4. Watershed Characterization

4.1. Physical Characteristics

4.1.1. Geography and Topography

The Neshanic River Watershed is located in Hunterdon County, New Jersey and encompasses Raritan, Delaware, and East Amwell Townships and Flemington borough as shown in Figure 4.1.

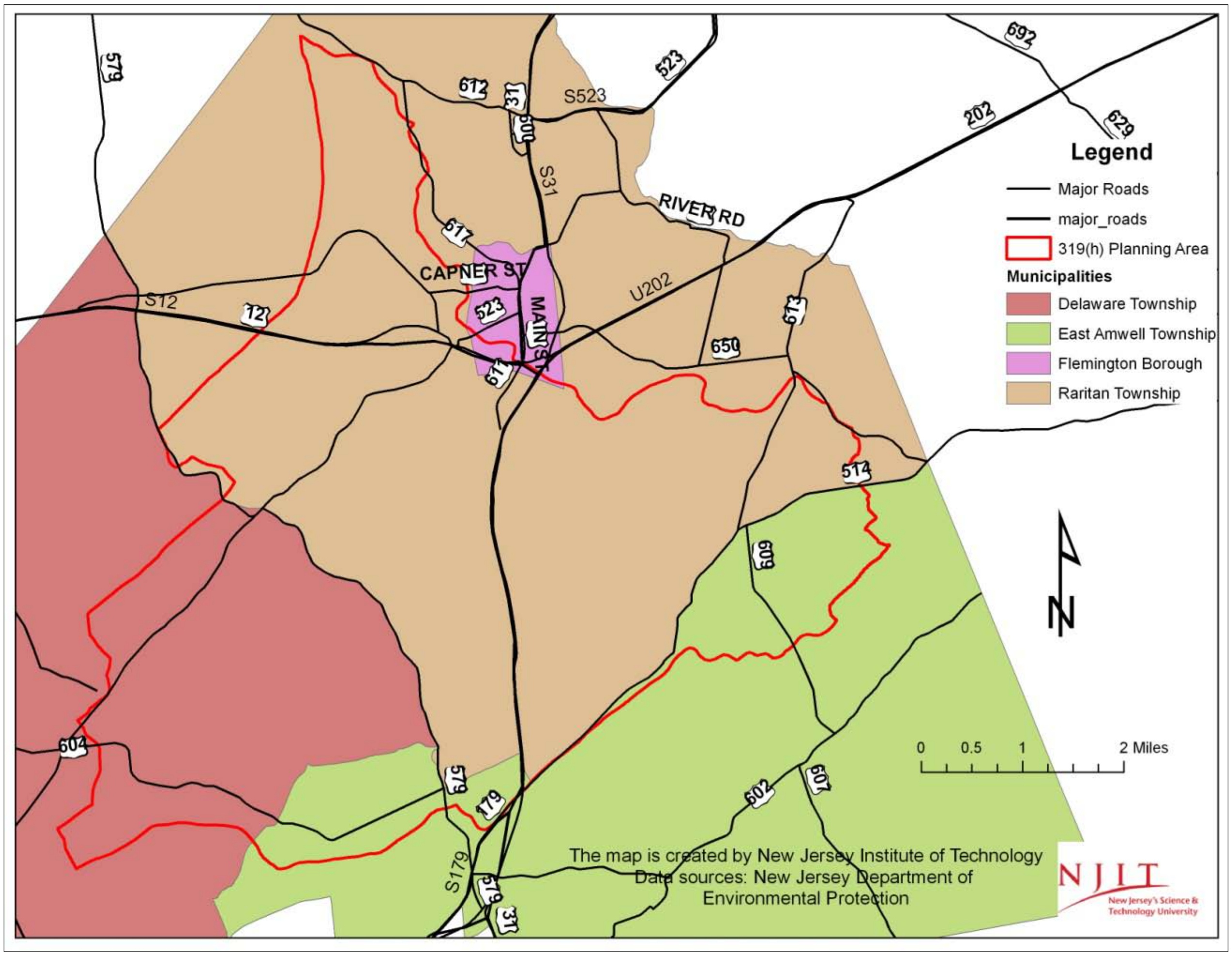


Figure 4.1: Location and transportation network in the Neshanic River Watershed

Interstate highway US202 is a major east-west thoroughfare passing through the watershed. State highway NJ12 runs from the Uhlerstown-Frenchtown Bridge at the Delaware River border between New Jersey and Pennsylvania, crosses the watershed in the north and intersects with US202 and Route31 at the Flemington Circle in Flemington just outside of the watershed in the east. There are also several county routes (CR) that connect the highways and communities in the watershed, including CR514 (from US202 in East Amwell Township to Bayway Avenue in Elizabeth), CR 609 (from CR602 in E. Amwell Township to CR514 in East Amwell Township), CR613 (from CR514 in Raritan Township to US202 in Readington

Township), CR579 (from John Fitch Parkway, namely US29, in Trenton to US173 in Greenwich Township), CR523 (from Main Street, namely US29, in Stockton to Hillside Avenue, namely US 202, in Bedminster Township), CR 604 (from CR 519 in Delaware Township to CR 579 in East Amwell Township) and Old Croton Road (Old US12).

Figure 4.2 shows the spatial distribution of elevation in the watershed. Elevation in the Neshanic River Watershed ranges from 101 to 689 feet above sea level. Areas with higher elevation are located along the northwestern ridge of the watershed, mostly in Raritan Township. Areas with lower elevation are located in the eastern portion of the watershed, mostly along the main Neshanic streams. The elevation of the southern ridge of the watershed generally exceeds 200 feet above sea level. Slopes in the watershed range from 0 to 85 percent. However, the watershed is generally flat. Only 5 percent of the watershed has a slope greater than 15 percent. The steeply sloped areas are located inside the southwestern to northern ridges in upland areas of the watershed and along the tributaries to the Neshanic River main stream in the lower part of the watershed.

