitrate-Nitrite as N	-0.482	(-0.957, 0.696)	0.411
Fecal Coliforms	Nitrate-Nitrite as N	-0.991	(-0.999, -0.859)	0.001
Discharge	Nitrate-Nitrite as N	0.146	(-0.845, 0.911)	0.815
TSS	Total P	0.371	(-0.760, 0.944)	0.539
Fecal Coliforms	Total P	0.811	(-0.249, 0.987)	0.095
Discharge	Total P	-0.123	(-0.907, 0.852)	0.844
Fecal Coliforms	TSS	0.393	(-0.749, 0.947)	0.513
Discharge	TSS	-0.467	(-0.956, 0.706)	0.428
Discharge	Fecal Coliforms	-0.112	(-0.905, 0.855)	0.857



Method

Correlation type	Pearson
Rows used	5

ρ: pairwise Pearson correlation

Correlations

	Nitrate-Nitrite as N	Total P	TSS	Fecal Coliforms
Total P	-0.832			
TSS	-0.724	0.852		
Fecal Coliforms	0.241	0.265	0.433	
Discharge	0.329	0.090	0.242	0.670

Pairwise Pearson Correlations

Sample 1	Sample 2	Correlation	95% CI for ρ	P-Value
Total P	Nitrate-Nitrite as N	-0.832	(-0.989, 0.188)	0.080
TSS	Nitrate-Nitrite as N	-0.724	(-0.980, 0.437)	0.166
Fecal Coliforms	Nitrate-Nitrite as N	0.241	(-0.814, 0.926)	0.696
Discharge	Nitrate-Nitrite as N	0.329	(-0.780, 0.939)	0.589
TSS	Total P	0.852	(-0.122, 0.990)	0.067
Fecal Coliforms	Total P	0.265	(-0.806, 0.930)	0.666
Discharge	Total P	0.090	(-0.861, 0.901)	0.885
Fecal Coliforms	TSS	0.433	(-0.727, 0.952)	0.467
Discharge	TSS	0.242	(-0.814, 0.926)	0.695
Discharge	Fecal Coliforms	0.670	(-0.520, 0.976)	0.216

Appendix K

Data Usability Assessment Report

WAPPINGER CREEK WATERSHED REVITALIZATION WATER QUALITY MONITORING PROJECT

Data Usability Assessment Report

January 13, 2020

Revision 2.0

Matt Alexander – Project Manager
Village of Wappingers Falls
845-297-8773
mayor@wappingersfallsny.gov

CONTENTS

A: Project Management

Approval Sheet

The undersigned Quality Assurance Officer (QAO) has reviewed the Data Usability Assessment Report (DUAR) and certifies that the DUAR has been completed using the proper format and required contents. The QAO's certification does not guarantee the overall quality of the project described by the DUAR, nor does it imply that the QAO granted permission to the project staff to proceed without an approved Quality Assurance Project Plan (QAPP).

Mayor, Matt Alexander
Project Manager
Village of Wappingers Falls

Date: 1/17/2020

John Szarowski
Contractor Project Manager
KC Engineering and Land Surveying PC

Date: 1/17/20

RoseAnn Garry
Quality Assurance Officer
NYS Department of Environmental Conservation
Bureau of Water Assessment and Management

Date: 01/21/2020

Project Organization

The following people/parties actively participated in this Project and its oversight:

Name: Matt Alexander
Title: Project Manager
Organization: Village of Wappingers Falls (Mayor)
Responsibilities: Coordinating between parties, overseeing project tasks and budget.
2582 South Ave, Wappingers Falls, NY, 12590; 845-297-8773; mayor@wappingersfallsny.gov

Name: John Szarowski
Title: Contractor Project Manager
Organization: KC Engineering
Responsibilities: Overseeing and reviewing work related to project sampling and creation of 9 Element plan.
2142 NY-302, Circleville, NY, 10919; 845-673-3199; jszarowski@kcepc.com

Name: Vijay Eppakayala
Title: Sampling Manager
Organization: KC Engineering
Responsibilities: Creating and overseeing sampling program, writing 9 Element Plan.
2142 NY-302, Circleville, NY, 10919, 845-673-3204, veppakayala@kcepc.com

Name: RoseAnn Garry
Title: Quality Assurance Officer
Organization: NYS DEC Bureau of Water Resource Management
Responsibilities: Review project deliverables for validity and compliance with QC protocols
625 Broadway, Albany NY, 12233, 518-402-8159, roseann.garry@dec.ny.gov

Ryan Stratton
Title: Project Quality Assurance Manager
Organization: KC Engineering
Responsibilities: Review project deliverables for validity and compliance with QC protocols
2142 NY-302, Circleville, NY, 10919, 845-228-3894, rstratton@kcepc.com

Sean Carroll
Title: Public Outreach Officer
Organization: Cornell Coop. Extension (Dutchess County)
Responsibilities: Perform public outreach meetings and inform the public of the project and its goals in the communities of interest.
2715 US-44, Millbrook, NY, 12545, 845-677-8223 x147, smc427@cornell.edu

Data Usability Assessment

The goal of the Data Usability Assessment Report (DUAR) is to define the procedures used to collect and compile environmental data from a completed project. Combine the results from the verification of the field sampling and analytical procedures with the results of the data validation to provide a summary for data users regarding any limitations in the data set.

Problem Definition

The purpose of the Wappinger Creek Watershed Revitalization Plan (Project) is to create a digital model of the Creek and watershed, which can be used to model pollution loads and water quality. This model will then be used to select and design projects/BMP (Best Management Practices), targeted to improve water quality and reduce pollution. The data collected will be used as a base line to determine the effectiveness of the BMPs. Currently Wappinger Creek is on the NYS 303(d) list of impaired/TMDL (Total Max Daily Load) waters.

303(d) Part 1 – Requiring a TMDL
Segment #1305-0001 – phosphorus and silt/sediment

303(d) Part 3b – TMDL Deferred - Verification of Pollutant/Sources needed
Segment #1201-0094 – floatables, copper, pathogen, and low dissolved oxygen

Project Description

Contained entirely within Dutchess County, the Wappinger Creek watershed spans 211 square miles and is one of the five major tributaries that feed into the lower Hudson River (Findlay *et al.,* 2010). The watershed encompasses large portions of the Town of Pine Plains, the Town of Milan, the Town of Clinton, the Town of Stanford, the Town of Washington, the Village of Millbrook, the Town of Pleasant Valley, the Town of LaGrange, the Town of Poughkeepsie, the Town of Wappinger, the Village of Wappingers Falls, and small portions of the Town of Hyde Park and the Town of Fishkill (Findlay *et al.,* 2010).

Historically, this watershed has been the lifeblood of these communities, supplying, water, recreation, electrical power, and flood storage. At present, the watershed is in need of revitalization. Recent observations of Wappinger Creek found the watershed to be overloaded with phosphorus and plugged with silt (Cadmus Group, 2009). These pollutants are deteriorating water quality and have reduced the lake's capacity for flood storage. Wappinger Lake is on the 2016 303(d) list of impaired waterbodies, which require development of a total maximum daily load (TMDL) and is a restoration target for pollutant reduction (NYSDEC, 2016. *2016 section 303(d) list of impaired waters requiring a TMDL/ other strategy*). Since Wappinger Lake outlets into the Hudson River, and acts as a sink for substances that travel downstream, it is an indicator of water quality issues in the greater watershed.

The NYSDEC Division of Water, Bureau of Water Resource Management oversees the development of strategies to restore and protect the waters of New York State. This bureau's responsibilities include the development of water-quality based effluent limits, participating in watershed management groups, and water quality restoration strategies such as Total Maximum Daily Loads (TMDL). Phosphorus has long been recognized as a critical nutrient controlling the growth of phytoplankton in rivers and streams. Although there are currently no numerical water quality standards established for phosphorus the NYSDEC does have numeric guidance values for phosphorus which will assist in setting expectations of pollutant loads.

Computer modeling techniques will be used to estimate water quality conditions in Wappinger Creek using, streamflow data, water quality sample data, land use classifications, and point source concentration data from WWTPs to develop a defensible justification, in the form of a watershed pollutant load assessment, for better watershed management practices and phosphorus load reduction that will result in improved water quality conditions in the watershed.

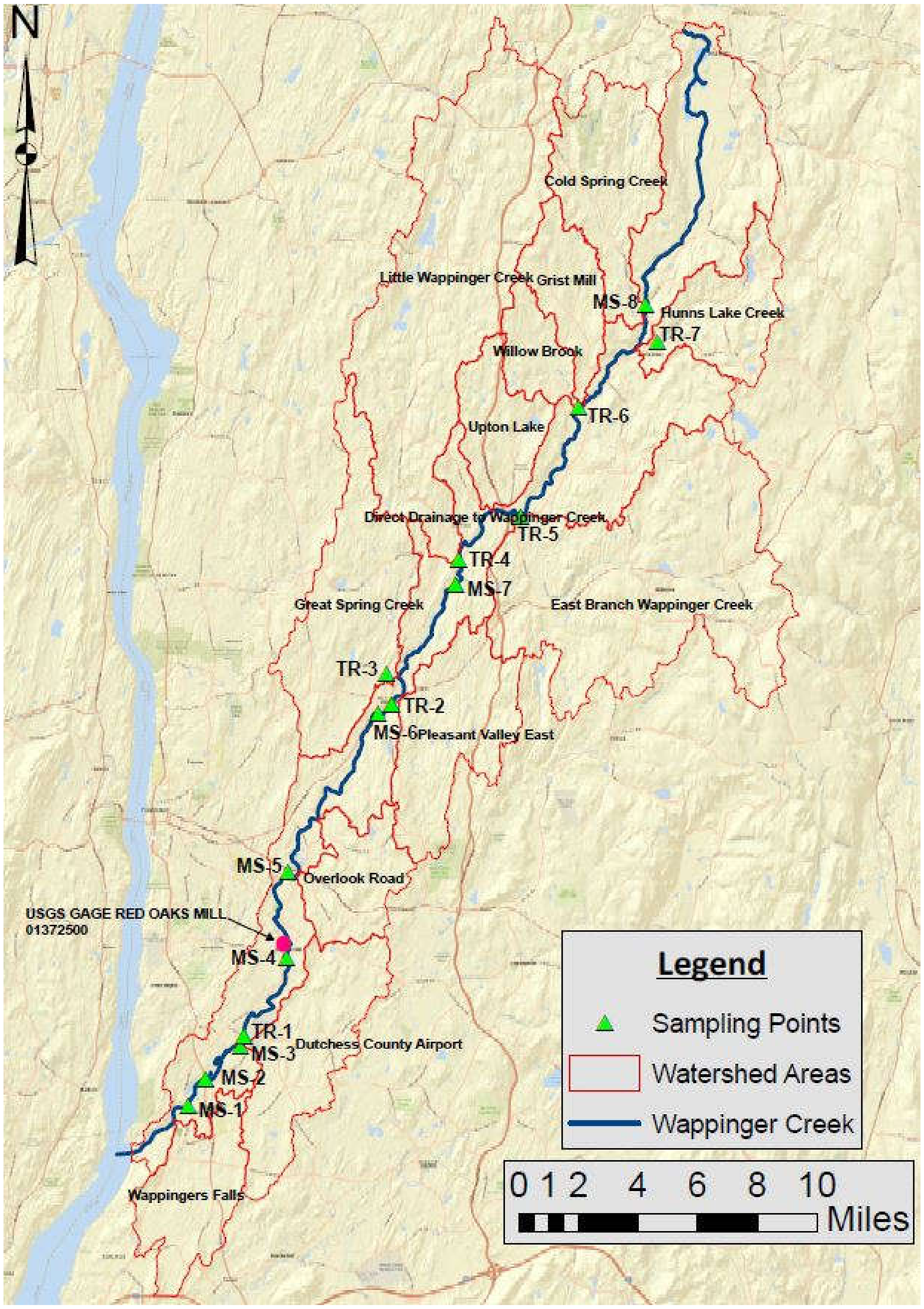


Figure 1. Map of USGS stream gages and sampling locations along the Wappinger Creek, New York

Development of pollutant loads for Wappinger Creek is a multistep process and requires determining potential sources of the contaminants and quantifying the loads of contaminants entering the waterway. The primary steps in this process include the development of hydrologic and water quality simulation models to estimate the flow volumes and contaminant concentrations along the creek to simulate current conditions. Finally, the calibrated models will be used to help in the development of pollutant loads.

Once a month water quality samples were taken at 15 different locations within the watershed. These were conducted between September 2017 – November 2018 (No samples taken in Dec, Jan, & Feb due to frozen water sources). Each sample was analyzed for several variables (temperature, pH, turbidity, T.S.S., E. coli, D.O., phosphorus, nitrogen).

Analyte	Method
Nitrate Nitrite as N	10-107-04-1C
TKN as N	EPA 351.2
Total Phosphorus	EPA 365.3 1978
pH	SM 4500 H+B
Biological Oxygen Demand	SM 5210B-2011
Dissolved Oxygen	SM 4500 O C
Turbidity	SM2130B-2011
Total Suspended Solids	SM2540D-2011
Total Nitrogen	EPA Total Nitrogen
Fecal Coliform	SM 9222D-97, IDEXX Colilert-18

Table 1. Analytes and Analytical Methods

Site ID	Site Name	Latitude	Longitude	Type of Site
MS-1	West Main Street Bridge	41.5992	-73.9202	Mainstream
MS-2	Albany Post Road bridge	41.6091	-73.9118	Mainstream
MS-3	Dutchess County Airport	41.6209	-73.8947	Mainstream
TR-1	New Hackensack Road	41.6248	-73.8931	Tributary
MS-4	USGS Gauging Station (01372500)	41.5031	-73.8725	Mainstream
MS-5	State Route 55	41.6842	-73.8664	Mainstream
MS-6	Dutchess Turnpike	41.7416	-73.8280	Mainstream
TR-2	Highway 44	41.7451	-73.8214	Tributary
TR-3	Great Spring Creek at Wigsten Road	41.7562	-73.8241	Tributary
MS-7	Creek Road at Camp Nooteeming	41.7886	-73.7904	Mainstream
TR-4	Little Wappinger Creek at Salt Point	41.7975	-73.7890	Tributary
TR-5	East Branch of Wappinger Creek at Hibernia Road	41.8139	-73.7581	Tributary
TR-6	Willow Brook at Point Turnpike	42.7267	-73.7072	Tributary
TR-7	Hunns Lake Creek at Route 82A	41.8757	-73.6927	Tributary
MS-8	Cold Spring Road at Community of McIntyre	41.8899	-73.6983	Mainstream

Table 2. Sample Locations

Sample	Date	Sample	Date
1	9/12/2017	8	5/1/2018
2	10/20/2017	9	6/5/2018
3	10/31/2017	10	7/24/2018
4	11/20/2017	11	8/15/2018
5	11/21/2017	12	9/27/20188
6	3/6/2018	13	10/31/2018
7	4/3/2018	14	11/28/2018

Table 3. Sample Dates

Quality Objectives & Criteria

The goal of the sampling program is to create an initial base line of water quality variables, that can be used to measure the effectiveness of future BMPs, by comparing the results of these samples, to those taken after construction of the BMP(s) have been completed. The analysis performed can be seen in ***Table 1***. The following was done to ensure the data collected was both accurate and valid:

1. Samples were collected at 15 different points (***Table 2***) throughout the watershed to ensure that they were indicative of the entire watershed.
2. Samples were collected on a monthly basis, over the course of a year. In total 14 collection events were conducted (totaling 156 samples). This was to ensure a large enough data set was available and to capture seasonal changes in the watershed.
3. The laboratory (Envirotest) is a certified and accredited lab that performed numerous QC tests during their analysis of the samples. This included duplicate batches, Lab Control Spikes (LCS), Method Blanks, and Matrix Spikes.
4. The water sample collection process was conducted by Village of Wappingers Falls personnel but were trained by KC staff experienced and knowledgeable with the process.
5. Samples were collected and delivered to the Laboratory (Envirotest) on the same day as collection.

Limitations and deficiencies present in the water sample data set and/or collection process:

1. No water samples were collected in the months of December, January, and February; due to below freezing temperatures, which made collection of samples impossible/difficult.
2. Sampling consisted of taking only one sample per location, per month. More frequent sampling would have resulted in a larger more comprehensive data set and reduced statistical variance.
3. A Field Data Sheet was supposed to be completed for each sampling event, but project records only contain 3/14.
4. No field duplicates, equipment blanks, field blanks, or trip blanks were part of the sample collection process.

Documents & Records

During the collection of samples, a field data sheet was created to record relevant information from the sampling process. These were to be digitally archived in the dedicated project folder, however the majority of these are missing. Chain of Custody Forms (COC) were archived in a similar manner, but all are accounted for. All sample analysis was received from the Lab (Envirotest) via email and immediately placed in the project folder.

During the statistical analysis process, care was taken to ensure data was accurately transcribed from laboratory forms into the electronic database, which was used to calculate averages, standard deviations, etc. for the data sets.

B: Data Generation

Sampling Process Design

Sampling was conducted by The Village of Wappingers Falls on monthly basis from September 2017 to November 2018. KC Engineering provided assistance and training to the Village's staff, during the collection process. Samples were collected from 15 points in the watershed. These can be seen in *Figure 1*. The water samples collected were analyzed for nutrients, sediment, coliforms, DO, BOD using sterile containers, supplied by the Testing Laboratory (Envirotest). The results of sample analysis are to be used as an initial baseline that will be compared to future sample data to measure the effectiveness of BMPs and to identify trends in the watershed's water quality.