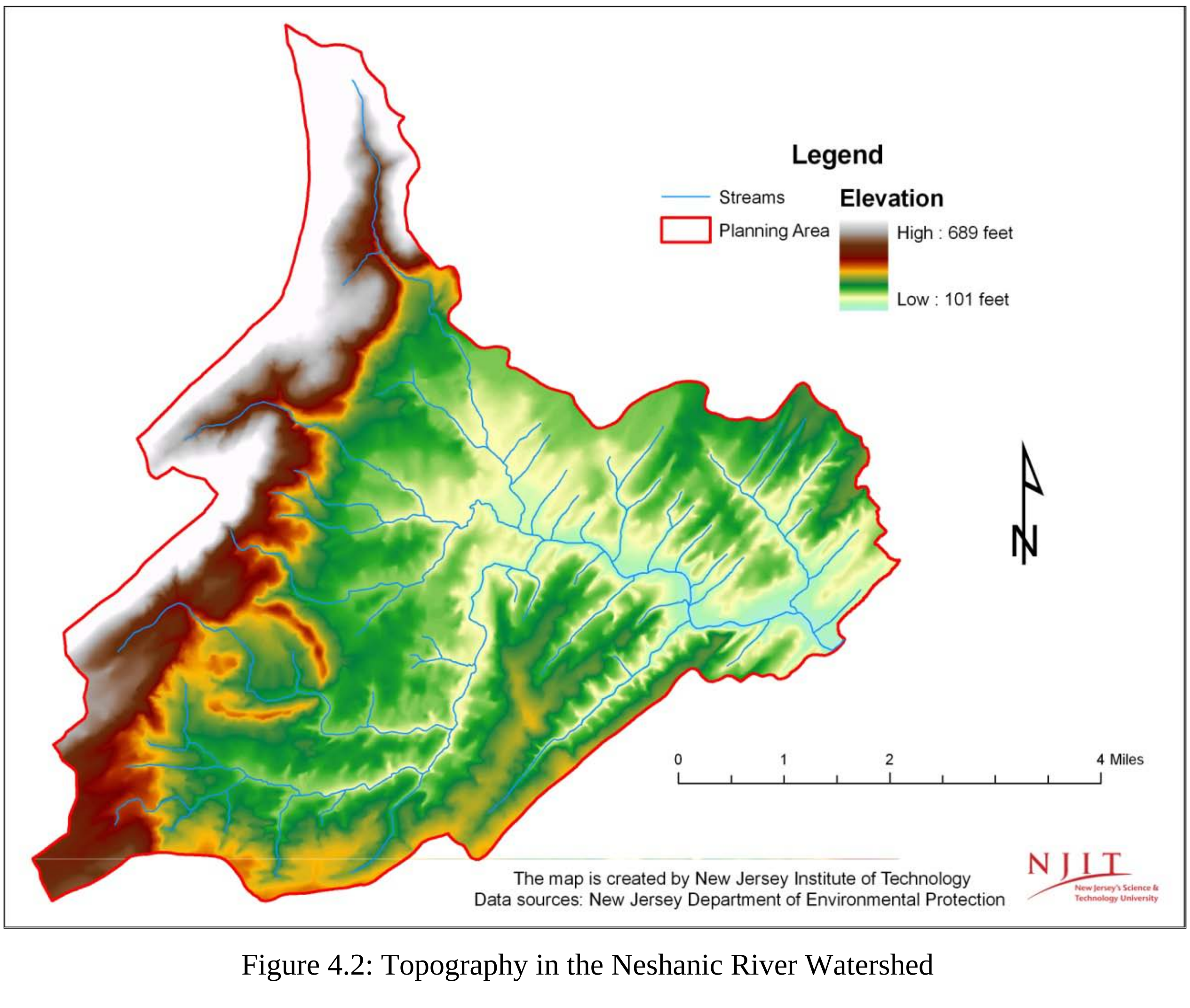


Figure 4.2: Topography in the Neshanic River Watershed

4.1.2. Demographics

Table 4.1 presents the total area, area in the watershed, population and population density of each of the four municipalities. Raritan Township has an area of 37.75 mi^2, which equates to 50 percent of the township located in the watershed. East Amwell Township only has 14 percent of its area in the watershed. Although Flemington Borough is the smallest municipality in the watershed, it has the highest population density of 3,888 people per mi^2 in 2000, which is more than seven times higher than for Raritan Township. The latter is the second most densely populated municipality in the watershed based on the 2000 U.S. Census. Population growth is quite different among the four municipalities. During the 1980s and 1990s, there was substantial population growth in Raritan Township and almost no growth in Flemington Borough. Both Delaware and East Amwell Townships experienced large population growth in the 1980s and almost no growth in the 1990s. Population growth in the 1980s and 1990s was primarily driven by a suburbanization process (i.e., the migration of corporations out of traditional urban centers). Firms like Exxon, Foster Wheeler and Merck established their corporate offices in Hunterdon County, attracting more people to the neighboring communities in the county (NJDLWD, 2006).

Table 4.1: Area, population and population density of municipalities in the Neshanic River Watershed

Municipality	Area (mi^2)	In watershed		Population			2000 Pop. density (people/mi^2)
		mi^2	percent	2000	1990	1980	
Raritan Township	37.75	19.02	50.38	19,809	15,616	8,292	524
Delaware Township	36.99	7.82	21.14	4,478	4,512	3,816	121
Flemington Borough	1.08	0.16	14.81	4,200	4,047	4,132	3,888
East Amwell Township	28.64	4.00	13.97	4,455	4,332	3,468	155

As indicated by the U.S. 2000 Census, the population in Delaware Township was 4,478 and 98 percent of the population was white. There were about 1,889 households in the township. The median household income was $76,523 in 2000, with 3.4 percent of the population and 2.3 percent of families below the poverty level. Of the total number of people living in poverty, 1.2 percent were under the age of 18 and 12.2 percent were 65 or older.

Raritan Township had a population of 19,809 in 2000 and 93 percent of the population was white. There were about 6,937 households in the township. Median household income in 2000 was $87,766, but grew to $109,477 in 2007. About 1.2 percent of families and 2 percent of the population were below the poverty level. Of the total number of people living in poverty, 1.6 percent were under the age of 18 and 2.9 percent were above the age of 65.

For East Amwell Township, the population in 2000 was 4,455 and 97 percent of the population was white. There were about 1,584 households in the township. Median household income was $85,664 in 2000. About 1.8 percent of families and 1.7 percent of the population were below the poverty level. Of the total number of people living in poverty, 2.2 percent were under the age of 18.