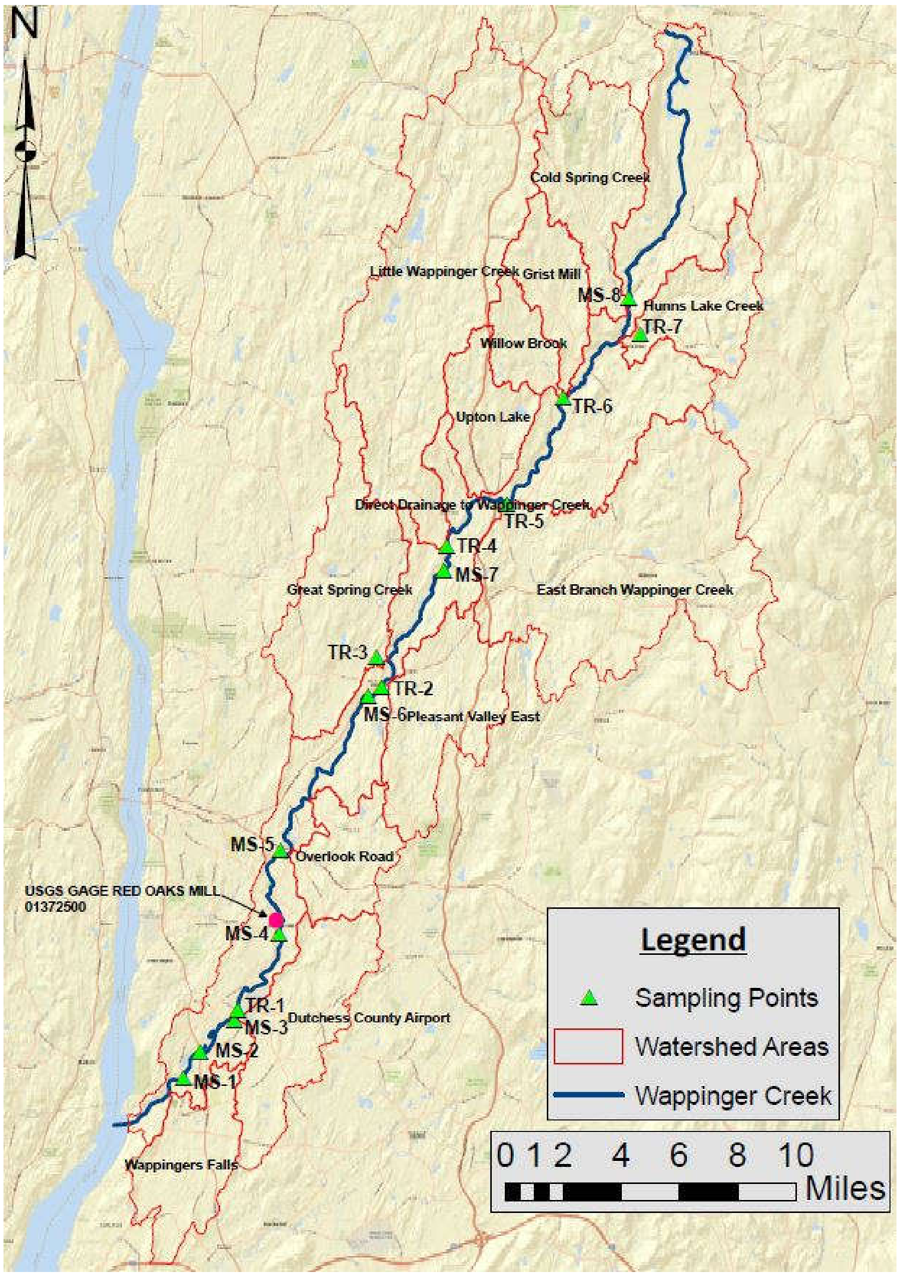


Figure 1. Map of USGS stream gages and sampling locations along the Wappinger Creek, New York

Sampling Methods

Water samples were collected from Wappinger Creek and various tributaries. All monitoring sites are located at bridges or wadable sections along the sections of the mainstream and tributaries. Sampling typically started at approximately at 7 AM at the upstream end of the project area and worked downstream. All sites were sampled on the same day. Sampling consists of collecting water from the center of the stream, using a container affixed to a pole. Water was then transferred to the laboratory supplied containers, which are then placed into a cooler with ice. During this process, water was placed directly into laboratory containers from the collection device. In between samples (different locations) the sample collection device was rinsed with distilled water.

Sampling was conducted by the Village of Wappingers Falls personnel. These individuals accompanied a knowledgeable KC staff member on the first sample collection event to receive training and instruction on the proper procedures and protocol. Throughout the remaining sample events, KC aided in collection of samples on occasion. Overall KC staff were involved in collection of 5 of the 14 sample sets.

Analyte	Container	Number	Preservative
Phosphorus & Nitrogen	250 ml plastic jar	1	Sulfuric Acid
Fecal coliform	125 ml sterile plastic	1	NA
Dissolved Oxygen (D.O.)	DO kit	1	NA (Reagents: Manganous Sulfate & Alkaline iodide-azide)
Total Suspended Solids (T.S.S.) & Biological Oxygen Demand (B.O.D.)	1000 ml plastic jar	1	NA
Turbidity & pH	1000 ml plastic jar	1	NA

Table 4. Sample Containers

Equipment List:

- Cooler with ice
- Sterile sample containers
- Disposable gloves
- Permanent marker
- Watch
- Camera
- Portable pH meter
- Thermometer
- DO azide modification kit supplied by laboratory
- Datasheet notebook

Sampling Handling & Custody

Samples were collected then transported by the sampler, to the Laboratory (Envirotest), on the same day. Immediately following the sample collection, they were placed into a cooler with ice, to maintain sample quality. A Chain of Custody (COC) form accompanied all samples to the laboratory and was scanned and placed into the project folder for record keeping purposed.

Analytical Methods

All analysis was performed in a certified laboratory (Envirotest).

Analyte	Method
Nitrate Nitrite as N	10-107-04-1C
TKN as N	EPA 351.2
Total Phosphorus	EPA 365.3 1978
pH	SM 4500 H+B
Biological Oxygen Demand	SM 5210B-2011
Dissolved Oxygen	SM 4500 O C
Turbidity	SM2130B-2011
Total Suspended Solids	SM2540D-2011
Total Nitrogen	EPA Total Nitrogen
Fecal Coliform	SM 9222D-97, IDEXX Colilert-18

Table 5. Sample Analysis Methodology

Quality Control

All sample analysis was done at a NYS certified laboratory (Envirotest), that has extensive in-house quality control and assurance procedures, documented in their Quality Systems Manual. Every sample underwent quality control testing, including duplicate batches, LCS spikes, method blanks, and matrix spikes. The results of the tests were included in the sample analysis report and reviewed. During the sample collection process, the sample collection device was rinsed with distilled water in between sampling locations.

Analyte	Method	QC Tests	Frequency
Nitrate Nitrite as N	10-107-04-1C	MB, LCS, MS, MSD	Every 20
TKN as N	EPA 351.2	MB, LCS, MS, MSD	Every 20
Total Phosphorus	EPA 365.3 1978	MB, LCS, MS, MSD	Every 20
pH	SM 4500 H+B	LCS, DU	Every 10
Biological Oxygen Demand	SM 5210B-2011	LCS, DU	Every 10
Dissolved Oxygen	SM 4500 O C	None	NA
Turbidity	SM2130B-2011	LCS, DU	Every 20
Total Suspended Solids	SM2540D-2011	MB, LCS DU	Every 20 Every 10
Total Nitrogen	EPA Total Nitrogen	None	NA
Fecal Coliform	SM 9222D-97, IDEXX Colilert-18	MB, DU	Every 10

Table 6. Quality Control Summary

Sample analysis results underwent crosschecking during their transfer from the analysis reports into the electronic database for statistical analysis. One individual was responsible for data entry and another for data review. Any inconsistency was flagged, and the correct value was found in the original laboratory sample analysis reports.

Any data outlier in a sample was flagged then analyzed. All outliers were found to be within the data range of the data set as a whole (all sample locations & all sample dates) or correlated with outliers in other samples from the same day. Therefore, all outliers were able to be rectified and can be included in the data set as valid data.

The sampling program did have some data gaps. As previously mentioned, no samples were taken between December and February due to freezing temperatures. Also, in some sampling events, there were not a full 15 samples taken. The sampling in Sept 2017, October 2017, November 2017, and July 2018 contained 5, 5, 13, and 13 samples respectfully.

Data Management

Data was generated in the field via Field Notebooks and by the testing laboratory (Envirotest) with the sample analysis reports. All data was archived in a dedicated electronic database maintained by KC Engineering, a project specific folder. The database has automatic backup protection. All hardcopies are first scanned, then entered into the database. Paper copies were maintained until the electronic transfer was completed and the quality of the scan was reviewed and confirmed to be acceptable. Electronic information (lab reports) were immediately placed into the database upon receival.

Vijay Eppakayala was the individual in charge of overseeing the data management system.

C: Assessment & Oversight

Assessment & Response Actions

During one of the sampling events (July 2018), two (2) bottles were broken and the samples were lost. This reduced the number of samples for MS-1 and MS-2 from 11 to 10, a 9% reduction. The decrease in sample size increased the potential for statistical variation. To prevent similar accidents, the samplers were instructed to handle all samples with extreme care during the sampling and transport process. A protective plastic bubble wrap was used to protect all sample containers during transport. The final four sampling events included zero broken sample containers.

Reports to Management

The data collected is not a comprehensive survey of the entire watershed's water quality. It was limited to 14 sampling events over the course of 442 days and 15 locations in a watershed of 211 square miles. The sampling program's goal was to create an initial state that could be used as a comparison for future sampling data, conducted after the completion of BMPs, solely to judge their effectiveness. Any other use of the data cannot be endorsed without further analysis.

D: Data Review & Evaluation

Data Review, Verification, and Validation

No external/independent data review/validation was performed as part of this project. KC Engineering was responsible for the review of all data, and information associated with the sample collection and analysis.

Laboratory QC test results were included with the sample analysis reports. This data was reviewed and any QC test result that fell out of the acceptable range was flagged, then investigated to determine if it had a potential to impact the data validity. If it was determined that the data was possibly compromised, then that data was omitted and not used in establishing the baseline levels' for The Creek.

The majority of laboratory QC tests were within acceptable ranges and those that were not are not believed to be indicative of unreliable data. The QC tests with multiple failures are discussed below:

- BOD: All BOD samples were below the reporting limit (RL) of 3 or 4 mg/L. Based on the failures, the results should have been skewed high, but were still below the RL. Therefore, all data can be confidently said to be below the RL.
- TKN: Two TKN tests were just outside of the acceptable RPD of 20% (22 and 23%). However the individual TKN recoveries were within the acceptable range (50-150%), just that in these instances one was high and one was low. This resulted in the RPD comparison being slightly high. The majority of samples came back below the RL (1.0 or 0.5 mg/L) so the data was not effected by these few instances.
- Coliform: QC tests involved 10x dilution. A difference of one colony per plate would thus be magnified to a difference of 10. This allows a small difference in the plates' colony count (4 vs 5) to appear much larger than in reality. There was a strong correlation between samples taken on the same day, so the data appears to be valid. The difference in QC tests could be explained by a non-homogenous sample.

No sample analysis data was purposively excluded from the project.

Verification and Validation Methods

The data was analyzed by location and sample event to calculate the standard deviation and geometric mean for each analyte. This data is to be reported in the Nine Element Plan the initial state of the watershed prior to any BMPs.

The Standard Deviation

$$\sigma = \sqrt{\frac{\sum(x - X)^2}{n}}$$

σ = standard deviation
X = arithmetic Mean
x = sample result
n = number of samples

Geometric mean

$$X_G = \sqrt[n]{x_1 * x_2 * x_3 \ldots * x_n}$$

x = sample result
n = number of samples

Matrix Spike Analysis

A portion of the Matrix Spike quality control tests was conducted using actual sample water collected in the field, while the other portion utilized laboratory prepared samples. The results of both sets were compared as a quality assurance check, the results are listed below. The average recovery % and relative percent difference (RPD) for both sets are well within the acceptable ranges.

	Recovery (%)				
Group	**MS**	**MSD**	**Limit**	**RPD**	**Limit**
Field	97.3	97.2	50-150	9.1	20.0
Lab	102.6	107.4	50-150	2.0	20.0

EVALUATING DATA IN TERMS OF USER NEEDS

The results of the sampling program were compared to NYSDEC Part 703 Surface Water Standards to ensure that they were within the known ranges for a waterbody such as Wappinger Creek. The majority of data collected was within the expected ranges. The data set, though small, should provide a suitable baseline for the watershed's water quality that can be compared to future data to determine an improvement/degradation in the water quality, or to measure the local effects of any BMPs.

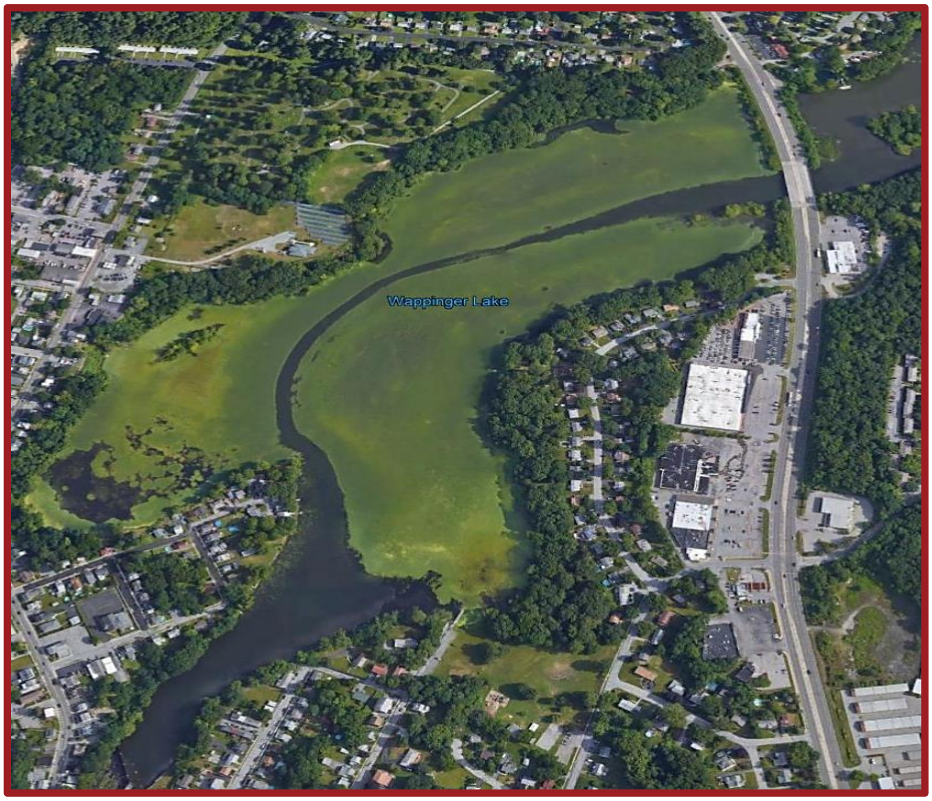
Appendix L

Bathymetric Study

Wappinger Lake

Bathymetric Study and

Sediment Evaluation Report



Prepared for:

THE VILLAGE OF WAPPINGER FALLS

Town of Wappinger Falls

Dutchess County, NY

Prepared

August 2018

Revised

KC # 4600-080

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1.0 Introduction

Spanning 88 acres, Wappinger Lake is a freshwater lake within the Village of Wappinger Falls, Dutchess County, NY. A small lake was first created at this location with the construction of a masonry dam across Wappingers Creek in the 1840s. The current dam which expanded the lake to its current size was constructed in 1910-11. The lake was evaluated in 1993 by the United States Army Corps of Engineers, (USACE), who found a significant amount of sediment outpouring from the Wappinger Creek Watershed, resulting in eutrophic conditions within the lake (USACE 1993, *Wappinger Lake Dutchess County, New York, Clean Lake Study*).

These characteristics were reaffirmed by the New York State Department of Environmental Conservation (NYSDEC) in a preliminary report that documented elevated amounts of sediment, nutrients and fecal coliforms present in the lake (Paggi, Martin and Del Bene, 2009). Eutrophication of the lake has occurred as a result of the deposition of sediment and nutrients, encouraging blooms of green and blue-green algae and increased aquatic plant growth.

Wappinger Lake is a site used for recreation and fishing, which is currently threatened by the lake conditions. Sediment deposition and eutrophication has led to a decrease in fish populations, along with a decrease in aesthetic qualities of the lake, reducing recreational value. As of 2016, Wappinger Lake has been placed on the 303d list of impaired water bodies that require a total maximum daily load (TMDL) of nutrients to avoid further eutrophication of the lake. Potential exposure to toxic blue-green algal blooms threatens human and wildlife health. If current conditions persist, the lake will likely become inaccessible.

Figure 1.1 Aerial View of Wappinger Lake

The purpose of this report was to investigate the condition of Wappinger Lake and suggest solutions to potentially remediate the observed characteristics. Survey and data samples were taken in order to evaluate current lake conditions. Appropriate remediation procedures are discussed and evaluated based on overall cost and effectiveness.

1.1 Project Objectives

To determine the conditions of Wappinger Lake, a bathymetric survey was conducted to determine the depth of Wappinger Lake as well as any lake bottom characteristics. Sampling has found the lake depth to range from less than 1 ft to 16 ft deep with an average depth of 6 ft. Sediment sampling occured at twelve sampling locations, four at 15 ft and eight and 3 ft depths. Sediment collected was sent to a laboratory for analysis of any contaminant concentration in the samples including: volatile organic compounds (VOCs), heavy metals, pesticides, PAH's, total nitrogen, total phosphorus and total pathogens.

Sediment was also sampled at four separate locations to test for fecal colliforms and *E.coli* concentrations. Surface water samples were also taken to analyze the dissolved oxygen content, total suspended sediment (TSS), pathogens, fecal colliforms, pH and nutrient content. The results of the bathymetric survey, sediment sampling and water sampling allow for the proposal of approprite solutions to sediment deposition and eutrophication observed in Wappinger Lake. The solutions are each evaluated on their benefits to the lake's conditions and their estimated cost.