For Flemington Borough, the population in 2000 was 4,200 and 88 percent of the population was white. There were about 1,804 households in the borough. Median household income was $39,886 in 2000. About 5.0 percent of families and 6.9 percent of the population were below the poverty level. Of the total people living in poverty, 7.5 percent were under the age of 18 and 3.0 percent were above the age of 65.

This information is for 276 census blocks that are completely or partially in the watershed. Total population in the watershed was about 13,338 in 2000, with 6,515 males and 6,823 females. The race of the population was 12,523 whites, followed by 396 Asians, 347 Hispanic, 175 multi-racial and 155 black. Age wise, 1,039 were under the age of 5, 2,970 were between the ages of 5 and 17, 374 between 18 and 21, 791 between 22 and 29, 2,335 between 30 and 39, 2,748 between 40 and 49, 1,925 between 50 and 64, and 1,156 65 or older. Median age was 37 for the entire total population, 36.4 for males and 37.3 for females. There were about 4,623 households in the watershed.

Demographic characteristics have changed dramatically during the last decade. Unlike the population growth in the 1980s and 1990s that was primarily driven by the migration of corporations to the suburbs, population growth in the 2000s was driven primarily by exurbanization (i.e., the migration of people out of the traditional population centers into rural areas) (Nelson, 1992; Davis, et al., 1994). Such exurbanization increases low density, rural residential development. The 2010 Census results in Table 4.2 indicate that Raritan Township and Flemington Borough experienced high population growth during the period 2000-2010. Although there was a small increase in population in Delaware Township, the population of East Amwell Township declined between 2000 and 2010. The number of dwelling units in Raritan and Delaware Townships increased over 13 percent during the period 2000-2010.

Table 4.2: Changes in population and number of dwelling units for municipalities in the Neshanic River Watershed, 2000-2010

Municipality	Population			Number of Dwelling Units		
	2000	2010	Change	2000	2010	Change
Raritan Township	19,809	22,185	+12.0 %	7,094	8,288	+16.8%
Delaware Township	4,478	4,563	+1.9%	1,701	1,927	+13.3%
Flemington Borough	4,200	4,581	+9.1%	1,876	1,926	+2.7%
East Amwell Township	4,455	4,013	-9.9%	1,624	1,580	-2.7%

4.1.3. Climate

The climate of the region is humid subtropical, with typically hot and humid summers and cold winters. According to the weather data for the period 1955 – 2008 in the Flemington Weather Station located at 40.56°N 74.88°W maintained by the National Climate Center, the average high air temperatures in summer (June to August) were in the range 81 – 86 °F and the average low temperatures in summer were in the range 55 – 61 °F. On average, 19 days each summer had air temperatures that exceeded 90 °F. It was rare for the summer temperature to exceed 100 °F. The average high temperature in winter (December to February) was in the range 37 – 41 °F and average low temperature in winter was in the range 19 – 29 °F. For brief interludes, winter temperature fell in the range 10 – 20 °F and 50 – 60 °F. Spring and autumn can exhibit wide temperature variations, ranging from chilly to warm, although they usually have milder temperatures and lower humidity than in summer.

Mean annual precipitation of the watershed was about 48 inches during the period 1955-2008. It rained, on average, 104 days a year. Rain days were uniformly spread throughout the year. Snowfall in winter season varies from year to year and ranged from 5 to 30 inches. For some years, nor'easters occurred in winter and early spring, which are capable of causing blizzards or flooding. Drought and rain-free periods can last for weeks. Hurricanes and tropical storms, such as Hurricane Floyd in 1999, are rare.

4.1.4. Geology

The Neshanic River Watershed is located wholly within the Piedmont Plain physiographic province of New Jersey, which has rolling hills with wide, shallow valleys. It belongs to the broader geological region known as the Newark Rift Basin, which contains Triassic and Jurassic rocks deposited in a large sedimentary basin that formed during the breakup of Pangea, the giant continent that existed about 200 to 250 million years ago. Figure 4.3 depicts the spatial distribution of bedrock in the watershed.

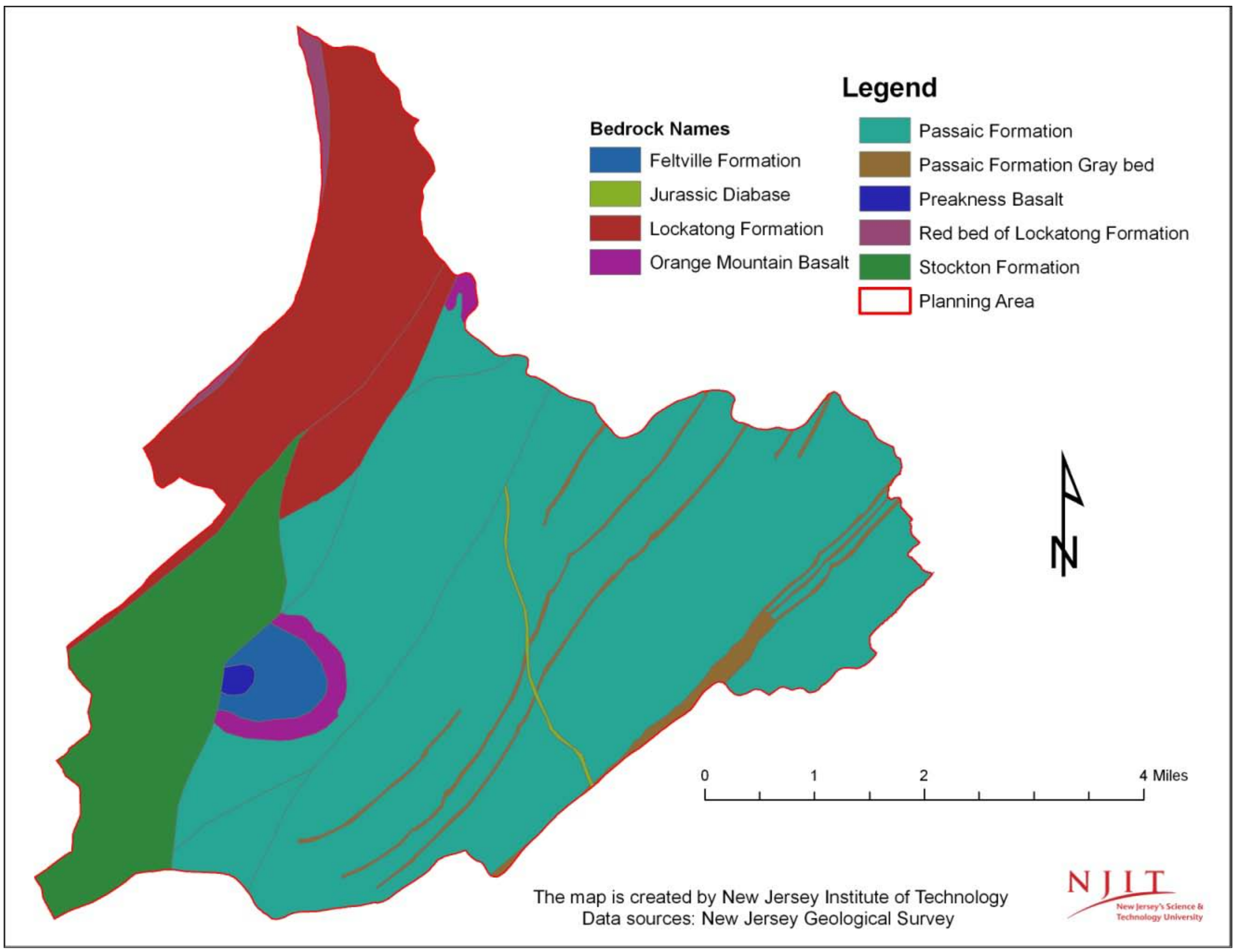


Figure 4.3: Spatial distribution of bedrock in the Neshanic River Watershed

The dominant bedrock in the watershed includes the Stockton Formation (13 percent of the watershed), Lockatong Formation (17 percent of the watershed) and Passaic Formation (63 percent of the watershed), which are the three oldest formations in Newark Rift Basin (Schlische, 1992). The Passaic Formation is located in the lower part of the watershed whereas the Lockatong and Stockton Formations are distributed along the western edge of the watershed. Water movement in these consolidated rocks is primarily through joints, bedding planes and fractures, that were created by the original deposition and weathering of the rock formations. This type of flow allows relatively limited movement of water through aquifers.

4.1.5. Soils

The Neshanic River Watershed has relatively uniform soils of the Brunswick formation developed from Triassic red shale. In non-wetland areas the soils are characteristically shallow, well-drained and loamy. Texturally, all of the watershed soils are silt-loams (USDA, 1974). The soil information for the watershed was derived from the Soil Survey Geographic (SSURGO) Database for Hunterdon County, New Jersey, which was obtained from the NRCS and the U.S. Department of Agriculture. There are 52 different types of soils in the watershed excluding Water and ROPF (rough broken land, shale). Figure 4.4 illustrates the spatial distribution of soil types in the watershed. Each soil type has a distinct map unit symbol (MUSYM) name.