1.2 Existing Conditions

Current conditions of Wappinger Lake are observed to show advanced stages of eutrophication and sediment build-up. Strains of green and blue-green algae are present on the lake's surface, indicating the presence of elevated nutrient levels and sediment within the lake. Invasive aquatic plants are also prominent on the surface and bottom of the lake. Identified invasive plants include water chestnut, *Trapa natans,* and Eurasian water milfoil, *Myriophyllum spicatum* which are observed to inhabit a significant portion of the lake. Pictured in Figure 1, water chestnut is shown blanketing the surface of Wappinger Lake. Clear lake surfaces are limited to the channel that begins at the mouth of the lake under South Road overpass and runs through the middle of the lake ending at the Wappinger Falls Dam.

Figure 1.2 Water chestnut (*Trapa natans*) covering the surface of Wappinger Lake

1.3 Project Location

Location of all observations were made at Wappinger Lake in Wappinger Falls, Dutchess County, New York. Wappinger Creek, which feeds into Wappinger Lake, is a tributary to the Hudson River. The creek, designated as 857-2 including P-365, Wappinger Lake, is classified as a Class B, Standard B water body. The standards refer to the Official Compilation Code, Rules, and Regulation of the State of New York, Chapter X – Division of Waters. These values govern water quality standards for taste, color, odor-producing, toxic, and other deleterious substances

2.0 Bathymetry

2.1 Methodology & Data Processing

From April 15 through May 8, 2019, KC performed GPS coupled depth soundings utilizing an InnerSpace Technology Model 620 single beam echosounder. This unit utilizes a 200 kHz transducer and a single frequency Trimble ProXRS GPS receiver. The echosounder automatically collects and stores geo-tagged depth observations at pre-set intervals while the survey technician runs a grid pattern over the surface.

An unmanned Seafloor Systems radio controlled HyDrone equipped with a HydroLite echosounder with a Trimble R-10 RTK GPS unit was utilized to supplement manned boat soundings in shallow areas inaccessible by the manned boat. Proper calibration in calm water conditions was performed to generally yield a vertical accuracy of 0.1-0.3 feet.

Vertical control was accomplished by redundant dual frequency RTK GPS observations utilizing the NYSDOT RTN network. A level staff was set in close proximity to the launch area and calibrated to read the current water level. The water level was checked from the boat before and after each sounding run with any significant differences noted. A bar check was performed on a daily basis, prior to all runs, to QA/QC the echosounder readings. Adjustments were made to account for boat draft, water salinity, and temperature. Shoreline at the time of survey was plotted based on record imagery and/or photogrammetric mapping commissioned by the Village in 2014.

Following data collection, data was downloaded and processed, and a 3D surface generated to provide a TIN suitable for producing one foot contour intervals. Vertical datum was referenced to NAVD 88. Horizontal system NYS State Plane, Eastern Zone 3101 (NAD83). Results were provided as a digital base map in AutoCad Civil 3d format.

2.2 Results

The bathymetric survey showed a channel beginning at the dam on the southwestern end of the lake. The lake's deepest point is 16 ft and occurs near the dam. The 60 ft wide channel has an average depth of about 10 ft and spans about half the length of the lake. The typical depth outside of the channel is 3 to 4 ft. Average depth across all sections of the lake is around 6 ft. Multiple approaches were used to verify the volume of approximate sediment in the lake. A surface was created using slopes from the adjacent land to estimate the area of the lake bottom.

The volume between this surface and the survey base map represents the sediment accumulated and was found to be approximately 1.5 million cubic yards. Using the lake's surface area of 88 acres, this was calculated to be approximately 10 ft of sediment accumulation. This data is consistent with the field data depths and reports of the lake's depth prior to its sedimentation, around 17 ft. Removal of all 1.5 million cubic yards (10 ft depth) of sediment would result in the lake returning to it's original depth of 17 ft. The possibility of restoring the lake to only a 10 ft depth was discussed for cost reasons. This would require removal of about 0.9 million cubic yards (7 ft depth) of sediment.

3.0 Sediment Sampling

3.1 Methodology

Following the bathymetric study, 3 ft sediment samples were taken from eight separate locations within the lake shown on Figure 3.1. Up to three samples of sediment were extracted from each sample location at 1 ft intervals for a total of 17 samples collected. The samples were stored in ice and transported to EnviroTest Laboratories in Newburgh, NY. The samples were tested for contaminants including volatile organic compounds (VOCs), heavy metals, pesticides PAH's, total nitrogen and total phosphorus and total pathogens.

Sampling locations are depicted in Figure 3.1. Locations were selected in order to depict a range of sediment samples that encompass characteristics from all parts of Wappinger Lake while being easy to access from watercraft. Due to the significant amount of water chestnut covering the lake surface, samples were unable to be acquired far from the main channel. Samples 6 and 7 are exceptions that were able to be acquired from land rather than watercraft.

Figure 3.1: 3 ft Sediment Sampling Locations

KC Engineering and Land Surveying, P.C.

Location 1

The first sediment sample was taken near the Wappinger Dam along the western shoreline. Lake conditions at this sampling site were more clear than other areas of the lake. Water chestnut was sparse in this location with only a few isolated patches. Lake depth was measured to be 5.5 ft. Only one foot of sediment could be collected at this location before refusal.

Location 2

This sample was taken near the center of the lake, west of the main channel. Presence of water chestnut was severe at this location, leaving no surface water visible. Water depth at this location was measured at 2.6 ft. Three feet of sediment was able to be collected from this location.

Location 3

This sample was taken near the Route 9 bridge to the left of the main channel. Water chestnut cover was severe at this location, leaving no surface water visible. Water depth was measured at 3.3 ft. Three feet of sediment was collected from this location.

Location 4

This sample was taken near the middle of the lake to the right of the main channel. This sample location was heavily covered by water chestnut leaving no surface water visible. Water depth was observed at 2.5 ft. Two feet of sediment was collected from this location.

Location 5

This sample was taken near the inlet at the west portion of the lake. Water chestnut was heavily present at this location obscuring the majority of the lake surface. Water depth was measured at 4.2 ft. Two feet of sediment was collected from this location.

Location 6

This sample was taken on land from the pier at the end of Spring Street. Water chestnut was not present at this location, however, the water surface was obsured by green and blue green algal blooms as well as common duckweed, *Lemna minor*. Water depth was measured to be 2.4 ft at this location. Only two feet of sediment was able to be collected from this location.

Location 7

This sample was taken from land from the shoreline at the southeast side of the lake. Water chestnut was sparse at this location with algal cover visible between water chestnut rosettes. Water depth was measured at 2.1 ft. Only two feet of sediment was able to be collected from this location.

Location 8

This sample was taken near Fisherman's Park in the middle of the lake to the right of the main channel. Water chestnut obscured the majority of the water surface at this location with surface water visible between rosettes. Water depth was measured at 2.2 ft. Three feet of sediment was collected from this location.

Sampling Location	Latitude	Longitude	Water Depth (ft)	Sediment Sampled (ft)
Location 1	41°36'6.17"N	73°55'9.13"W	5.5	<1
Location 2	41°36'27.69"N	73°54'56.05"W	2.6	3
Location 3	41°36'30.75"N	73°54'45.82"W	3.3	3
Location 4	41°36'24.30"N	73°54'52.42"W	2.5	2
Location 5	41°36'19.18"N	73°55'7.36"W	4.2	2
Location 6	41°36'9.26"N	73°54'57.15"W	2.4	2
Location 7	41°36'13.09"N	73°54'54.47"W	2.1	2
Location 8	41°36'19.24"N	73°55'3.06"W	2.2	3

Table 3.1 Sediment Sample Location Information

Additional 15 ft deep sediment samples were taken from four separate locations within the lake shown on Figure 3.2. Up to three samples of sediment were extracted from each sample location at 5 ft intervals for a total of 11 samples collected. Samples were subject to the same procedures as the 3 ft samples.

Figure 3.2: 15 ft Sediment Sampling Locations

Four one-foot samples were taken for fecal coliform testing within the lake, at the locations shown on Figure 3.3.

Figure 3.3: Fecal Colliform Sampling Locations

3.1.1 *Sampling Equipment*

Sediment samples were collected using an AMS Basic Soil Kit. A 3 ft clear PVC liner was inserted into the soil core, attached to an extension rod to retrieve sediment in sites located in greater depths. To prevent sediment leakage, soil catchers were placed at the bottom of the PVC liners, maintaining the integrity of the samples collected and minimizing sediment disturbance. All sediment samples were stored in containers that were appropriately labeled and stored in ice for laboratory analysis.

To collect data on VOC's, 15g of each sediment sample was collected using a terra core sampling kit and stored appropriately. Other equipment used included rinse buckets, cleaning supplies, waste solvent containers, and container labels. Safety precautions were of high priority as sediment samples may contain hazardous waste that required the use of safety gloves, safety goggles and specialized waste disposal equipment to minimize risk of exposure and contamination.

3.1.2 *Sampling*

Sediment survey was conducted at eight locations in Wappinger Lake. Coordinates of these locations, along with the water depth and amount of sediment collected at these locations are depicted in Table 3.1. Sampling was conducted using watercraft provided by the Wappinger Falls Fire Department.

Prior to use, sampling equipment was cleaned with a biodegradable detergent, washed with phosphate free soap, rinsed with distilled water, and was then allowed to dry. Sediment was collected by driving the soil core into the sediment perpendicular to the sediment layer and then extracting the PVC liner and capping either end to keep the sediment column intact. Sediment was brought to shore and samples were spilt accordingly for lab analysis. Each three ft liner was divided in up to three samples, measured by each foot of sediment collected. For sites where less than three feet of sediment was collected, the number of samples taken from that site were adjusted accordingly. A terra core sampler was used to take three 5g samples of sediment to be deposited into glass vials for VOC's analysis.

In conjunction with sampling at these eight locations, four separate locations were sampled for fecal coliforms. Sampling at these locations followed the same procedure as the previous samples, however, one 60g sample was taken, representing the entire sediment column collected at each location.

3.2 Laboratory Analysis

Collected samples were analyzed by EnviroTest Labs Inc. in Newburgh, NY. Each sample was tested for a wide parameter of contaminants which are listed in Appendix B. A Reporting Limit (RL) for each contaminant was established as the smallest amount of contaminant that could be reported by the laboratory as well as a Method Detection Limit (MDL) as the minimum amount of contaminant that can be reported with 99% confidence as a value greater than 0. Results of the laboratory analysis include contaminants found in samples that are greater than the RL or greater than the MDL.

Table 3.2 Parameter List and Laboratory Methods

Category	**Specific Parameters**	**Laboratory Method**
Metals	Target Analyte List Metals	EPA 6010C
	Hg	EPA 7471B
Organics	VOCs	EPA 8260C
	PCBs	EPA 8082
	PAHs	EPA 8270D
	Organochlorine Pesticides	EPA 8081B
Nutrients	TKN as N	EPA 351.2
	Total Nitrogen	Total Nitrogen
	Total Phosphorous	EPA 365.3 1978
Pathogens	Total Coliform	SM 9223B-2004
	E. Coli	SM 9223B-2004

3.3 Results

Contaminant concentrations found in the eight 3 ft sediment samples are represented by Tables 3.3-3.7. Table 3.3 is an overview of minimum and maximum contaminants volumes. Tables 3.4 to 3.6 break down analyte concentrations by 0-1', 1-2' and 2-3' depths. Finally, table 3.7 specifies minimum and maximum contaminant concentrations at each sample location.

Contaminant concentrations found in the four 15 ft sediment samples are represented by Tables 3.8-3.11. Tables 3.8 to 3.10 break down analyte concentrations by 0-5', 5-10' and 10-15' depths. Table 3.11 is an overview of minimum and maximum contaminants volumes.

A wide range of contaminants in the sediment samples exceeded the RL and MDL levels put forth by EnviroTest Laboratories, however, only contaminant volumes that exceed levels stated in the Sediment Cleanup Objectives (SCO) are considered significant.

Fecal coliform testing followed the guidelines set forth by the American Water Works Association in their *Standard Methods for The Examination of Water and Wastewater* (18^{th} - 22^{nd} Edition).

3.3.1 Sediment Management Standards

Several state and national level regulations exist to protect humans and (or) wildlife that come into direct or indirect contact with the pollutants in lakes. Aquatic wildlife such as fish and macro-invertebrates and humans can experience acute and/or chronic toxicity from direct contact with sediments in the water column or bed sediment.

Sediment Cleanup Objectives (SCO) represent the contaminant levels in soil with no restrictions on the site for the protection of public health, groundwater and ecological resources. Concentrations at or below the SCO correspond to sediment quality which no adverse effects to human or benthic community.

This review presents the general results and describes the minimum and maximum levels for each chemical analyzed and detected at one or more sample sites, as well as results for each sampling location. The results are compared with the Sediment Cleanup Objectives set forth by NYSDEC 6 NYCRR PART 375 (Environmental Remediation Programs).

Table 3.3 Contaminant Minimum and Maximum Volume by Sediment Layer

Analyte	Depth 0'-1'		Depth 1'-2'		Depth 2'-3'	
	Min mg/kg	Max mg/kg	Min mg/kg	Max mg/kg	Min mg/kg	Max mg/kg
Benzo[a]anthracene	0.34	0.34	0.14	0.14	0	0
Benzo[a]pyrene	0.39	0.39	0.13	0.70	0.47	0.68
Benzo[b]fluoranthene	0.66	0.66	0.21	0.21	0	0
Benzo[g,h,i]perylene	0.20	0.20	0	0	0	0
Benzo[k]fluoranthene	0.23	0.23	0	0	0	0
Bis(2-ethylhexyl) phthalate	0.16	0.16	0.13	1.20	0	0
Chrysene	0.53	0.53	0.19	0.19	0	0
Fluoranthene	0.18	0.99	0.32	0.32	0	0
Indeno[1,2,3-cd]pyrene	0.32	0.32	0	0	0	0
Phenanthrene	0.43	0.43	0.14	0.14	0	0
Pyrene	0.16	0.83	0.30	0.30	0	0
4,4' DDD	0	0	0	0	0.0098	0.0098
4,4' DDE	0.0058	0.0058	0.010	0.013	0.0056	0.018
Methylene Chloride	0.0031	0.018	0.0029	0.0067	0.0069	0.0069
Acetone	0.041	0.56	0.047	0.80	0.23	0.81
Carbon Disulfide	0.0018	0.0018	0.0025	0.0025	0	0
2-Butanone (MEK)	0.0060	0.13	0.0068	0.070	0.012	0.070
p-Isopropyltoluene	0	0	0.0045	0.0045	0	0
Al	7,200	20,000	13,000	21,000	13,000	17,000
As	3.4	5.4	3.6	7.5	2.7	5.7
Ca	1,300	8,800	2,300	8,600	2,900	4,000
Cd	1.5	2.3	1.7	2.3	0	0

Analyte	Depth 0'-1'		Depth 1'-2'		Depth 2'-3'	
	Min mg/kg	Max mg/kg	Min mg/kg	Max mg/kg	Min mg/kg	Max mg/kg
Cr	11	21	14	21	14	19
Cu	15	66	19	36	14	32
Fe	17,000	30,000	20,000	25,000	19,000	23,000
K	1,600	1,600	1,700	1,900	0	0
Mg	4,000	11,000	4,800	7,500	4,100	5,800
Ni	21	23	17	24	16	21
Pb	12	100	9.7	100	8.8	35
Mn	320	860	260	570	310	450
V	20	**30**	17	24	15	21
Zn	70	230	64	230	61	120
Ba	70	98	47	110	74	94
Mercury	0.041	0.15	0.013	0.13	0.016	0.12
TKN as N	700	1,700	340	1,900	740	1,900
Total Phosphorus	150	940	190	1,500	110	700
Percent Solids	30	77	48	86	49	78
Total Nitrogen	700	1,700	340	1,900	740	1,900

Table. 3.4 Analyte Concentration by Depth (0'-1')

Analyte	Depth 0'-1'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Benzo[a]anthracene	0.34	0.34	1	1	1	5.6	11	NS	1	
Benzo[a]pyrene	0.39	0.39	1	1	1	1	1.1	2.6	22	
Benzo[b]fluoranthene	0.66	0.66	1	1	1	5.6	11	NS	1.7	
Benzo[g,h,i]perylene	0.20	0.20	100	100	100	500	1000	NS	1000	
Benzo[k]fluoranthene	0.23	0.23	0.8	1	3.9	56	110	NS	1.7	
Bis(2-ethylhexyl) phthalate	0.16	0.16								0.0006 A(C)
Chrysene	0.53	0.53	1	1	3.9	56	110	NS	1	
Fluoranthene	0.18	0.99	100	100	100	500	1000	NS	1000	
Indeno[1,2,3-cd]pyrene	0.32	0.32	0.5	0.5	0.5	5.6	11	NS	8.2	
Phenanthrene	0.43	0.43	100	100	100	500	1000	NS	1000	
Pyrene	0.16	0.83	100	100	100	500	1000	NS	1000	
4,4' DDD	0	0	0.0033	2.6	13	92	180	0.0033	14	8×10^{-8} H(FC)
4,4' DDE	0.0058	0.0058	0.0033	1.8	8.9	62	120	0.0033	17	7×10^{-9} H(FC)
Methylene Chloride	0.0031	0.018	0.05	51	100	500	1000	12	0.05	0.2 H(FC)
Acetone	0.041	0.56	0.05	100	100	500	1000	2.2	0.05	
Carbon Disulfide	0.0018	0.0018								
2-Butanone (MEK)	0.0060	0.13	0.12	100	100	500	1000	100	0.12	
p-Isopropyltoluene	0	0								
Al	7,200	20,000								0.1 A(C)