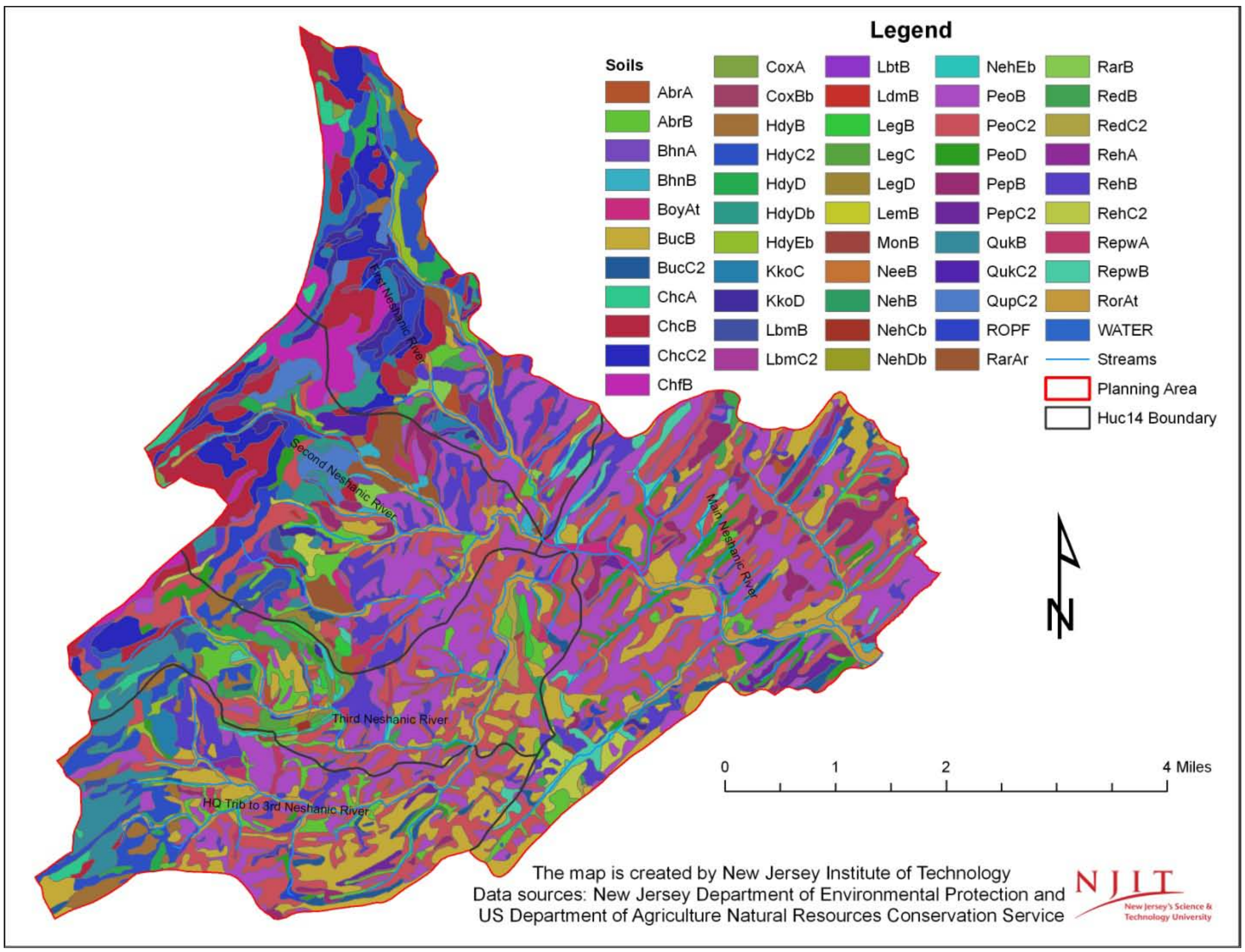


Figure 4.4: Distribution of soil types in the Neshanic River Watershed

Major soils types in the watershed are: Penn channery silt loam with 6 to 12 percent slopes, eroded (PeoC2 with 16.6 percent); Penn channery silt loam with 2 to 6 percent slopes (PeoB with 16.4 percent); Bucks silt loam, 2 to 6 percent slopes (BucB with 8.1 percent); Reaville silt loam, 2 to 6 percent slopes (RehB with 6.8 percent); Chalfont silt loam, 2 to 6 percent slopes (ChcB with 4.7 percent); Rowland silt loam, 0 to 2 percent slopes, frequently flooded (RorAt with 4.5 percent); Hazleton channery loam, 6 to 12 percent slopes, eroded (HdyC2 with 3.8 percent); and Abbottstown silt loam, 2 to 6 percent slopes (AbrB with 3.6 percent). These soil types cover 64.6 percent of the area of the watershed. Table 4.3 presents the acreage and area distribution of each soil type in the watershed by MUSYM. The Neshanic River Watershed has soils that are very suitable for agriculture. According to NRCS, 82.8 percent of the watershed is underlain by soils classified as either Prime Farmland (33.3 percent) or Farmland of Statewide Importance (49.5 percent). Prime Farmland soils are generally soils that are best suited for food, feed, forage, fiber and oilseed crops. Farmlands of statewide importance include soils that do not meet the criteria as Prime Farmland, but are nearly Prime Farmland and economically produce high yields of crops when treated and managed according to acceptable farming methods. Crop yields in Farmland of Statewide Importance soils can be as high as crop yields in Prime Farmland soils if conditions are favorable. The prime farmland designation is also given in Table 4.3. Given such natural resource conditions, it is not surprising that agriculture predominates historical use of the watershed until the last three decades when rapid urbanization occurred.

Table 4.3: Area distribution and farmland designation of soils in the Neshanic River Watershed

MUSYM	Soil Name	Acres	Percent
AbrA[1]	Abbottstown silt loam, 0 to 2 percent slopes	94.20	0.5
AbrB[1]	Abbottstown silt loam, 2 to 6 percent slopes	709.69	3.6
BhnA[2]	Birdsboro silt loam, 0 to 2 percent slopes	7.95	0.0
BhnB[2]	Birdsboro silt loam, 2 to 6 percent slopes	48.16	0.2
BoyAt[1]	Bowmansville silt loam, 0 to 2 percent slopes, frequently flooded	153.06	0.8
BucB[2]	Bucks silt loam, 2 to 6 percent slopes	1601.24	8.1
BucC2[1]	Bucks silt loam, 6 to 12 percent slopes, eroded	200.30	1.0
ChcA[1]	Chalfont silt loam, 0 to 2 percent slopes	143.03	0.7
ChcB[1]	Chalfont silt loam, 2 to 6 percent slopes	932.21	4.7
ChcC2[1]	Chalfont silt loam, 6 to 12 percent slopes, eroded	577.50	2.9
ChfB[1]	Chalfont-Quakertown silt loams, 0 to 6 percent slopes	417.51	2.1
CoxA[1]	Croton silt loam, 0 to 2 percent slopes	24.84	0.1
CoxBb	Croton silt loam, 0 to 6 percent slopes, very stony	35.11	0.2
HdyB[1]	Hazleton channery loam, 2 to 6 percent slopes	308.73	1.6
HdyC2[1]	Hazleton channery loam, 6 to 12 percent slopes, eroded	755.20	3.8
HdyD	Hazleton channery loam, 12 to 18 percent slopes	174.98	0.9
HdyDb	Hazleton channery loam, 6 to 18 percent slopes, very stony	228.71	1.2
HdyEb	Hazleton channery loam, 18 to 40 percent slopes, very stony	113.93	0.6
KkoC	Klinesville channery loam, 6 to 12 percent slopes	264.83	1.3
KkoD	Klinesville channery loam, 12 to 18 percent slopes	214.15	1.1
LbmB[2]	Lansdale loam, 2 to 6 percent slopes	63.37	0.3

LbmC2[1]	Lansdale loam, 6 to 12 percent slopes, eroded	66.12	0.3
LbtB[1]	Lansdowne silt loam, 2 to 6 percent slopes	11.81	0.1
LdmB[2]	Lawrenceville silt loam, 2 to 6 percent slopes	5.71	0.0
LegB[2]	Legore gravelly loam, 2 to 6 percent slopes	92.41	0.5
LegC[1]	Legore gravelly loam, 6 to 12 percent slopes	92.39	0.5
LegD	Legore gravelly loam, 12 to 18 percent slopes	54.17	0.3
LemB[1]	Lehigh silt loam, 2 to 6 percent slopes	1.99	0.0
MonB[2]	Mount Lucas silt loam, 2 to 6 percent slopes	15.48	0.1
NeeB[2]	Neshaminy gravelly loam, 2 to 6 percent slopes	7.89	0.0
NehB[2]	Neshaminy silt loam, 2 to 6 percent slopes	24.74	0.1
NehCb	Neshaminy silt loam, 6 to 12 percent slopes, very stony	6.31	0.0
NehDb	Neshaminy silt loam, 12 to 18 percent slopes, very stony	7.96	0.0
NehEb	Neshaminy silt loam, 18 to 35 percent slopes, very stony	35.39	0.2
PeoB[2]	Penn channery silt loam, 2 to 6 percent slopes	3262.31	16.4
PeoC2[1]	Penn channery silt loam, 6 to 12 percent slopes, eroded	3299.31	16.6
PeoD	Penn channery silt loam, 12 to 18 percent slopes	373.27	1.9
PepB[2]	Penn-Bucks complex, 2 to 6 percent slopes	537.57	2.7
PepC2[1]	Penn-Bucks complex, 6 to 12 percent slopes, eroded	118.70	0.6
QukB[2]	Quakertown silt loam, 2 to 6 percent slopes	442.38	2.2
QukC2[1]	Quakertown silt loam, 6 to 12 percent slopes, eroded	106.70	0.5
QupC2[1]	Quakertown-Chalfont silt loams, 6 to 12 percent slopes, eroded	214.42	1.1
ROPF	Rough broken land, shale	355.24	1.8
RarAr[2]	Raritan silt loam, 0 to 3 percent slopes, rarely flooded	265.12	1.3
RarB[2]	Raritan silt loam, 3 to 8 percent slopes	68.37	0.3
RedB[2]	Readington silt loam, 2 to 6 percent slopes	165.74	0.8
RedC2[1]	Readington silt loam, 6 to 12 percent slopes, eroded	59.90	0.3
RehA[1]	Reaville silt loam, 0 to 2 percent slopes	21.70	0.1
RehB[1]	Reaville silt loam, 2 to 6 percent slopes	1350.82	6.8
RehC2[1]	Reaville silt loam, 6 to 12 percent slopes, eroded	164.68	0.8
RepwA	Reaville wet variant silt loam, 0 to 2 percent slopes	304.02	1.5
RepwB	Reaville wet variant silt loam, 2 to 6 percent slopes	330.66	1.7
RorAt	Rowland silt loam, 0 to 2 percent slopes, frequently flooded	897.05	4.5
Water	Water	12.26	0.1
Total		19841.31	100.0

Note: 1. NRCS designated “Farmland of Statewide Importance”
2. NRCS designated “Prime Farmland”

4.1.6. Vegetation

The watershed contains agricultural lands, forests, wetlands and urban lands that contain vegetation that is typical of the Raritan River Basin and New Jersey Piedmont Plain Region. The agricultural lands are devoted to row crop production, including corn, soybeans, wheat, rye, hay, warm season grass, such as alfalfa and timothy, and pasture with fescue and various cool-season and warm-season grasses. Typical forest species in the New Jersey Piedmont Plain are red oak (*Quercus rubra*), white oak (*Quercus alba*) and black oak (*Quercus velutina*). Other less abundant canopy species include hickory (*Carya* spp.), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), tulip tree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), black birch (*Betula lenta*), American elm (*Ulmus americana*) and Green Ash (*Fraxinus Americana*). The understory of the forest is dominated by flowering dogwood (*Cornus florida*) and includes saplings of canopy species. Viburnums (*Viburnum acerifolium, V.prunifolium, V. dentatum*), spicebush (*Lindera benzoin*), American hornbeam (*Carpinus caroIiniana*) and witch hazel (*Hamamelis virginiana*) are major shrub-layer species while two cherry species (*Prunus serotina*, *P. avium*) are commonly associated with the forest edge (Robichaud and Anderson, 1994). Just outside of the watershed, the Herrontown Woods Preserve in Princeton, N.J. and Rutgers University's Hutcheson Memorial Forest in Franklin Township are well-studied woodlands that are analogous to what mesic Piedmont forests with limited human disturbance resemble. In the Hutcheson Memorial Forest, the average tree age is over 230 years old on ground that reportedly has never been plowed (Forman and Elfstrom, 1975, Robichaud and Anderson, 1994). In contrast, the younger stand at Herrontown was last timber-harvested in 1920. Also, there are larger forested areas close to the watershed on the Sourlands Mountain to the south and on Cushetunk Mountain. Both areas are hilly volcanic uplands that rise above the adjacent piedmont (Cantlon, 1953).

Historically, agriculture and urban development have been the major threats to the diverse vegetation in the forest and wetlands. In recent years, deer and invasive and exotic species have become major threats to the diversity of vegetation. Deer have a significant negative impact on the abundance, growth, regeneration and diversity of 700-800 native plant and animal species in New Jersey. In areas having high deer populations, deer consume ground cover and shrubs, affecting birds and other animals that rely on this vegetation; their populations decrease and may eventually disappear locally due to loss of habitat (New Jersey Audubon Society, 2005). Recent surveys have estimated deer density in Hunterdon County at over 180 per square mile. The Hunterdon County Board of Agriculture concluded that deer have caused severe damage to agricultural crops. Within the county, the reported deer harvest has declined by 27 percent, from a peak of 14,700 in 1999 to 10,700 in 2006.

In the absence of native ground cover, aggressive exotic plants, many introduced from Asia as ornamentals, begin to take over the forest floor, limiting the ability of native plants and dependent birds and animals to recover. Invasive exotic plant species out-compete native species when the latter are stressed by deer, climate change, forest fragmentation and pollution. Invasive species of concern in the watershed include:

- Trees:
  Norway maple *(Acer platanoides)*
  Tree of heaven, Stink tree *(Ailanthus altissima)*
  Princess tree, *Paulownia (Paulownia tomentosa)*
  Sweet cherry, Bird cherry *(Prunus avium)*
  Black locust *(Robinia pseudoacacia)*

- Shrubs*:*
  Japanese barberry *(Berberis thunbergii)*
  Autumn olive *(Eleagnus umbellata)*
  Burning bush winged euonymus *(Euonymus alatus)*
  Border privet *(Ligustrum obtusifolium)*
  Tartarian honeysuckle *(Lonicera tatarica)*
  Multi flora rose *(Rosa multiflora)*
  Wineberry *(Rubus phoenicolasius)*
  Siebold's viburnum *(Viburnum sieboldii)*

- Vines:
  Porcelainberry *(Ampelopsis brevipedunculata)*
  Oriental bittersweet, Asiatic bittersweet *(Celastrus orbiculatus)*
  English ivy *(Hedera helix)*
  Japanese honeysuckle *(Lonicera japonica)*
  Grapevine *(Vitis spp.)*
  Wisteria *(Wisteria floribunda)*