Analyte	Depth 0'-1'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
As	3.4	5.4	13	16	16	16	16	13	16	0.15* A(C), 0.34* A(A)
Ca	1,300	8,800								
Cd	1.5	2.3	2.5	2.5	4.3	9.3	60	4	7.5	
Cr	11	21								
Cu	15	66	50	270	270	270	10000	50	1720	
Fe	17,000	30,000								
K	1,600	1,600								
Mg	4,000	11,000								
Ni	21	23	30	140	310	310	10000	30	130	
Pb	12	100	63	400	400	1000	3900	63	450	
Mn	320	860	1600	2000	2000	10000	10000	1600	130	
V	20	30							450	
Zn	70	230	109	2200	10000	10000	10000	109	2000	
Ba	70	98	350	350	400	400	10000	433		
Mercury	0.041	0.15	0.18	0.81	0.81	2.8	5.7	0.18	2480	
TKN as N	700	1,700							820	
Total Phosphorus	150	940							0.73	7 x 10^{-7}* H(FC), 0.00077 A(C), 0.0014 A(A), 2 x 10^{-6}* (W)
Percent Solids	30	77								
Total Nitrogen	700	1,700								

H(FC)- Health (Fish Consumption), A(C)-Aquatic (Chronic), A(A)-Aquatic (Acute), W-Wildlife, * - Dissolved form

Table. 3.5 Analyte Concentration by Depth (1'-2')

Analyte	Depth 1'-2'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Benzo[a]anthracene	0.14	0.14	1	1	1	5.6	11	NS	1	
Benzo[a]pyrene	0.13	0.70	1	1	1	1	1.1	2.6	22	
Benzo[b]fluoranthene	0.21	0.21	1	1	1	5.6	11	NS	1.7	
Benzo[g,h,i]perylene	0	0	100	100	100	500	1000	NS	1000	
Benzo[k]fluoranthene	0	0	0.8	1	3.9	56	110	NS	1.7	
Bis(2-ethylhexyl) phthalate	0.13	1.20								0.0006 A(C)
Chrysene	0.19	0.19	1	1	3.9	56	110	NS	1	
Fluoranthene	0.32	0.32	100	100	100	500	1000	NS	1000	
Indeno[1,2,3-cd]pyrene	0	0	0.5	0.5	0.5	5.6	11	NS	8.2	
Phenanthrene	0.14	0.14	100	100	100	500	1000	NS	1000	
Pyrene	0.30	0.30	100	100	100	500	1000	NS	1000	
4,4' DDD	0	0	0.0033	2.6	13	92	180	0.0033	14	8×10^{-8} H(FC)
4,4' DDE	0.010	0.013	0.0033	1.8	8.9	62	120	0.0033	17	7×10^{-9} H(FC)
Methylene Chloride	0.0029	0.0067	0.05	51	100	500	1000	12	0.05	0.2 H(FC)
Acetone	0.047	0.80	0.05	100	100	500	1000	2.2	0.05	
Carbon Disulfide	0.0025	0.0025								
2-Butanone (MEK)	0.0068	0.070	0.12	100	100	500	1000	100	0.12	
p-Isopropyltoluene	0.0045	0.0045								
Al	13,000	21,000								0.1 A(C)

Analyte	Depth 1'-2'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
As	3.6	7.5	13	16	16	16	16	13	16	0.15* A(C), 0.34* A(A)
Ca	2,300	8,600								
Cd	1.7	2.3	2.5	2.5	4.3	9.3	60	4	7.5	
Cr	14	21								
Cu	19	36	50	270	270	270	10000	50	1720	
Fe	20,000	25,000								
K	1,700	1,900								
Mg	4,800	7,500								
Ni	17	24	30	140	310	310	10000	30	130	
Pb	9.7	100	63	400	400	1000	3900	63	450	
Mn	260	570	1600	2000	2000	10000	10000	1600	2000	
V	17	24								
Zn	64	230	109	2200	10000	10000	10000	109	2480	
Ba	47	110	350	350	400	400	10000	433	820	
Mercury	0.013	0.13	0.18	0.81	0.81	2.8	5.7	0.18	0.73	7×10^{-7}* H(FC), 0.00077* A(C), 0.0014* A(A), 2×10^{-6}* (W)
TKN as N	340	1,900								
Total Phosphorus	190	1,500								
Percent Solids	48	86								
Total Nitrogen	340	1,900								

H(FC)- Health (Fish Consumption), A(C)-Aquatic (Chronic), A(A)-Aquatic (Acute), W-Wildlife, * - Dissolved form

Table. 3.6 Analyte Concentration by Depth (2'-3')

Analyte	Depth 2'-3'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Benzo[a]anthracene	0	0	1	1	1	5.6	11	NS	1	
Benzo[a]pyrene	0.47	0.68	1	1	1	1	1.1	2.6	22	
Benzo[b]fluoranthene	0	0	1	1	1	5.6	11	NS	1.7	
Benzo[g,h,i]perylene	0	0	100	100	100	500	1000	NS	1000	
Benzo[k]fluoranthene	0	0	0.8	1	3.9	56	110	NS	1.7	
Bis(2-ethylhexyl) phthalate	0	0								0.0006 A(C)
Chrysene	0	0	1	1	3.9	56	110	NS	1	
Fluoranthene	0	0	100	100	100	500	1000	NS	1000	
Indeno[1,2,3-cd]pyrene	0	0	0.5	0.5	0.5	5.6	11	NS	8.2	
Phenanthrene	0	0	100	100	100	500	1000	NS	1000	
Pyrene	0	0	100	100	100	500	1000	NS	1000	
4,4' DDD	0.0098	0.0098	0.0033	2.6	13	92	180	0.0033	14	8×10^{-8} H(FC)
4,4' DDE	0.0056	0.018	0.0033	1.8	8.9	62	120	0.0033	17	7×10^{-9} H(FC)
Methylene Chloride	0.0069	0.0069	0.05	51	100	500	1000	12	0.05	0.2 H(FC)
Acetone	0.23	0.81	0.05	100	100	500	1000	2.2	0.05	
Carbon Disulfide	0	0								
2-Butanone (MEK)	0.012	0.070	0.12	100	100	500	1000	100	0.12	
p-Isopropyltoluene	0	0								
Al	13,000	17,000								0.1 A(C)
As	2.7	5.7	13	16	16	16	16	13	16	0.15* A(C), 0.34* A(A)

Analyte	Depth 2'-3'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Ca	2,900	4,000								
Cd	0	0	2.5	2.5	4.3	9.3	60	4	7.5	
Cr	14	19								
Cu	14	32	50	270	270	270	10000	50	1720	
Fe	19,000	23,000								
K	0	0								
Mg	4,100	5,800								
Ni	16	21	30	140	310	310	10000	30	130	
Pb	8.8	35	63	400	400	1000	3900	63	450	
Mn	310	450	1600	2000	2000	10000	10000	1600	2000	
V	15	21								
Zn	61	120	109	2200	10000	10000	10000	109	2480	
Ba	74	94	350	350	400	400	10000	433	820	
Mercury	0.016	0.12	0.18	0.81	0.81	2.8	5.7	0.18	0.73	7×10^{-7}* H(FC), 0.00077* A(C), 0.0014* A(A), 2×10^{-6}* (W)
TKN as N	740	1,900								
Total Phosphorus	110	700								
Percent Solids	49	78								
Total Nitrogen	740	1,900								

H(FC)- Health (Fish Consumption), A(C)-Aquatic (Chronic), A(A)-Aquatic (Acute), W-Wildlife, * - Dissolved form

Table 3.7 Minimum and maximum concentrations of contaminant by location

Analyte	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Benzo[a]anthracene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.14 Max: 0.34	Min: 0 Max: 0	Min: 0 Max: 0
Benzo[a]pyrene	Min: 0 Max: 0	Min: 0.43 Max: 0.47	Min: 0.68 Max: 0.68	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.13 Max: 0.39	Min: 0 Max: 0	Min: 0.70 Max: 0.70
Benzo[b]fluoranthene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.21 Max: 0.66	Min: 0 Max: 0	Min: 0 Max: 0
Benzo[g,h,i]perylene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.20 Max: 0.20	Min: 0 Max: 0	Min: 0 Max: 0
Benzo[k]fluoranthene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.23 Max: 0.23	Min: 0 Max: 0	Min: 0 Max: 0
Bis(2-ethylhexyl)phthalate	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.13 Max: 0.16	Min: 0 Max: 0	Min: 1.20 Max: 1.20
Chrysene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.19 Max: 0.53	Min: 0 Max: 0	Min: 0 Max: 0
Fluoranthene	Min: 0 Max: 0	Min: 0.29 Max: 0.29	Min: 0.16 Max: 0.16	Min: 0.20 Max: 0.20	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0
Ideno[1,2,3-cd]pyrene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min:0 Max: 0	Min: 0 Max: 0	Min: 0.32 Max: 0.32	Min: 0 Max: 0	Min: 0 Max: 0
Phenanthrene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.14 Max: 0.43	Min: 0 Max: 0	Min: 0 Max: 0
Pyrene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.16 Max: 0.16	Min: 0.16 Max: 0.16	Min: 0 Max: 0	Min: 0.30 Max: 0.83	Min: 0 Max: 0	Min: 0 Max: 0
4,4' DDD	Min: 0 Max: 0	Min: 0.0098 Max: 0.0098	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0
4,4' DDE	Min: 0 Max: 0	Min: 0.013 Max: 0.018	Min: 0.0056 Max: 0.011	Min: 0.0058 Max: 0.010	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0

Analyte	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Methylene Chloride	Min: 0 Max: 0	Min: 0.0067 Max: 0.018	Min: 0.00049 Max: 0.00049	Min: 0.0037 Max: 0.0063	Min: 0.0031 Max: 0.029	Min: 0.0039 Max: 0.012	Min: 0.0033 Max: 0.0033	Min: 0.0033 Max: 0.0033
Acetone	Min: 0.54 Max: 0.54	Min: 0.23 Max: 0.56	Min: 0.27 Max: 0.35	Min: 0.31 Max: 0.32	Min: 0.041 Max: 0.047	Min: 0.15 Max: 0.50	Min: 0.043 Max: 0.048	Min: 0.80 Max: 0.81
Carbon Disulfide	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.0018 Max: 0.0018	Min: 0.0025 Max: 0.0025	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0
2-Butanone (MEK)	Min: 0.13 Max: 0.13	Min: 0.046 Max: 0.12	Min: 0.062 Max: 0.078	Min: 0.068 Max: 0.070	Min: 0.0060 Max: 0.0068	Min: 0.034 Max: 0.11	Min: 0 Max: 0	Min: 0.012 Max: 0.17
p-Isopropyltoluene	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0.0045 Max: 0.0045	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0
Al	Min: 7,200 Max: 7,200	Min: 15,000 Max: 18,000	Min: 10,000 Max: 14,000	Min: 14,000 Max: 16,000	Min: 18,000 Max: 20,000	Min: 15,000 Max: 16,0000	Min: 17,000 Max: 19,000	Min: 13,000 Max: 21,000
As	Min: 0 Max: 0	Min: 5.7 Max: 6.3	Min: 3.9 Max: 4.0	Min: 3.8 Max: 4.3	Min: 3.4 Max: 3.6	Min: 5.4 Max: 7.5	Min: 3.9 Max: 6.4	Min: 2.7 Max: 4.0
Ca	Min: 8200 Max: 8200	Min: 4600 Max: 8800	Min: 2900 Max: 4600	Min: 4000 Max: 4900	Min: 1300 Max: 1300	Min: 8600 Max: 18,000	Min: 0 Max: 0	Min: 2300 Max: 2400
Cd	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 1.5 Max: 1.9	Min: 2.3 Max: 2.3	Min: 1.7 Max: 2.3	Min: 0 Max: 0
Cr	Min:11 Max: 11	Min: 17 Max: 20	Min: 12 Max: 15	Min: 15 Max: 17	Min: 16 Max: 18	Min: 18 Max: 21	Min: 15 Max: 15	Min: 14 Max: 21
Cu	Min: 25 Max: 25	Min: 29 Max: 36	Min:19 Max: 23	Min: 21 Max: 23	Min: 21 Max: 27	Min: 33 Max: 66	Min:15 Max: 22	Min: 14 Max: 29
Fe	Min: 20,000 Max: 20,000	Min: 20,000 Max: 23,000	Min: 17,000 Max: 21,000	Min: 21,000 Max: 24,000	Min: 20,000 Max: 25,000	Min: 24,000 Max: 25,000	Min: 22,000 Max: 30,000	Min: 19,000 Max: 25,000
K	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 0 Max: 0	Min: 1600 Max: 1700	Min: 0 Max: 0	Min: 0 Max: 0	Min: 1900 Max: 1900

Analyte	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Mg	Min: 0 Max: 0	Min: 5600 Max: 6100	Min: 4000 Max: 5200	Min: 5700 Max: 6600	Min: 4900 Max: 5600	Min: 7500 Max: 11,000	Min: 4800 Max: 5800	Min: 4100 Max: 6000
Ni	Min: 0 Max: 0	Min: 21 Max:23	Min:17 Max: 18	Min: 19 Max: 22	Min: 21 Max: 23	Min: 22 Max: 23	Min: 18 Max: 22	Min: 16 Max: 24
Pb	Min: 100 Max: 100	Min: 35 Max: 55	Min:18 Max: 25	Min: 28 Max: 38	Min:12 Max: 14	Min: 100 Max: 100	Min: 20 Max: 9.7	Min: 8.8 Max: 24
Mn	Min: 600 Max: 600	Min: 450 Max: 570	Min: 350 Max: 430	Min:440 Max: 590	Min: 320 Max: 330	Min: 460 Max: 610	Min: 260 Max: 860	Min: 310 Max: 420
V	Min: 0 Max: 0	Min: 21 Max: 24	Min: 0 Max: 0	Min: 20 Max: 20	Min: 20 Max: 22	Min: 22 Max: 30	Min: 17 Max: 21	Min: 15 Max: 23
Zn	Min: 130 Max: 130	Min: 90 Max: 130	Min: 83 Max: 86	Min: 99 Max: 130	Min: 70 Max: 74	Min: 230 Max: 230	Min: 64 Max: 70	Min: 61 Max: 100
Ba	Min: 0 Max: 0	Min: 82 Max: 90	Min: 74 Max: 74	Min: 0 Max: 0	Min: 77 Max: 81	Min: 69 Max: 69	Min: 47 Max: 70	Min: 94 Max: 110
Mercury	Min: 0.15 Max: 0.15	Min: 0.092 Max: 0.12	Min: 0.057 Max: 0.069	Min: 0.036 Max: 0.041	Min: 0.026 Max: 0.044	Min: 0.11 Max: 0.13	Min: 0.013 Max: 0.018	Min: 0.016 Max: 0.066
TKN as N	Min: 1700 Max: 1700	Min: 1600 Max: 1900	Min: 1400 Max: 1500	Min: 1300 Max: 1600	Min: 340 Max: 700	Min: 970 Max: 1700	Min: 490 Max: 960	Min: 740 Max: 1900
Total Phosphorus	Min: 160 Max: 160	Min: 110 Max: 190	Min:530 Max: 1300	Min: Max:	Min: 450 Max: 510	Min: 840 Max: 940	Min: 300 Max: 560	Min: 440 Max: 830
Percent Solids	Min: 30 Max: 30	Min: 35 Max: 49	Min: 44 Max: 55	Min: 49 Max: 54	Min: 75 Max: 82	Min: 38 Max: 63	Min: 77 Max: 86	Min: 57 Max: 78
Total Nitrogen	Min: 1700 Max: 1700	Min: 1600 Max: 1900	Min: 1400 Max: 1500	Min: 1300 Max: 1600	Min: 340 Max: 700	Min: 840 Max: 940	Min: 490 Max: 960	Min: 740 Max: 1900

Table 3.8 Analyte Concentration by Depth (0'-5')

Analyte	Depth 0'-5'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Benzo[a]pyrene	0	0	1	1	1	1	1.1	2.6	22	
Benzo[b]fluoranthene	0.25	0.25	1	1	1	5.6	11	NS	1.7	
Chrysene	0.16	0.16	1	1	3.9	56	110	NS	1	
Fluoranthene	0.17	0.28	100	100	100	500	1000	NS	1000	
Pyrene	0.17	0.25	100	100	100	500	1000	NS	1000	
Methylene Chloride	0.011	0.073	0.05	51	100	500	1000	12	0.05	0.2 H(FC)
Acetone	0.089	0.24	0.05	100	100	500	1000	2.2	0.05	
Carbon Disulfide	0	0								
Chloroform	0	0	0.37	10	49	350	700	12	0.37	
Toluene	0	0	0.7	100	100	500	1000	36	0.7	
2-Butanone (MEK)	0.0065	0.067	0.12	100	100	500	1000	100	0.12	
Al	15,000	24,000								0.1 A(C)
Ca	2,700	12,000								
Cr	16	24								
Cu	20	37	50	270	270	270	10000	50	1720	
Fe	20,000	29,000								
K	2,000	3,500								
Mg	5,800	7,000								
Ni	22	28	30	140	310	310	10000	30	130	
Pb	23	48	63	400	400	1000	3900	63	450	
Mn	490	710	1600	2000	2000	10000	10000	1600	2000	
V	24	35								
Zn	120	160	109	2200	10000	10000	10000	109	2480	
Ba	140	140	350	350	400	400	10000	433	820	
Ti	0	0								
Mercury	0.12	0.21	0.18	0.81	0.81	2.8	5.7	0.18	0.73	7 x 10^{-7}* H(FC), 0.00077 A(C), 0.0014 A(A), 2 x 10^{-6}* (W)

Analyte	Depth 0'-5'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
TKN as N	2,400	3,100								
Total Phosphorus	2.4	3.1								
Percent Solids	39	50								
Total Nitrogen	2,400	3,100								

H(FC)- Health (Fish Consumption), A(C)-Aquatic (Chronic), A(A)-Aquatic (Acute), W-Wildlife, * - Dissolved form

Table 3.9 Analyte Concentration by Depth (5'-10')