- Annuals, Biennials, and Perennials*:*
  Garlic mustard *(Alliaria petiolata)*
  Mugwort *(Artemisia vulgaris)*
  Crown vetch *(Coronilla varia)*
  Purple loosestrife *(Lythrum salicaria)*
  Japanese knotweed, Mexican bamboo *(Fallopia japonica)*
  Periwinkle, myrtle, vinca *(Vinca minor)*

- Grasses*:*
  Japanese stiltgrass, basket or wire grass *(Microstegium vimineum)*
  Hardy bamboo *(Arundinaria, Bambusa*, Dendrocalamus ssp.)
  Common reed (*Phragmites australis)*

Vegetation in the Neshanic River Watershed is visibly stressed by deer browse and by invasive species, such as Multiflora rose (*Rosa multiflore),* Barberry (*Berberis thunbergii)* and Autumn olive (*Elaegnus umbellata*), which are less palatable to deer (C. Testa, personal communication). Non-native invasive species suppress the regeneration of native vegetation because they can grow without regard to competition. Autumn olive and multiflora rose shade the herb layer, limiting the growth of lower level vegetation which holds soil and provides protection from erosion. Notable exposure of soil in forests is common within the watershed.

4.1.7. Wildlife and Wildlife Habitat

The NJDEP Division of Fish and Wildlife classified the watershed into the Southern Highlands Zone when discussing the New Jersey Wildlife Action Plan (NJDEP, 2008b). This region supports two federal endangered and threatened species, six state endangered, 11 state threatened species, and 57 special concern and regional priority wildlife species, in addition to six game species of regional priority and six nongame fish species currently without state or regional status. The Bog turtle is the federally threatened species. The red-shouldered hawk, northern harrier, short-eared owl, upland sandpiper, vesper sparrow, green floater and Appalachian grizzled skipper are state endangered species. State threatened wildlife include the barred owl, Cooper’s hawk, long-eared owl, osprey, bobolink, grasshopper sparrow, savannah sparrow, wood turtle, long-tailed salamander, tidewater mucket and yellow lampmussel. Special concern wildlife includes cavity-nesters, colonial waterbirds, forest passerines, freshwater wetland birds, grassland birds, raptors and scrub-shrub birds. Latin names of all species can be found in the New Jersey Wildlife Action Plan (NJDEP, 2008b).

Like the rest of the Southern Highlands Zone, the watershed is dominated by agricultural fields of cropland and pastures, which are generally poor habitats for wildlife. However, if properly managed, pastures can be good habitat for wildlife. The forest in the watershed is highly fragmented and exists primarily as small patches interspersed by development and agriculture. Encroaching development, disturbance, habitat loss, fragmentation and degradation threaten wildlife. Use of pesticides, mowing and other agricultural practices endanger grassland birds and their habitats (NJDEP, 2008b).

4.1.8. Threatened and Endangered Species

The Endangered and Nongame Species Program within the Division of Fish & Wildlife at NJDEP has developed the “Critical Habitats” project (also known as the Landscape Project) that identifies critical habitats for endangered and threatened forested, forested wetland, emergent wetland and grassland species. Table 4.4 lists those species of concern supported by the Neshanic River Watershed and the habitat priority ranks in the NJ Landscape Project.

Table 4.4: List of endangered species and their habitat priority in the Neshanic River Watershed

Habitat Type	Name of Endangered Species	Habitat Priority Rank
Grassland	American Kestrel	2, 3 & 4
	Eastern Box Turtle	2 & 4
	Eastern Meadowlark	2
	Northern Harrier	4
Forest	Cooper's Hawk	3
	Eastern Box Turtle	2
	Forest Core	3
	Great Blue Heron	2
	Wood Turtle	3
Forest wetland	Cooper's Hawk	3
Emergent wetland	Bobolink	3

The habitat priority ranking is based on the conservation status of the species and listed as follows: Rank 5 is assigned to patches containing one or more occurrences of at least one wildlife species listed as endangered or threatened on the Federal list of endangered and threatened species; Rank 4 is assigned to patches with one or more occurrences of at least one State endangered species; Rank 3 is assigned to patches containing one or more occurrences of at least one State threatened species; Rank 2 is assigned to patches containing one or more occurrences of species considered to be species of special concern; and Rank 1 is assigned to patches that meet habitat-specific suitability requirements, such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species (Niles et al., 2008). Although the Neshanic River Watershed supports many concerned species, it does not provide an ideal habitat for those species since 2 and 3 are the most dominant habitat priority rankings.

4.1.9. Streams

The watershed contains 62.6 miles of streams including Walnut Brook, First, Second and Third Neshanic Rivers and a part of the Neshanic River main branch immediately above the Back Brook confluence with the Neshanic River. The Neshanic River is a tributary to the South Branch of the Raritan River which drains to the Atlantic Ocean. The Neshanic River and its tributaries are classified as FW2-NT, or freshwater (FW) non-trout (NT) in the newly released 2010 New Jersey Surface Water Classification Standards. “FW2” refers to: water bodies that are used for primary and secondary contact recreation; industrial and agricultural water supply; maintenance, migration, and propagation of natural and established biota; public potable water supply after conventional filtration treatment and disinfection; and any other reasonable uses. “NT” indicates freshwaters that have not been designated as trout production or trout maintenance. NT waters are not suitable for trout due to physical, chemical or biological characteristics, but can support other fish species (NJDEP 2010a).

4.1.10. Groundwater Recharge

Groundwater recharge is defined as the water that infiltrates the ground and reaches the water table regardless of the underlying geology. It supports aquifer recharge, stream baseflow and wetlands. In 2004, New Jersey Geological Survey (NJGS) estimated the groundwater recharge in New Jersey using the NJGS methodology developed by Charles et al. (1993). NJDEP 1995 land-use/land-cover update, NRCS soil and municipality-based climatic data were combined and used to estimate groundwater recharge in inches per year. Recharge was then ranked by volume (billions of gallons per year) using natural breaks in the percentage of total volume. There are six types of state ranks in the watershed. There are 8,535 acres (43 percent of the watershed) in State Rank C with the groundwater recharge ranging from 8 to 11 inches per year. Thirty-eight percent of the watershed is in State Rank B with the groundwater recharge ranging from 11 to 15 inches per year. Table 4.5 presents the area distribution of all state ranks.