Analyte	Depth 5'-10'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Benzo[a]pyrene	0.10	0.10	1	1	1	1	1.1	2.6	22	
Benzo[b]fluoranthene	0.18	0.18	1	1	1	5.6	11	NS	1.7	
Chrysene	0.13	0.13	1	1	3.9	56	110	NS	1	
Fluoranthene	0.21	0.21	100	100	100	500	1000	NS	1000	
Pyrene	0.20	0.20	100	100	100	500	1000	NS	1000	
Methylene Chloride	0.020	0.051	0.05	51	100	500	1000	12	0.05	0.2 H(FC)
Acetone	0.11	0.21	0.05	100	100	500	1000	2.2	0.05	
Carbon Disulfide	0.0022	0.0022								
Chloroform	0.0022	0.0022	0.37	0.37	10	49	350	700	12	0.37
Toluene	0.0024	0.0024	0.7	0.7	100	100	500	1000	36	0.7
2-Butanone (MEK)	0.025	0.042	0.12	100	100	500	1000	100	0.12	
Al	13,000	19,000								0.1 A(C)
Ca	2,600	6,000								
Cr	14	19								
Cu	19	28	50	270	270	270	10000	50	1720	
Fe	19,000	23,000								
K	1,700	2,900								
Mg	4,400	5,600								
Ni	19	22	30	140	310	310	10000	30	130	
Pb	18	40	63	400	400	1000	3900	63	450	
Mn	410	1,300	1600	2000	2000	10000	10000	1600	2000	
V	18	27								
Zn	80	130	109	2200	10000	10000	10000	109	2480	
Ba	82	120	350	350	400	400	10000	433	820	
Ti	0	0								
Mercury	0.11	0.11	0.18	0.81	0.81	2.8	5.7	0.18	0.73	7×10^{-7}* H(FC), 0.00077* A(C), 0.0014* A(A), 2×10^{-6}* (W)

Analyte	Depth 5'-10'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
TKN as N	1,400	2,500								
Total Phosphorus	0.16	4.2								
Percent Solids	45	69								
Total Nitrogen	1,400	2,300								

H(FC)- Health (Fish Consumption), A(C)-Aquatic (Chronic), A(A)-Aquatic (Acute), W-Wildlife, * - Dissolved form

Table 3.10 Analyte Concentration by Depth (10'-15')

Analyte	Depth 10'-15'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
Benzo[a]pyrene	0	0	1	1	1	1	1.1	2.6	22	
Benzo[b]fluoranthene	0	0	1	1	1	5.6	11	NS	1.7	
Chrysene	0	0	1	1	3.9	56	110	NS	1	
Fluoranthene	0	0	100	100	100	500	1000	NS	1000	
Pyrene	0	0	100	100	100	500	1000	NS	1000	
Methylene Chloride	0.0099	0.030	0.05	51	100	500	1000	12	0.05	0.2 H(FC)
Acetone	0.076	0.10	0.05	100	100	500	1000	2.2	0.05	
Carbon Disulfide	0	0								
Chloroform	0	0	0.37	0.37	10	49	350	700	12	0.37
Toluene	0	0	0.7	0.7	100	100	500	1000	36	0.7
2-Butanone (MEK)	0.020	0.023	0.12	100	100	500	1000	100	0.12	
Al	12,000	15,000								0.1 A(C)
Ca	2,100	4,900								
Cr	11	15								
Cu	13	17	50	270	270	270	10000	50	1720	
Fe	19,000	26,000								
K	0	0								
Mg	4,100	6,000								
Ni	17	23	30	140	310	310	10000	30	130	
Pb	16	20	63	400	400	1000	3900	63	450	
Mn	380	480	1600	2000	2000	10000	10000	1600	2000	
V	14	18								
Zn	73	91	109	2200	10000	10000	10000	109	2480	
Ba	61	65	350	350	400	400	10000	433	820	
Ti	3.2	3.2								
Mercury	0.016	0.12	0.18	0.81	0.81	2.8	5.7	0.18	0.73	7 x 10^{-7}* H(FC), 0.00077* A(C), 0.0014* A(A), 2 x 10^{-6}* (W)

Analyte	Depth 10'-15'		Unrestricted Use SCO	Restricted Use SCO						
				Protection of Public Health				Protection of Ecological Resources	Protection of Groundwater	
				Residential	Restricted-Residential	Commercial	Industrial			Surface Water Standard (Class B)
	Min mg/kg	Max mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l
TKN as N	680	1,400								
Total Phosphorus	1.4	2.3								
Percent Solids	63	76								
Total Nitrogen	740	1,400								

H(FC)- Health (Fish Consumption), A(C)-Aquatic (Chronic), A(A)-Aquatic (Acute), W-Wildlife, * - Dissolved form

Table 3.11 Contaminant Minimum and Maximum Volume by Sediment Layer

Analyte	Depth 0'-5'		Depth 5'-10'		Depth 10'-15'	
	Min mg/kg	Max mg/kg	Min mg/kg	Max mg/kg	Min mg/kg	Max mg/kg
Benzo[a]pyrene	0	0	0.10	0.10	0	0
Benzo[b]fluoranthene	0.25	0.25	0.18	0.18	0	0
Chrysene	0.16	0.16	0.13	0.13	0	0
Fluoranthene	0.17	0.28	0.21	0.21	0	0
Pyrene	0.17	0.25	0.20	0.20	0	0
Methylene Chloride	0.011	0.073	0.020	0.051	0.0099	0.030
Acetone	0.089	0.24	0.11	0.21	0.076	0.10
Carbon Disulfide	0	0	0.0022	0.0022	0	0
Chloroform	0	0	0.0022	0.0022	0	0
Toluene	0	0	0.0024	0.0024	0	0
2-Butanone (MEK)	0.0065	0.067	0.025	0.042	0.020	0.023
Al	15,000	24,000	13,000	19,000	12,000	15,000
Ca	2,700	12,000	2,600	6,000	2,100	4,900
Cr	16	24	14	19	11	15
Cu	20	37	19	28	13	17
Fe	20,000	29,000	19,000	23,000	19,000	26,000
K	2,000	3,500	1,700	2,900	0	0
Mg	5,800	7,000	4,400	5,600	4,100	6,000
Ni	22	28	19	22	17	23
Pb	23	48	18	40	16	20
Mn	490	710	410	1,300	380	480
V	24	35	18	27	14	18
Zn	120	160	80	130	73	91
Ba	140	140	82	120	61	65
Ti	0	0	0	0	3.2	3.2
Mercury	0.12	0.21	0.11	0.11	0.016	0.12
TKN as N	2,400	3,100	1,400	2,500	680	1,400
Total Phosphorus	2.4	3.1	0.16	4.2	1.4	2.3
Percent Solids (%)	39	50	45	69	63	76
Total Nitrogen	2,400	3,100	1,400	2,300	740	1,400

3.4 Summary

Sediment samples were taken in several groups. The first group of sediment samples were 3 ft deep and consisted of 8 locations (1-8) which were tested for 38 analytes. Maximum analyte concentration levels were compared to SCO contaminant levels. Out of the 38 analytes tested, only 7 had levels above the SCO standards, they include: Acetone, 2-Butanone (MEK), 4-4'-DDD, 4-4'-DDE, Lead, Zinc, and Copper. Three analytes, 4,4' DDD, 2-Butanone (MEK), and Copper were found only at one site. The most prevalent analytes were Zinc, which was found at half the sites sampled and Acetone, which was found at two adjacent sites in concentrations as high as 16 times the SCO. 2-Butanone (MEK) was the least prevalent analyte, found only at one site, with concentrations narrowly exceeding the SCO. Other analytes were limited to one or two sites with concentrations around double the SCO.

The second group of sediment samples were 15 ft deep and tested the same analytes in four locations, A-D. Four analytes had levels above the SCO contaminant levels, they include: Acetone, Zinc, Mercury, and Methylene Chloride. Acetone and Zinc were again the most prevalent of the analytes and were found at each of the four sampling locations. Average valves of Acetone were over double the SCO standard at the four sites. Mercury and methylene chloride were the least prevalent, and both were found at only half of the sites and did not persist through the 15 ft depth of the sample.

Table 3.12 summaries the analytes which exceeded SCO concentrations for both sets of samples including the maximum concentrations found, and the sites and depths were SCO exceedances occurred.

Table 3.12 Summary of Sediment Cleanup Objectives Exceeded

Analyte	Max Conc. (mg/kg)	SCO (mg/kg)	Sites	Depths
4,4' DDD	0.0098	0.0033	2	2-3 ft
4,4' DDE	0.08	0.033	2, 4	0-3 ft
Acetone	0.81	0.05	2, 8, A-D	0-3 ft, 0-15 ft
2-Butanone (MEK)	0.13	0.12	1	0-1 ft
Cu	66	50	6	0-1 ft
Pb	100	63	1, 6	0-2 ft
Zn	230	109	1, 2, 4, 6, A-D	0-3 ft, 0-10 ft
Mercury	0.21	0.18	A, B	0-5 ft
Methylene Chloride	0.073	0.05	B, C	0-10 ft

A third group of sediment samples consisted of four locations and measured Fecal Coliform and E.coli. Water quality for bathing beaches requires single sample concentrations below 235 E.coli per 100 mL and 1,000 fecal coliform bacteria per 100 mL. Of the four locations the average E.coli concentration was 12.6 colony forming units (CFU)/100mL with a max concentration of 27 CFU/100mL. Average fecal coliform concentration was 721 CFU/100mL, with two samples exceeding 2,000 CFU/100mL.

Table 3.13 Fecal Coliform and *E.coli* Volumes from Unique Sample Locations

Sample Location	Fecal Coliforms Total	*E.coli* Total
	(CFU/100mL)	(CFU/100mL)
Location 1	2000	27
Location 2	15	7.4
Location 3	250	6.3
Location 4	>2419.6	9.8

4.0 Water Sampling

4.1 Methodology

Water samples were taken to test for water quality, presence of suspended sediment, nutrients and coliforms in Wappinger Lake. Samples were collected from a single sampling point near the overpass north of the lake and prepared for laboratory analysis. Collected samples were tested for the level of dissolved oxygen, total suspended sediment (TSS), total nitrogen and total phosphorus, turbidity, coliforms, pH and temperature.

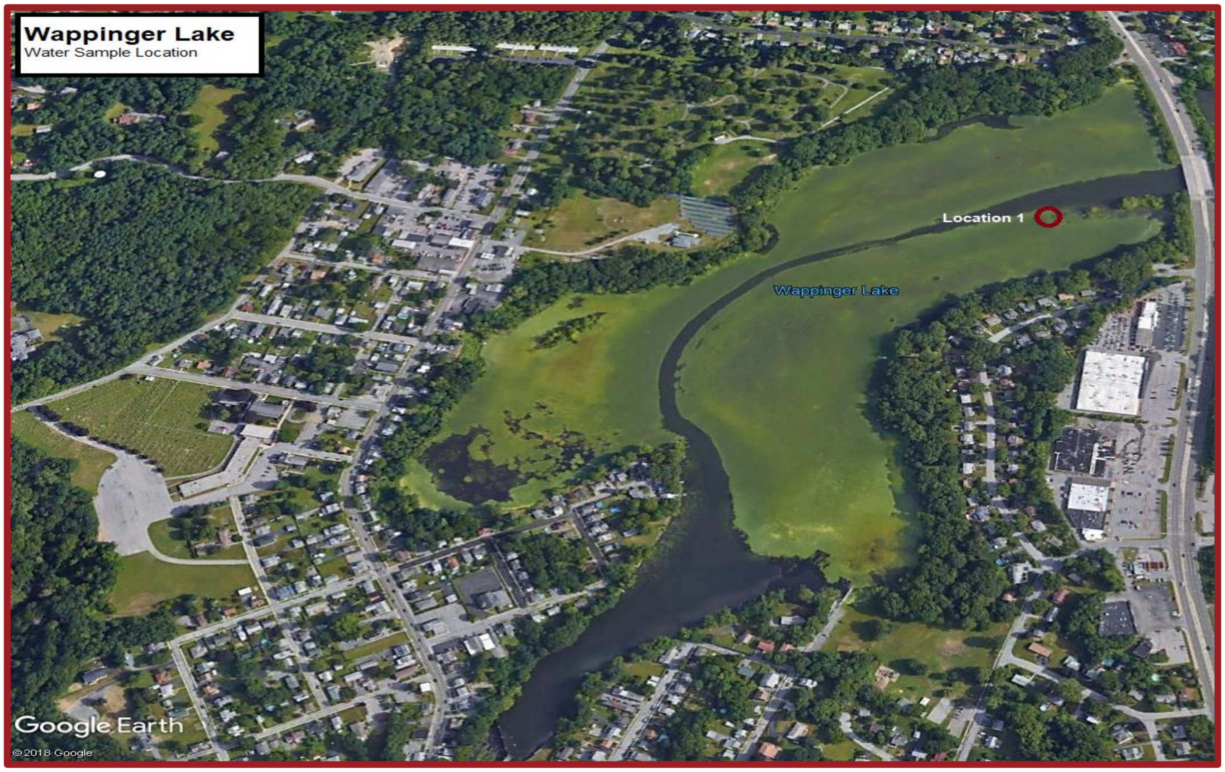

Figure 4.1 Wappinger Lake Water Sampling Location

4.1.1 Sampling Equipment

Water samples were collected using a 6 ft water sampler. In order to test for dissolved oxygen, a sample was collected in a separate sample bottle which included activators needed for analysis. Coliform testing also required the use of a separate sample container, distinguishable from the other containers. In total, five sample containers were used for water sampling. A submersible thermometer was used to measure the temperature of the sampled water.

4.1.2 Sampling

Water samples were taken from watercraft at one location within Wappinger Lake depicted in figure 4.1. Samples were taken using a 6 ft water sampler. Water was collected and poured into five separate sampling containers that were labelled accordingly. For the container used to measure dissolved oxygen, activation reagents were added consecutively and shaken between additions. All collected samples were stored in ice before being analyzed by EnviroTest Laboratories for pH, turbidity, dissolved oxygen, TSS, fecal coliforms, total phosphorus and total nitrogen.

4.2 Results

Table 4.1 Water Analyte Volumes from Lake Water Samples

Analyte	Measured Result	Reporting Limit
Nitrate, Nitrite as N	0.44mg/L	0.050
Total Phosphorus	0.058mg/L	0.010
pH	8.03 SU	0.200 SU
Temperature	17.8 degrees Celsius	5.00 degrees Celsius
Dissolved Oxygen	11mg/L	1.0mg/L
Turbidity	2.8 NTU	0.10 NTU
Total Suspended Sediment	4.0mg/L	2.0mg/L
Fecal Coliforms	130MPN/100mL	1.0MPN/100mL

5.0 Recommendations

No Action

Taking no action to remediate the conditions observed in Wappinger Lake can be considered. By taking no action sediment deposition will persist, along with increases in aquatic plants. One benefit to taking no action is avoiding the negative impacts of sediment removal, which include disruption the lake's natural ecosystem and threats to native flora and fauna. By taking no action on the present conditions of Wappinger Lake, the possible negative effects of dredging can be avoided, and no expenditures would be made. However, the lake will not return to its previous depths without sediment removal. This will continue to decrease the aesthetic and recreation qualities of the lake. If no action is taken Wappinger Lake will fill in with sediment and become a wetland.

Dredging

Dredging is one solution to remediate the conditions present in Wappinger Lake. This would eliminate invasive aquatic plants present in Wappinger Lake including water chestnut and Eurasian milfoil. Removal of the excess sediment resulting in lower nutrients and fecal coliforms will stop the eutrophication of the lake. Without sediment removal, eutrophication, plant growth, and blue-green algae blooms will continue.

The costs of dredging and removing the excess sediment are significant. Mechanical dredging of the lake to its pre-sedimentation depth of 17 feet would require removal of approximately 1,500,000 cubic yards of sediment. The most significant cost associated with this project is disposal of the sediment, which may be classified as hazardous because of its contaminants. Costs for hazardous waste disposal range from $180 to $530 per ton.

Dewatering & Sediment Removal

While taking depth soundings on the lake, many areas were found to be inaccessible for the manned boat due to shallow conditions. These areas would make dredging challenging. Lowering the lake level prior to sediment removal would eliminate the challenges of dredging in shallow areas. Sediment removal would then be possible via traditional excavation methods. Costs for dewatering and sediment removal are attached in Appendix A and were calculated to range from $165 to $384 million dollars.

It was assumed for cost estimation purposes that only the top 5 feet of sediment would contain hazardous contaminants. Cost for removal of sediment deeper than 5 foot was assumed to be eligible for traditional dumpsite disposal, however actual contaminates in the sediment will vary. Disposal costs also assumed coordination with the existing superfund site at the former bleachery in Wappingers Falls, where hazardous waste also needs to be removed. This reduced the mileage of travel involved with the hazardous waste hauling.

Recommendations

If no action is taken to remediate Wappinger Lake sediment and plant growth will continue and the area will develop increasingly wetland conditions. Of the remediation options, dewatering and sediment removal is more cost and time efficient. The principal obstacle to remediation is high cost of sediment disposal. A complete cost estimate for dewatering and sediment removal is shown in Appendix A.

Resources

New York State Department of Environmental Conservation. (2016*) 2016 section 303(d) list of impaired waters requiring a TMDL/ other strategy*. New York Department of Environmental Conservation, Albany, NY. September 2016

Ohio Environmental Protection Agency. (2001) Ohio EPA sediment sampling guide. Ohio Environmental Protection Agency, Lazzarys Government Center, Columbus, OH. November 2001.

Paggi, Martin and Del Bene LLP. (2009) *Wappinger Lake sedimentation study*. Prepared for the Village of Wappinger Falls. Paggi, Martin and Del Bene LLP, Poughkeepsie, NY. December 2009

United States Army Corps of Engineers. (1993) *Wappinger Lake Dutchess County, New York, Clean Lake Study.* United States Army Corps of Engineers, New York District, New York, NY. April 1993.

Appendix A
Cost Estimate

KC Engineering and Land Surveying, P.C.
2142 Route 302, Circleville, NY 10919
Ph (845) 361-4541 l Fax (845) 361-1045
E-mail: info@kcepc.com l Web: www.kcepc.com

COST ESTIMATE PREPARED FOR: Wappinger Lake Sediment Removal

Project Name: **4600-080 - Wappinger Lake**
Project Location: **Wappinger Falls**
Prepared By: **KSC**
Revision Date: **7/30/19**

Dewatering 17' Depth

Reference	Description	UNIT	Low Cost	High Cost	Quantity	Low Total	High Total
31 23 16.432100	Excavation	BCY	$0.70	$1.50	1,500,000	$1,050,000	$2,250,000
02 81 20.101220	Solid Hazardous Waste Hauling	MILE	$5.20	$9.30	426,000	$2,215,200	$3,961,800
02 81 20.106000	Dumpsite Disposal Hazardous	TON	$180.00	$530.00	384,000	$69,120,000	$203,520,000
31 23 23. 200450	Waste Hauling	LCY	$7.40	$10.00	947,000	$7,007,800	$9,470,000
02 56 13.100105	Dumpsite Disposal Non-Hazardous	TON	$60.00	$94.00	768,000	$46,080,000	$72,192,000
				Subtotal		$125,473,000	$291,393,800
	Contingency (10%)					$138,020,300	$320,533,180
						$165,624,360	**$384,639,816**

A location adjustment factor of 1.2 is assumed

Appendix B
Laboratory Results

Lab Results not included in Appendix. Contact KC Engineering & Land Surveying for complete records. #4600-080

Appendix M

Recommendations Summary Table

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.1 COLD SPRING CREEK SUBWATERSHED																																	
8.1 REC #1	8.1 COLD SPRING CREEK	TR-7	MILAN	Develop partnership with Dutchess County Planning to identify both government owned and non-government owned properties for the protection of buffer zones along the Creek. Also, consider incentivizing deed restrictions and easements for additional buffer zones.	Increasing the acreage of buffer zones throughout the watershed and along Wappinger Creek's headwaters and tributaries.	$$$	2 - 5	Identify parcels to protected land in the watershed.	6,992	30%	2,098	109,103	71	417	11	1887	1	1	X	X	X	X	X										
8.1 REC #1	8.1 COLD SPRING CREEK	TR-7	STANFORD	Develop partnership with Dutchess County Planning to identify both government owned and non-government owned properties for the protection of buffer zones along the Creek. Also, consider incentivizing deed restrictions and easements for additional buffer zones.	Increasing the acreage of buffer zones throughout the watershed and along Wappinger Creek's headwaters and tributaries.	$$$	2 - 5	Identify parcels to protected land in the watershed.	6,992	40%	2,797	145,471	95	556	11	2517	1	2	X	X	X	X	X										
8.1 REC #1	8.1 COLD SPRING CREEK	TR-7	PINE PLAINS	Develop partnership with Dutchess County Planning to identify both government owned and non-government owned properties for the protection of buffer zones along the Creek. Also, consider incentivizing deed restrictions and easements for additional buffer zones.	Increasing the acreage of buffer zones throughout the watershed and along Wappinger Creek's headwaters and tributaries.	$$$	2 - 5	Identify parcels to protected land in the watershed.	6,992	30%	2,098	109,103	71	417	11	1887	1	1	X	X	X	X	X										
8.1 Rec #2	8.1 COLD SPRING CREEK	TR-7	MILAN	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Reduce sediment, phosphorous, nitrate and fecal coliform loads from forested lands.	$	2	Add 1-2 management plans for selected forested areas.	6,992	30%	2,098				See Note 1									X									
8.1 Rec #2	8.1 COLD SPRING CREEK	TR-7	STANFORD	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Reduce sediment, phosphorous, nitrate and fecal coliform loads from forested lands.	$	2	Add 1-2 management plans for selected forested areas.	6,992	40%	2,797				See Note 1									X									
8.1 Rec #2	8.1 COLD SPRING CREEK	TR-7	PINE PLAINS	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Reduce sediment, phosphorous, nitrate and fecal coliform loads from forested lands.	$	2	Add 1-2 management plans for selected forested areas.	6,992	30%	2,098				See Note 1									X									
8.1 Rec #3	8.1 COLD SPRING CREEK	TR-7	MILAN	Promote wetlands protection.	Protect existing wetlands from future development.	$	1-2	Local municipality adopts legislation to protect wetlands.	6,992	30%	2,098				See Note 1																		
8.1 Rec #3	8.1 COLD SPRING CREEK	TR-7	STANFORD	Promote wetlands protection.	Protect existing wetlands from future development.	$	1-2	Local municipality adopts legislation to protect wetlands.	6,992	40%	2,797				See Note 1																		
8.1 Rec #3	8.1 COLD SPRING CREEK	TR-7	PINE PLAINS	Promote wetlands protection.	Protect existing wetlands from future development.	$	1-2	Local municipality adopts legislation to protect wetlands.	6,992	30%	2,098				See Note 1																		

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.1 Rec #4	8.1 COLD SPRING CREEK	TR-7	MILAN	Promote land conservation.	Increase conserved land in the watershed.	$$	1-2	Add 2 Dutchess County or municipally designated conservation areas in the watershed.	6,992	30%	2,098				See Note 1				X	X	X						X						
8.1 Rec #4	8.1 COLD SPRING CREEK	TR-7	STANFORD	Promote land conservation.	Increase conserved land in the watershed.	$$	1-2	Add 2 Dutchess County or municipally designated conservation areas in the watershed.	6,992	40%	2,797				See Note 1				X	X	X						X						
8.1 Rec #4	8.1 COLD SPRING CREEK	TR-7	PINE PLAINS	Promote land conservation.	Increase conserved land in the watershed.	$$	1-2	Add 2 Dutchess County or municipally designated conservation areas in the watershed.	6,992	30%	2,098				See Note 1				X	X	X						X						
8.1 Rec #5	8.1 COLD SPRING CREEK	TR-7	MILAN	Promote roadside ditch management programs with training.	Increase the number of roads for which roadside ditches are managed.	$	1-2	Add a targeted number of roads each year.	6,992	30%	2,098				See Note 1										X								X
8.1 Rec #5	8.1 COLD SPRING CREEK	TR-7	STANFORD	Promote roadside ditch management programs with training.	Increase the number of roads for which roadside ditches are managed.	$	1-2	Add a targeted number of roads each year.	6,992	40%	2,797				See Note 1										X								X
8.1 Rec #5	8.1 COLD SPRING CREEK	TR-7	PINE PLAINS	Promote roadside ditch management programs with training.	Increase the number of roads for which roadside ditches are managed.	$	1-2	Add a targeted number of roads each year.	6,992	30%	2,098				See Note 1										X								X
8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED																																
8.2 Rec #1	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Increase funding with recommended outcomes for the Dutchess County AEM program.	Reduce sediment, phosphorous, nitrate and fecal coliform loads from agricultural lands.	$	1-2	Add 10 agricultural landowners/year to partner with DC Soil & Water.	- Dutchess County Legislature, WQIP, LWRP, CDBG			2495464	4226	24538	5, 6	0	167	584			X	X				X							
8.2 Rec #2	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Agricultural landowners should continue to work with Dutchess County Soil and Water Conservation District to implement AEM program on farms in the subwatershed.	Identification of management practices that reduce phosphorus loads.	$$	1 (ongoing)	Reduce phosphorus loads in the creek by 5% in each year.	LWRP			2495464	4226	24538	8	0	50	54			X												
8.2 Rec #3	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Permits for the other facilities should be modified to include phosphorus monitoring. The non-POTW facilities should be encouraged to tie into the municipal sewer system, where available.	Have a creek wide monitoring of phosphorus to better understand where it is stemming from and the best way to deter more pollution.	$	1	More than 25% of municipalities monitoring phosphorus levels regularly.	DEC WQIP Dutchess County						See Note 3							X					X						X

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town
8.2 Rec #4	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Work with NYSDEC to develop TMDL for Wappinger Lake and/or implement BMPs to address impairment from sediment and phosphorus.	Remove groundwater sources of phosphorus from lake.	$$$$$	2 - 3	Reduce phosphoric pollutants in water that contribute to invasive species growth.	New projects would have to comply with lower phosphorous and sediment control infrastructure in their site plans.		
8.2 Rec #5	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Implement a surveying and testing program to document locations of septic systems and verify failing systems requiring replacement in accordance with the sanitary code.	Where appropriate, the proper infrastructure should be installed to connect failing septic systems to the municipal system.	$$$	3 - 5	Decommission outdated septics and get more properties onto municipal systems.	- EFC (WIA, IMG, 0% interest and state rate programs), WQIP, LWRP, CDBG, USDA Water & Sewer		
8.2 Rec #6	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Study streambanks and identify locations where riparian buffers and/or streambank stabilization is needed.	Increase knowledge of where water quality projects are needed.	$	2 - 3	Study 3 miles of creek or tributary streambanks per year starting in the second year.	- Dutchess County, MIG, EFC Engineering Grant		
8.2 Rec #7	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	ALL MUNICIPALITIES	Preserve and enhance riparian buffers for projects that provide public access to the Wappinger Creek.	Buffers deter pollutants and chemicals from running off into the creek. They also help with sediment retention.	$$	1 - 3	Implement vegetative buffers along the creek.	WQIP, CDBG		
8.2 Rec #8	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	FISHKILL	Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.	Move on from the century long methods of land use along the creek and acknowledge more contemporary and environmentally safer ways to develop infrastructure.	$$$	2 - 4	A developed and implemented marketing strategy for the watershed for use by partner agencies.	Cornell Cooperative Extension partnership, DC SOIL & WATER, DC MS-4, DC PLANNING, LOCAL PLANNING BOARDS		
8.2 Rec #8	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	PLEASANT VALLEY	Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.	Move on from the century long methods of land use along the creek and acknowledge more contemporary and environmentally safer ways to develop infrastructure.	$$$	2 - 4	A developed and implemented marketing strategy for the watershed for use by partner agencies.	Cornell Cooperative Extension partnership, DC SOIL & WATER, DC MS-4, DC PLANNING, LOCAL PLANNING BOARDS		
8.2 Rec #8	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	LAGRANGE	Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.	Move on from the century long methods of land use along the creek and acknowledge more contemporary and environmentally safer ways to develop infrastructure.	$$$	2 - 4	A developed and implemented marketing strategy for the watershed for use by partner agencies	Cornell Cooperative Extension partnership, DC SOIL & WATER, DC MS-4, DC PLANNING, LOCAL PLANNING BOARDS		

No.	Loads from all sources excluding point sources, septic systems and groundwater: Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Reduction in Pollutant by Recommended Management Practice: Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)
8.2 Rec #4							
8.2 Rec #5				See Note 2			
8.2 Rec #6	2495464	4226	24538	19, 27	198639	12	12
8.2 Rec #7	2,495,464	4,226	24,538	11, 23	83848	89	186
8.2 Rec #8 (FISHKILL)				See Note 1			
8.2 Rec #8 (PLEASANT VALLEY)	374320	634	3681	36	7299	3	6
8.2 Rec #8 (LAGRANGE)	199637	338	1963	36	3893	2	3

ELIGIBLE GRANT FUNDING

No.	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.2 Rec #4															
8.2 Rec #5			X	X				X		X	X				
8.2 Rec #6							X		X	X					
8.2 Rec #7				X				X							
8.2 Rec #8 (FISHKILL)												X	X	X	
8.2 Rec #8 (PLEASANT VALLEY)												X	X	X	
8.2 Rec #8 (LAGRANGE)												X	X	X	

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town
8.2 Rec #8	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	POUGHKEEPSIE	Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.	Move on from the century long methods of land use along the creek and acknowledge more contemporary and environmentally safer ways to develop infrastructure.	$$$	2 - 4	A developed and implemented marketing strategy for the watershed for use by partner agencies.	Cornell Cooperative Extension partnership, DC SOIL & WATER, DC MS-4, DC PLANNING, LOCAL PLANNING BOARDS		
8.2 Rec #8	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	WAPPINGER	Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.	Move on from the century long methods of land use along the creek and acknowledge more contemporary and environmentally safer ways to develop infrastructure.	$$$	2 - 4	A developed and implemented marketing strategy for the watershed for use by partner agencies.	Cornell Cooperative Extension partnership, DC SOIL & WATER, DC MS-4, DC PLANNING, LOCAL PLANNING BOARDS		
8.2 Rec #8	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	WAPPINGERS FALLS	Encourage commercial and industrial landowners in the southern portion of the subwatershed to incorporate Green Infrastructure and Low Impact Development into their renovations and planning initiatives.	Move on from the century long methods of land use along the creek and acknowledge more contemporary and environmentally safer ways to develop infrastructure.	$$$	2 - 4	A developed and implemented marketing strategy for the watershed for use by partner agencies.	Cornell Cooperative Extension partnership, DC SOIL & WATER, DC MS-4, DC PLANNING, LOCAL PLANNING BOARDS		
8.2 Rec #9	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	WAPPINGERS FALLS	Stage removal of sediment from Wappingers Lake and mix with biochar.	Evaluate removal of nutrients, phosphorus, and contaminants in sediment.	$$$	1-2				
8.2 Rec #10	8.2 DIRECT DRAINAGE TO WAPPINGER CREEK SUBWATERSHED	MS	WAPPINGERS FALLS	Evaluate a pilot project membrane bioreactor (MBR) sewage treatment plant.	Evaluate MBR treatment process for implementation at other treatment plants in the watershed.	$	1-2				
				8.3 DUTCHESS COUNTY AIRPORT SUBWATERSHED							
8.3 Rec #1	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Retrofit developed land with stormwater detention / retention ponds.	Reduce runoff into the creek that contributes pollutants and sedimentation.	$$	1-3	Treat 1% of developed area using retention pond(s).	- DC MIG		
8.3 Rec #1	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Retrofit developed land with stormwater detention / retention ponds.	Reduce runoff into the creek that contributes pollutants and sedimentation.	$$	1-3	Treat 1% of developed area using retention pond(s).	- DC MIG		
8.3 Rec #2	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Attempt Natural Conveyance Restoration wherever possible.	Reduce runoff into the creek that contributes pollutants and sedimentation.	$$	1-3	Restore one natural conveyance per year.	- GIGP - EFC - WQIP - DC MIG - LWRP - CDBG		

No.	Town	Loads from all sources excluding point sources, septic systems and groundwater: Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Reduction in Pollutant by Recommended Management Practice: Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)
8.2 Rec #8	POUGHKEEPSIE	374320	634	3681	36	7299	3	6
8.2 Rec #8	WAPPINGER	99819	169	982	36	1946	1	2
8.2 Rec #8	WAPPINGERS FALLS	24955	42	245	36	487	0	0
8.2 Rec #9	WAPPINGERS FALLS	24955	42	245				
8.2 Rec #10	WAPPINGERS FALLS	24955	42	245				
8.3 Rec #1	LAGRANGE	110556	143	1110	31	210	0	0
8.3 Rec #1	WAPPINGER	331667	428	3330	31	630	0	0
8.3 Rec #2	LAGRANGE	110556	143	1110	See Note 1			

No.	Town	ELIGIBLE GRANT FUNDING: Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.2 Rec #8	POUGHKEEPSIE												X	X	X	
8.2 Rec #8	WAPPINGER												X	X	X	
8.2 Rec #8	WAPPINGERS FALLS												X	X	X	
8.2 Rec #9	WAPPINGERS FALLS															
8.2 Rec #10	WAPPINGERS FALLS															
8.3 Rec #1	LAGRANGE							X								
8.3 Rec #1	WAPPINGER							X								
8.3 Rec #2	LAGRANGE			X	X	X		X	X		X					

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.3 Rec #2	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Attempt Natural Conveyance Restoration wherever possible.	Reduce runoff into the creek that contributes pollutants and sedimentation.	$$	1-3	Restore one natural conveyance per year.	- GIGP - EFC - WQIP - DC MIG - LWRP - CDBG			331667	428	3330	See Note 1						X	X	X		X	X		X					
8.3 Rec #3	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Promote and educate about lawn care practices to residential property owners.	Encourage safer and more environmentally friendly lawn care to reduce pesticide runoff into creek.	$	1-2	Education event on lawn care practices at public event.	- CCEDC -WIC -DC			110556	143	1110	See Note 2									X			X						
8.3 Rec #3	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Promote and educate about lawn care practices to residential property owners.	Encourage safer and more environmentally friendly lawn care to reduce pesticide runoff into creek.	$	1-2	Education event on lawn care practices at public event.	- CCEDC -WIC -DC			331667	428	3330	See Note 2									X			X						
8.3 Rec #4	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Amend the two SPDES facilities in the subwatershed to monitor phosphorus.	Provide more in depth analysis on phosphorus emissions to find better reduction methods.	$$	1-2	Two SPDES facilities to monitor phosphorus.	EFC ENGINEERING GRANT						See Note 3													X					
8.3 Rec #5	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Study streambanks and identify locations where streambank stabilization is needed.	Reduce sediment displacement along the creek.	$$	1-2	Stabilize Agricultural and Non-Agricultural streambanks.	-GIGP -CDBG			110556	143	1110	19, 27	8800	5	1					X			X							
8.3 Rec #5	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Study streambanks and identify locations where streambank stabilization is needed.	Reduce sediment displacement along the creek.	$$	1-2	Stabilize Agricultural and Non-Agricultural streambanks.	-GIGP -CDBG			331667	428	3330	19, 27	26400	16	1					X			X							
8.3 Rec #6	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Purchase Green Pond so that it can be improved as a water filtration system.	Green Pond becomes a viable water filtration system.	$	1	Purchased by 2021.	-Dutchess Land Conservancy -Dutchess County Open Space -GIGP -WQIP -EFC						See Note 1				X	X		X	X					X					
8.3 Rec #7	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Restore Green Pond so that it can be more effective at treating water quality from its outfalls.	Green Pond becomes a viable water filtration system.	$$	1-3	Pond restored by 2023/24.	-GIGP -WQIP -EFC						See Note 1							X	X					X					
8.3 Rec #8	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Consider retrofit project like biochar where the outfalls into Green Pond are located.	Reduce pollution in sediment.	$	1	Study of efficacy of biochar for tributaries completed.	-Dutchess County MIG -EFC ENGINEERING GRANT						See Note 1										X			X					
8.3 Rec #9	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Encourage engineered septic system installations and/or connection to municipal sewer.	Decommission outdated septic systems that pose a threat to the creek.	$$$	2-4	Decommission 10 septic systems and attached them to municipal sewer.	-CDBG -EFC -WQIP						See Note 2							X				X		X					
8.3 Rec #9	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Encourage engineered septic system installations and/or connection to municipal sewer.	Decommission outdated septic systems that pose a threat to the creek.	$$$	2-4	Decommission 10 septic systems and attached them to municipal sewer.	-CDBG -EFC -WQIP						See Note 2							X				X		X					

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town
8.3 Rec #10	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Install phosphorus removal in WWTF's.	Remove phosphorus from the creek.	$$$	3-5	Reduce phosphorus levels in the creek by 5% by 2024.	-WQIP -USDA WATER		
8.3 Rec #10	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Install phosphorus removal in WWTF's.	Remove phosphorus from the creek.	$$$	3-5	Reduce phosphorus levels in the creek by 5% by 2024.	-WQIP -USDA WATER		
8.3 Rec #11	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	LAGRANGE	Consider consolidation of WWTF's with larger better maintained systems.	Condense water treatment facilities along the watershed to better maintain and reduce emissions into creek.	$$$$	3-5	Decrease phosphorous from the 5 largest WWTF's upstream or consolidate them with facilities which have phosphorous reduction infrastructure.	-WQIP -EFC -DOS LGE -LWRP		
8.3 Rec #11	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Consider consolidation of WWTF's with larger better maintained systems.	Condense water treatment facilities along the watershed to better maintain and reduce emissions into creek.	$$$$	3-5	Decrease phosphorous from the 5 largest WWTF's upstream or consolidate them with facilities which have phosphorous reduction infrastructure.	-WQIP -EFC -DOS LGE -LWRP		
8.3 Rec #12	8.3 DUTCHESS AIRPORT SUBWATERSHED	TR-1	WAPPINGER	Place biochar at the base of the Green Pond Dam.	Evaluate Biochar's performance for removing nutrients and phosphorus from Wappingers Creek tributaries.	$$$	1-2				
8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED											
8.4 Rec #1	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	WASHINGTON	Identify the farms that would be candidates for conservation easements.	Reduce agricultural runoff and livestock excrement from entering watershed.	$	1	Identify 5 farms or 250 acres.	- Dutchess County Planning - Dutchess County Soil and Water		
8.4 Rec #1	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	PLEASANT VALLEY	Identify the farms that would be candidates for conservation easements.	Reduce agricultural runoff and livestock excrement from entering watershed.	$	1	Identify 5 farms or 250 acres.	- Dutchess County Planning - Dutchess County Soil and Water		
8.4 Rec #2	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	WASHINGTON	Identify the farms that would be candidates for conversion of cropland to hay.	Reduce agricultural runoff.	$	1	Identify 2 farms or 100 acres.	-Dutchess County Planning -Dutchess County Soil and Water		
8.4 Rec #2	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	PLEASANT VALLEY	Identify the farms that would be candidates for conversion of cropland to hay.	Reduce agricultural runoff.	$	1	Identify 2 farms or 100 acres.	-Dutchess County Planning -Dutchess County Soil and Water		

No.	Loads from all sources excluding point sources, septic systems and groundwater: Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Reduction in Pollutant by Recommended Management Practice: Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)
8.3 Rec #10				See Note 1			
8.3 Rec #10				See Note 1			
8.3 Rec #11				See Note 3			
8.3 Rec #11				See Note 3			
8.3 Rec #12							
8.4 Rec #1	1445049	3054	14325	4	13005	4	1
8.4 Rec #1	144505	339	1592	4	1445	0	0
8.4 Rec #2	1445049	3054	14325	See Note 1			
8.4 Rec #2	144505	339	1592	See Note 1			

No.	ELIGIBLE GRANT FUNDING: Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.3 Rec #10				X							X				
8.3 Rec #10				X							X				
8.3 Rec #11			X	X						X					
8.3 Rec #11			X	X						X					
8.3 Rec #12															
8.4 Rec #1	X	X													
8.4 Rec #1	X	X													
8.4 Rec #2	X	X													
8.4 Rec #2	X	X													

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater: Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Reduction in Pollutant by Recommended Management Practice: Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	ELIGIBLE GRANT FUNDING: Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.4 Rec #3	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	WASHINGTON	Develop a Comprehensive Nutrient Management Plan (CMP) for farms with phosphorous indexing.	Identify phosphorus focal points and develop plan for reduction.	$	2	Completion of plan.	Dutchess County Soil and Water			1445049	3054	14325	5, 6	0	120	341		X													
8.4 Rec #3	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	PLEASANT VALLEY	Develop a Comprehensive Nutrient Management Plan (CMP) for farms with phosphorous indexing.	Identify phosphorus focal points and develop plan for reduction.	$	2	Completion of plan.	Dutchess County Soil and Water			144505	339	1592	5, 6	0	13	38		X													
8.4 Rec #4	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	WASHINGTON	Encourage farmers to implement BMP's that focus on manure storage facilities, pasture practices, stream bank stabilization projects and calf facilities.	Reduce agricultural runoff and livestock excrement from entering watershed.	$	1-2	5 farms or 250 acres of farms implement BMP's for manure storage facilities, etc.	Dutchess County Soil and Water			1445049	3054	14325	7, 8, 15, 19	103263	86	92		X													
8.4 Rec #4	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	PLEASANT VALLEY	Encourage farmers to implement BMP's that focus on manure storage facilities, pasture practices, stream bank stabilization projects and calf facilities.	Reduce agricultural runoff and livestock excrement from entering watershed.	$	1-2	5 farms or 250 acres of farms implement BMP's for manure storage facilities, etc.	Dutchess County Soil and Water			144505	339	1592	7, 8, 15, 19	11474	9	11		X		X											
8.4 Rec #7	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	WASHINGTON	Work with NYSDEC to complete assessments of Unassessed streams.	Further analyze pollutant levels and better identify point sources.	$	1-3	Complete assessment.	DEC			1445049	3054	14325																			X
8.4 Rec #7	8.4 EAST BRANCH WAPPINGER CREEK SUBWATERSHED	TR-5	PLEASANT VALLEY	Work with NYSDEC to complete assessments of Unassessed streams.	Further analyze pollutant levels and better identify point sources.	$	1-3	Complete assessment.	DEC			144505	339	1592																			X
8.5 GREAT SPRING CREEK SUBWATERSHED																																	
8.5 Rec #1	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Encourage the creation of sewer districts for towns where there are no public WWTF's.	Consolidate sewage flow along the creek for better monitoring and maintenance.	$$$$	3-5	Create 2 new sewer districts where septic is primarily used.	- Municipalities -DC Water -EFC -WQIP						See Note 3							X						X				X	
8.5 Rec #1	8.5 GREAT SPRING CREEK SUBWATERSHED		CLINTON	Encourage the creation of sewer districts for towns where there are no public WWTF's.	Consolidate sewage flow along the creek for better monitoring and maintenance.	$$$$	3-5	Create 2 new sewer districts where septic is primarily used.	- Municipalities -DC Water -EFC -WQIP						See Note 3							X						X				X	
8.5 Rec #1	8.5 GREAT SPRING CREEK SUBWATERSHED		HYDE PARK	Encourage the creation of sewer districts for towns where there are no public WWTF's.	Consolidate sewage flow along the creek for better monitoring and maintenance.	$$$$	3-5	Create 2 new sewer districts where septic is primarily used.	- Municipalities -DC Water -EFC -WQIP						See Note 3							X						X				X	
8.5 Rec #1	8.5 GREAT SPRING CREEK SUBWATERSHED		POUGHKEEPSIE	Encourage the creation of sewer districts for towns where there are no public WWTF's.	Consolidate sewage flow along the creek for better monitoring and maintenance.	$$$$	3-5	Create 2 new sewer districts where septic is primarily used.	- Municipalities -DC Water -EFC -WQIP						See Note 3							X						X				X	
8.5 Rec #2	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Encourage engineered septic systems for private residences for both new construction as well as the replacement of aging systems.	Update septic systems to meet current standards and reduce fecal coliform emissions.	$$	4-6	Update 1,000 septic systems.	-WQIP -Municipalities -County Legislation						See Note 2							X						X				X	
8.5 Rec #2	8.5 GREAT SPRING CREEK SUBWATERSHED		CLINTON	Encourage engineered septic systems for private residences for both new construction as well as the replacement of aging systems.	Update septic systems to meet current standards and reduce fecal coliform emissions.	$$	4-6	Update 1,000 septic systems.	-WQIP -Municipalities -County Legislation						See Note 2							X						X				X	

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.5 Rec #2	8.5 GREAT SPRING CREEK SUBWATERSHED		HYDE PARK	Encourage engineered septic systems for private residences for both new construction as well as the replacement of aging systems.	Update septic systems to meet current standards and reduce fecal coliform emissions.	$$	4-6	Update 1,000 septic systems.	-WQIP -Municipalities -County Legislation						See Note 2							X						X				X	
8.5 Rec #2	8.5 GREAT SPRING CREEK SUBWATERSHED		POUGHKEEPSIE	Encourage engineered septic systems for private residences for both new construction as well as the replacement of aging systems.	Update septic systems to meet current standards and reduce fecal coliform emissions.	$$	4-6	Update 1,000 septic systems.	-WQIP -Municipalities -County Legislation						See Note 2							X						X				X	
8.5 Rec #3	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Work with Dutchess County Soil & Water to enact BMP's including crop covers, vegetative filter strips, no till crops and Comprehensive Nutrient Plans.	Reduce agricultural runoff and encourage safer farming activities along the watershed.	$	1-3	Identify farms where BMP's would be best used, educate them and get them to enact the use of the BMP's.	-Dutchess County Soil & Water -Cornell Coopertive Extension -DEC -EFC			546089	983	4834	1, 2, 3, 5, 6	12014, 10266, 5843, 0, 0	6, 3, 1, 10, 29	4, 1, 1, 100, 15										X		X		X	X
8.5 Rec #3	8.5 GREAT SPRING CREEK SUBWATERSHED		CLINTON	Work with Dutchess County Soil & Water to enact BMP's including crop covers, vegetative filter strips, no till crops and Comprehensive Nutrient Plans.	Reduce agricultural runoff and encourage safer farming activities along the watershed.	$	1-3	Identify farms where BMP's would be best used, educate them and get them to enact the use of the BMP's.	-Dutchess County Soil & Water -Cornell Coopertive Extension -DEC -EFC			119534	215	1058	1, 2, 3, 5, 6	2630, 2247, 1279, 0, 0	1, 1, 0, 2, 6	1, 0, 0, 22, 3										X		X		X	X
8.5 Rec #3	8.5 GREAT SPRING CREEK SUBWATERSHED		HYDE PARK	Work with Dutchess County Soil & Water to enact BMP's including crop covers, vegetative filter strips, no till crops and Comprehensive Nutrient Plans.	Reduce agricultural runoff and encourage safer farming activities along the watershed.	$	1-3	Identify farms where BMP's would be best used, educate them and get them to enact the use of the BMP's.	-Dutchess County Soil & Water -Cornell Coopertive Extension -DEC -EFC			123627	223	1094	1, 2, 3, 5, 6	2720, 2324, 1323, 0, 0	1, 1, 0, 2, 7	1, 0, 0, 23, 3										X		X		X	X
8.5 Rec #3	8.5 GREAT SPRING CREEK SUBWATERSHED		POUGHKEEPSIE	Work with Dutchess County Soil & Water to enact BMP's including crop covers, vegetative filter strips, no till crops and Comprehensive Nutrient Plans.	Reduce agricultural runoff and encourage safer farming activities along the watershed.	$	1-3	Identify farms where BMP's would be best used, educate them and get them to enact the use of the BMP's.	-Dutchess County Soil & Water -Cornell Coopertive Extension -DEC -EFC			29474	53	261	1, 2, 3, 5, 6	648, 554, 315, 0, 0	0, 0, 0, 1, 2	0, 0, 0, 5, 1										X		X		X	X
8.5 Rec #4	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	Reduce fecal coliform emissions into the watershed by protecting stream bank property areas from livestock access.	$$$	3	Implement vegetative buffers along the creek, using purchase, easements, deed restrictions.	- GIGP -LWRP -Dutchess County Open Space -Dutchess County Land Conservancy			546089	983	4834	11	9447	10	16	X	X	X		X										
8.5 Rec #4	8.5 GREAT SPRING CREEK SUBWATERSHED		CLINTON	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	Reduce fecal coliform emissions into the watershed by protecting stream bank property areas from livestock access.	$$$	3	Implement vegetative buffers along the creek, using purchase, easements, deed restrictions.	- GIGP -LWRP -Dutchess County Open Space -Dutchess County Land Conservancy			119534	215	1058	11	2068	2	4	X	X	X		X										
8.5 Rec #4	8.5 GREAT SPRING CREEK SUBWATERSHED		HYDE PARK	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	Reduce fecal coliform emissions into the watershed by protecting stream bank property areas from livestock access.	$$$	3	Implement vegetative buffers along the creek, using purchase, easements, deed restrictions.	- GIGP -LWRP -Dutchess County Open Space -Dutchess County Land Conservancy			123627	223	1094	11	2139	2	4	X	X	X		X										

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater: Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Reduction in Pollutant by Recommended Management Practice: Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	ELIGIBLE GRANT FUNDING: Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.5 Rec #4	8.5 GREAT SPRING CREEK SUBWATERSHED		POUGHKEEPSIE	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	Reduce fecal coliform emissions into the watershed by protecting stream bank property areas from livestock access.	$$$	3	Implement vegetative buffers along the creek, using purchase, easements, deed restrictions.	- GIGP -LWRP -Dutchess County Open Space -Dutchess County Land Conservancy			29474	53	261	11	510	1	1	X	X	X		X										
8.5 Rec #5	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Install phosphorus reduction infrastructure in Brookside Meadows WWTF.	Reduce phosphorus levels in the watershed and promote environmentally better practices.	$$$$$	3	Show signs of reduction in subwatershed within 3 years.	- GIGP -WQIP -EFC -LWRP						See Note 1						X	X	X					X					
8.5 Rec #6	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Amend the SPDES permit for Brookside Meadows WWTF to Incorporate phosphorus monitoring and a phosphorous permit limit.	Allow better monitoring and maintenance to Brookside Meadows to better calculate how to reduce phosphorus levels.	$	1	Establish phosphorus monitoring within the year.	DEC						See Note 3																		X
8.5 Rec #7	8.5 GREAT SPRING CREEK SUBWATERSHED		PLEASANT VALLEY	Work with municipalities and creekfront landowners to install streambank projects.	Install more creekfront projects to reduce phosphorus, fecal coliform and other agricultural and roadside pollutants.	$$$	3	Install six new stream bank projects in the next three years.	- WQIP -DEC HREP -LWRP -CDBG			546089	983	4834	27	35769	2	2			X	X				X							X
8.5 Rec #7	8.5 GREAT SPRING CREEK SUBWATERSHED		CLINTON	Work with municipalities and creekfront landowners to install streambank projects.	Install more creekfront projects to reduce phosphorus, fecal coliform and other agricultural and roadside pollutants.	$$$	3	Install six new stream bank projects in the next three years.	- WQIP -DEC HREP -LWRP -CDBG			119534	215	1058	27	7829	1	0			X	X				X							X
8.5 Rec #7	8.5 GREAT SPRING CREEK SUBWATERSHED		HYDE PARK	Work with municipalities and creekfront landowners to install streambank projects.	Install more creekfront projects to reduce phosphorus, fecal coliform and other agricultural and roadside pollutants.	$$$	3	Install six new stream bank projects in the next three years.	- WQIP -DEC HREP -LWRP -CDBG			123627	223	1094	27	8098	1	0			X	X				X							X
8.5 Rec #7	8.5 GREAT SPRING CREEK SUBWATERSHED		Poughkeepsie	Work with municipalities and creekfront landowners to install streambank projects.	Install more creekfront projects to reduce phosphorus, fecal coliform and other agricultural and roadside pollutants.	$$$	3	Install six new stream bank projects in the next three years.	- WQIP -DEC HREP -LWRP -CDBG			29474	53	261	27	1931	0	0			X	X				X							X
				8.6 GRIST MILL CREEK SUBWATERSHED																													
8.6 #1	8.6 GRIST MILL CREEK SUBWATERSHED		STANFORD	Promote and implement wetlands protection, land conservation and roadside ditch management programs.	Create buffers between used land and roads, and the watershed in order to reduce pollution and sediment runoff.	$$$	1-3	Dedicate land to conservation environmental conservation. Create vegetative buffers along the roadside.	-GIGP -WQIP -EFC -CDBG						See Note 1						X		X			X		X					
				8.7 HUNNS LAKE CREEK SUBWATERSHED																													
8.7 Rec #1	8.7 HUNNS LAKE SUBWATERSHED		STANFORD	Promote and implement land conservation / protection.	Counteract century long pollution with better understanding of the environment.	$$	2	Dedicate land to conservation environmental conservation.	- GIGP -WQIP -EFC -CDBG						See Note 1						X		X			X		X					
8.7 Rec #2	8.7 HUNNS LAKE SUBWATERSHED		STANFORD	Promote and implement roadside ditch management.	Reduce runoff from road into watershed.	$$	1-3	Create vegetative buffers along the roadside.	- CDBG -Dutchess County MIG						See Note 1										X	X							

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.7 Rec #3	8.7 HUNNS LAKE SUBWATERSHED		STANFORD	Reduce access of livestock to streams and stream banks vulnerable to erosion.	Reduce sedimentation and fecal coliform emissions from entering watersheds.	$$	3	Implement fencing to prevent livestock entering the creek.	- CDBG -GIGP -EFC			306882	699	3220	15, 23	6782	10	16					X			X		X					
8.7 Rec #4	8.7 HUNNS LAKE SUBWATERSHED		PINE PLAINS	Replace a weir in Twin Islands Lake and place biochar along the replacement weir.	Improve water quality and remove nutrients and phosphorus for a Wappingers Creek tributary.	$$$	1-2					306882	699	3220	15, 23	6782	10	16					X			X		X					
8.8 LITTLE WAPPINGER CREEK SUBWATERSHED																																	
8.8 Rec #1	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		MILAN	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Enhance sediment retention in forested areas.	$	1-3	Enact sustainable forestry practices in 100 acres.	- DEC HREP -GIGP -WQIP -EFC Engineering						See Note 1							X	X					X					X
8.8 Rec #1	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		STANFORD	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Enhance sediment retention in forested areas.	$	1-3	Enact sustainable forestry practices in 100 acres.	- DEC HREP -GIGP -WQIP -EFC Engineering						See Note 1							X	X					X					X
8.8 Rec #1	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		CLINTON	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Enhance sediment retention in forested areas.	$	1-3	Enact sustainable forestry practices in 100 acres.	- DEC HREP -GIGP -WQIP -EFC Engineering						See Note 1							X	X					X					X
8.8 Rec #1	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		PLEASANT VALLEY	Promote sustainable forestry practices that support water quality and sustainable economic principles, as well as reducing forest fragmentation for managed forests.	Enhance sediment retention in forested areas.	$	1-3	Enact sustainable forestry practices in 100 acres	- DEC HREP -GIGP -WQIP -EFC Engineering						See Note 1							X	X					X					X
8.8 Rec #2	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		MILAN	Work with residential homeowners to identify improperly functioning septic systems and develop procedures to have systems inspected, cleaned, and repaired or upgraded.	Reduce fecal coliform and phosphorus emissions by developing up-to-date septic systems with improved maintenance.	$$$$	1-4	Decommission or upgrade 200 septic tanks and use water treatment facilities within 3 years.	-Dutchess County MIG -NYSERDA						See Note 2										X								
8.8 Rec #2	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		STANFORD	Work with residential homeowners to identify improperly functioning septic systems and develop procedures to have systems inspected, cleaned, and repaired or upgraded.	Reduce fecal coliform and phosphorus emissions by developing up-to-date septic systems with improved maintenance.	$$$$	1-4	Decommission or upgrade 200 septic tanks and use water treatment facilities within 3 years.	-Dutchess County MIG -NYSERDA						See Ntoe 2										X								
8.8 Rec #2	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		CLINTON	Work with residential homeowners to identify improperly functioning septic systems and develop procedures to have systems inspected, cleaned, and repaired or upgraded.	Reduce fecal coliform and phosphorus emissions by developing up-to-date septic systems with improved maintenance.	$$$$	1-4	Decommission or upgrade 200 septic tanks and use water treatment facilities within 3 years.	-Dutchess County MIG -NYSERDA						See Note 2										X								
8.8 Rec #2	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		PLEASANT VALLEY	Work with residential homeowners to identify improperly functioning septic systems and develop procedures to have systems inspected, cleaned, and repaired or upgraded.	Reduce fecal coliform and phosphorus emissions by developing up-to-date septic systems with improved maintenance.	$$$$	1-4	Decommission or upgrade 200 septic tanks and use water treatment facilities within 3 years.	-Dutchess County MIG -NYSERDA						See Note 2										X								

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.8 rec #3	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		MILAN	Encourage farmers to implement BMPs that focus on land application of manure, manure collection, handling and storage.	Reduce fecal coliform levels in the creek and deter further contaminants from entering the creek.	$$	3	Deter 95% of manure from entering the lake by 2023.	-Dutchess County Legislation to increase funding to DC Soil & Water and CCE -DEC HREP -EFC Engineering			399698	597	2977	10	0	21	20														X	
8.8 rec #3	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		STANFORD	Encourage farmers to implement BMPs that focus on land application of manure, manure collection, handling and storage.	Reduce fecal coliform levels in the creek and deter further contaminants from entering the creek.	$$	3	Deter 95% of manure from entering the lake by 2023.	-Dutchess County Legislation to increase funding to DC Soil & Water and CCE -DEC HREP -EFC Engineering			81571	122	608	10	0	4	4														X	
8.8 rec #3	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		CLINTON	Encourage farmers to implement BMPs that focus on land application of manure, manure collection, handling and storage.	Reduce fecal coliform levels in the creek and deter further contaminants from entering the creek.	$$	3	Deter 95% of manure from entering the lake by 2023.	-Dutchess County Legislation to increase funding to DC Soil & Water and CCE -DEC HREP -EFC Engineering			654899	978	4878	10	0	35	33														X	
8.8 rec #3	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		PLEASANT VALLEY	Encourage farmers to implement BMPs that focus on land application of manure, manure collection, handling and storage.	Reduce fecal coliform levels in the creek and deter further contaminants from entering the creek.	$$	3	Deter 95% of manure from entering the lake by 2023.	-Dutchess County Legislation to increase funding to DC Soil & Water and CCE -DEC HREP -EFC Engineering			29133	44	217	10	0	2	1														X	
8.8 Rec #4	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		MILAN	Study streambanks and identify locations where riparian buffers and/or streambank stabilization is needed.	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	$$$	3	Implement vegetative buffers along the creek.	- GIGP - NYS LWRP - Dutchess County Open Space - Dutchess County Land Conservancy			399698	597	2977	11	6915	6	10	X	X	X		X										
8.8 Rec #4	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		STANFORD	Study streambanks and identify locations where riparian buffers and/or streambank stabilization is needed.	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	$$$	3	Implement vegetative buffers along the creek.	- GIGP - NYS LWRP - Dutchess County Open Space - Dutchess County Land Conservancy			81571	122	608	11	1411	1	2	X	X	X		X										
8.8 Rec #4	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		CLINTON	Study streambanks and identify locations where riparian buffers and/or streambank stabilization is needed.	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	$$$	3	Implement vegetative buffers along the creek.	- GIGP - NYS LWRP - Dutchess County Open Space - Dutchess County Land Conservancy			654899	978	4878	11	11330	10	17	X	X	X		X										
8.8 Rec #4	8.8 LITTLE WAPPINGERS CREEK SUBWATERSHED		PLEASANT VALLEY	Study streambanks and identify locations where riparian buffers and/or streambank stabilization is needed	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	$$$	3	Implement vegetative buffers along the creek.	- GIGP - NYS LWRP - Dutchess County Open Space - Dutchess County Land Conservancy			29133	44	217	11	504	0	1	X	X	X		X										
8.9 OVERLOOK ROAD SUBWATERSHED																																	

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.9 Rec #1	8.9 OVERLOOK ROAD SUBWATERSHED		LAGRANGE	Incorporate effective stormwater BMPs into new construction and existing development.	Potential BMPs should include rain gardens, down spout disconnects, permeable pavement, infiltration basins, detention ponds, rain barrels and cisterns, trees and tree boxes, and green roofs.	$	1-4	Enact new standards to establish all new stormwater BMP construction in new developments immediately.	Dutchess County legislation						See Note 1												X						
8.9 Rec #2	8.9 OVERLOOK ROAD SUBWATERSHED		LAGRANGE	Educate the public regarding lawn care, cleaning up pet waste and management.	Promote more eco-friendly methods of property maintenance.	$	1-4	Hold educational seminars in half of the municipalities and videos shown in all of the municipalities within the next year.	-DEC -Cornell Coopertive Extension -DC MS-4 Committee						See Note 2															X	X		X
Rec #3	8.9 OVERLOOK ROAD SUBWATERSHED		LAGRANGE	Stormwater Management Plans need to be reviewed and enforced.	Be better prepared for stormwater management as torrential rains become more apparent.			Update stormwater management plan.							See Note 2																		
Rec #4	8.9 OVERLOOK ROAD SUBWATERSHED		LAGRANGE	Deep and authentic analysis of Shady Brook home park to identify sources of vulnerability.	Develop equitable strategies that are realistic and effective to prevent damage to the vulnerable home park before it occurs.			Engage and analyze the sources of vulnerability.							See Note 1																		
8.10 PLEASANT VALLEY EAST WATERSHED																																	
8.10 Rec #1	8.10 PLEASANT VALLEY EAST SUBWATERSHED		PLEASANT VALLEY, CLINTON, LAGRANGE	Amend the SPDES permit for the Valley Dale sewage treatment plant to incorporate phosphorus monitoring.	Allow better monitoring and maintenance to Valley Dale to better calculate how to reduce phosphorus levels.	$	1-2	Have facility in the watershed monitoring phosphorus within 2 years.	DEC						See Note 3																		X
8.10 Rec #2			PLEASANT VALLEY, CLINTON, LAGRANGE	Property owners should be educated on proper maintenance of their septic systems and encouraged to make preventative repairs.	Educated property owners to further promote safer practices with septic and sewer systems creek wide.	$	1-4	Hold educational seminars in half of the municipalities and videos shown in all of the municipalities within the next year.	-DEC -Cornell Coopertive Extension						See Note 2															X			X
8.11 UPTON LAKE CREEK SUBWATERSHED																																	
8.11 Rec #1	8.11 UPTON LAKE CREEK SUBWATERSHED		CLINTON	Work with landowners to reduce pollution from on-site septic systems and encourage the use of alternative / innovative wastewater treatment systems.	Incorporate cluster/community based septic systems, sand filters, constructed wetlands, or composting toilets to reduce on-site septic pollution.	$$$	2-4	Decommission 200 septic tanks and use water treatment facilities within 3 years.	-EFC Engineering -DEC -NYSERDA						See Note 2																		
8.11 Rec #1	8.11 UPTON LAKE CREEK SUBWATERSHED		STANFORD	Work with landowners to reduce pollution from on-site septic systems and encourage the use of alternative / innovative wastewater treatment systems.	Incorporate cluster / community based septic systems, sand filters, constructed wetlands, or composting toilets to reduce on-site septic pollution.	$$$	1-4	Decommission 200 septic tanks and use water treatment facilities within 3 years.	-EFC Engineering -DEC -NYSERDA						See Note 2													X					X

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town	Loads from all sources excluding point sources, septic systems and groundwater			Reduction in Pollutant by Recommended Management Practice				ELIGIBLE GRANT FUNDING														
												Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)	Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
8.11 Rec #1	8.11 UPTON LAKE CREEK SUBWATERSHED		WASHINGTON	Work with landowners to reduce pollution from on-site septic systems and encourage the use of alternative / innovative wastewater treatment systems.	Incorporate cluster / community based septic systems, sand filters, constructed wetlands, or composting toilets to reduce on-site septic pollution.	$$$	1-4	Decommission 200 septic tanks and use water treatment facilities within 3 years.	-EFC Engineering -DEC -NYSERDA						See Note 2													X					X
8.12 WAPPINGERS FALLS SUBWATERSHED																																	
8.12 Rec #1	8.12 WAPPINGERS FALLS SUBWATERSHED		WAPPINGERS FALLS	Retrofit existing properties with new facilities, such as stormwater detention/retention ponds; also attempt natural conveyance restoration wherever possible.	Update facilities to be better equipped for modern day weather and contamination issues.	$$$	1-4	Increase I/I at facilities by 90% within 3 years.	GIGP, WQIP, EFC, CDBG, DC MIG						See Note 1							X	X		X	X		X					
8.12 Rec #2	8.12 WAPPINGERS FALLS SUBWATERSHED		WAPPINGERS FALLS	Promote lawn care practices and educate residential and property owners about using phosphorus-free products, cleaning up pet waste.	Lower phosphorus levels by promoting better lawn care methods to creekside property owners.	$	1-4	Hold educational seminars in half of the municipalities and videos shown in all of the municipalities within the next year.	-DEC -CCEDC						See Note 2									X									X
8.12 Rec #3	8.12 WAPPINGERS FALLS SUBWATERSHED		WAPPINGERS FALLS	Amend the permits for the two SPDES facilities in the subwatershed to monitor phosphorus and establish phosphorus permit limits.	Allow better monitoring and maintenance to better calculate how to reduce phosphorus levels.	$	1-3	Have both facilities in the watershed monitoring phosphorus within 2 years.	DEC						See Note 3																		X
Rec #4	8.12 WAPPINGERS FALLS SUBWATERSHED		WAPPINGERS FALLS	Stormwater Management Plans need to be reviewed and enforced.	Be better prepared for stormwater management as torrential rains become more apparent.			Update Stormwater management plan.							See Note 2																		
8.13 WILLOW BROOK SUBWATERSHED																																	
8.13 Rec #1	8.13 WILLOW BROOK SUBWATERSHED		STANFORD	Study streambanks and identify locations where riparian buffers and/or streambank stabilization is needed.	Deter further erosions and sedimentation as well as excess fecal coliform from entering the creek.	$$$	1-3	Implement vegetative buffers along the creek.	- GIGP, LWRP, DC OPEN SPACE, Dutchess Land Conservancy			202972	652	2778	23	3308	6	12	X	X	X		X										
8.13 Rec #2	8.13 WILLOW BROOK SUBWATERSHED		STANFORD	Restore and stabilize streambanks, particularly in areas characterized by steep slopes (> 15%) and highly erodible lands.	Prevent further runoff and sedimentation along the streambanks.	$$$	1-4	Restore and stabilize 3 miles of stream bank or reduce sedimentation runoff by 7% by 2024.	WQIP, LWRP, CDBG, DC MIG			202972	652	2778	27	13295	2	1		X	X				X	X							
RECOMMENDATIONS FOR ENTIRE WATERSHED																																	
Rec #1			ALL MUNICIPALITIES	Stream corridor overlay districts.	Protect streambank, flood zones and critical watershed areas with zoning requirements.	$	1-4	2 municipalities add overlay districts per year.	- Hudson Valley Greenway, lWRP, EFC Engineering												X							X					
Rec #2			ALL MUNICIPALITIES	County easement program.		$$$	1-4	100 acres / year.	- DC Open Space, Dutchess Land Conservancy										X	X													
Rec #3			ALL MUNICIPALITIES	Strengthen bonds with local and organizational non-profit.	Educate Municipal officials/landownersAcquire more funding for municipal projects.	$	1-3	25 Educational events.	CCEDC, WIC, DC MS-4															X							X		

Reduction expected by recommendation

No.	Subwatershed	Sample Point	Town	Recommendation	Goals	Cost	Time	Milestone	Acreage	% of Town in subwatershed	Acres of subwatershed in Town
Rec #4			ALL MUNICIPALITIES	Continue open communication between creek wide municipalities.	Have a coordinated approach to combating the various contaminants that plague the creek county wide.	$	1-3	Encourage more municipalities to join WIC, DC MS-4.	CCEDC, WIC, DC MS-4		
Rec #5			ALL MUNICIPALITIES	Culvert vulnerability assessments.	Evaluate ability to pass water through heavy traffic zones and promote safe and efficient methods of water movement.	$	1-3	Get 30 culverts assessed.	DC Soil & Water, DEC, LWRP		
Rec #6			ALL MUNICIPALITIES	Consider assessing the current condition and vulnerability of the systems.	Develop resilience strategies to reduce the risk of current or future failure or contamination.	$$	1-4	Assess 20 WWTF's, Flood zones, retention ponds, etc.	LWRP, EFC Engineering, DC MIG		
Rec #7 *			ALL MUNICIPALITIES	Restore and reinforce existing wetlands, floodplain ponds and watercourses.	Halt deterioration of existing natural water maintenance systems.	$$$$$	1-5	Restore 4 wetlands, flood plains &/or Wappinger Lake.	- GIGP, CDBG, WQIP, DC MIG, EFC		
Rec #8 *			ALL MUNICIPALITIES	Improve and modify design and management standards for stormwater runoff retention basins.	Reinforcing existing basins and implementing adaptive management plans.	$	1-4	Amend zoning code for a municipality in the watershed.	- Hudson Valley Greenway, LWRP, EFC Engineering		

Loads from all sources excluding point sources, septic systems and groundwater		
Sediment Load (lb/yr)	TP Load (lb/yr)	TN Load (lb/yr)

Reduction in Pollutant by Recommended Management Practice			
Recommended Practice	Sediment Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)

No.	ELIGIBLE GRANT FUNDING														
	Dutchess Land Conservancy	Dutchess County Open Space	LWRP	WQIP	GIGP	CCEDC	DC MIG	CDBG	Dutchess County	EFC	USDA	Cornell Coopertive Extension	CD MS-4	Dutchess County Soil and Water	DEC
Rec #4						X							X		
Rec #5			X											X	X
Rec #6			X				X			X					
Rec #7 *				X	X		X	X		X					
Rec #8 *			X							X					

1) Percent reduction for Phosphorus, Nitrogen and Sediment will need to be evaluated for each proposed treatment practice, conservation area, or maintenance program.
2) Percent reduction for Phosphorus, Nitrogen and Sediment on an individual site is insignificant until a significant number of sites have been corrected.
3) Percent reduction for Phorsphorus will be based on the revised Permit.

Appendix N

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Appendix O

Links to Data Sources

Links to Data Sources

Land Cover - https://www.mrlc.gov/data/nlcd-2011-land-cover-conus-0

Land Use - https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1300

Topography – https://datagateway.nrcs.usda.gov/GDGOrder.aspx

Municipal Boundaries - https://www.dutchessny.gov/Departments/Central-Information-Services/About-Us-OCIS.htm

FEMA Flood Zones - https://www.fema.gov/national-flood-hazard-layer-nfhl

National Hydrography Dataset - https://www.usgs.gov/core-science-systems/ngp/national-hydrography/national-hydrography-dataset?qt-science_support_page_related_con=0#qt-science_support_page_related_con

DEM - https://datagateway.nrcs.usda.gov/GDGOrder.aspx

Precipitation (1981-2010) - https://datagateway.nrcs.usda.gov/GDGOrder.aspx

Bedrock Geology - https://mrdata.usgs.gov/geology/state/state.php?state=NY

SPDES DMRs (2009-2018) - https://echo.epa.gov/trends/loading-tool/water-pollution-search

Stormwater Infrastructure - https://www.dutchessny.gov/Departments/Central-Information-Services/About-Us-OCIS.htm

Roads and Transportation - https://www.dutchessny.gov/Departments/Central-Information-Services/About-Us-OCIS.htm

Water Inventory/Priority Waterbodies List - https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1117

Population - https://dutchessny.gov/Departments/Planning/docs/popcorrections2010.pdf