Table 4.5: Area distribution of groundwater recharge in the Neshanic River Watershed

Groundwater Recharge		Area	
State Rank	Description	Acres	Percent
A	16-23 inches per year	321.13	1.6
B	11-15 inches per year	7607.65	38.3
C	8-11 inches per year	8534.67	43.0
D	1-7 inches per year	499.85	2.5
L	Hydric soils	156.92	0.8
W	Wetlands and open water	2721.09	13.7
Total		19841.31	100.0

Figure 4.5 presents the spatial distribution of the groundwater recharge based on the state ranking.

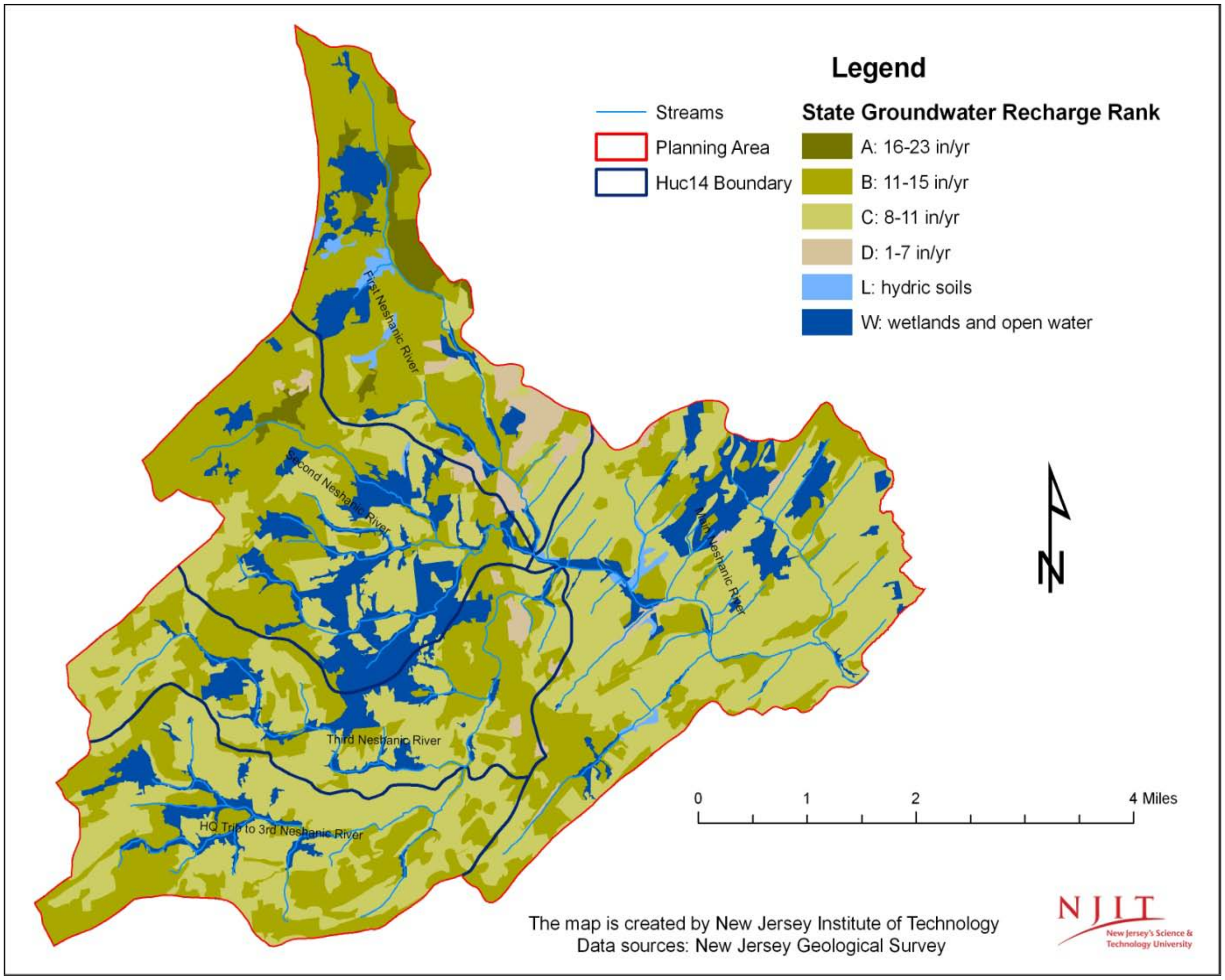


Figure 4.5: Spatial distribution of groundwater recharge in the Neshanic River Watershed

4.1.11. Hydrology and Morphology

Watershed hydrology characterizes water movement in a watershed in response to storm events. The average annual precipitation in the Neshanic River Watershed is about 48 inches. Estimated annual mean evapotranspiration, groundwater recharge, and runoff in the Neshanic River Watershed are 23.96 inches, 5.25 inches and 15.78 inches, respectively. Precipitation data are based on a long-term water budget analysis for the Raritan River Basin that assumes long-term stream baseflow equals long-term groundwater recharge (below the plant root zone) except for the impacts of depletive and consumptive uses within the watershed (NJWSA, 2000).

In this project, the watershed hydrological model SWAT was used to better understand the watershed hydrology. The model was carefully calibrated to evaluate the watershed hydrology during 1997 and 2008 based on the best available data. The SWAT assessment shows the streamflow is 21.32 inches, which is slightly higher than 21.03 inches (i.e., 5.25 + 15.78 inches) in the earlier study by NJWSA (2000); the difference is insignificant. More than 50 percent of the annual precipitation is lost by evapotranspiration during dry years and less than 50 percent during wet years in the watershed. Lateral flow contributions to streamflow and tributary loss in the watershed are not significant. Streamflow mainly comes from surface runoff and groundwater discharge. According to the annual precipitation, 1997 and 1998 were two dry years, and 2003 and 2006 were two wet years during the assessment period. In the wet years, the annual surface runoff contributions to streamflow are 66.3 percent and 65.1 percent and groundwater contributions are 33.0 percent and 34.2 percent in 2003 and 2006, respectively. During dry years, the annual surface runoff contributions are 70.4 percent and 62.6 percent and groundwater contributions are 28.9 percent and 37.4 percent in 1997 and 1998, respectively. Therefore, surface runoff dominates water yield in both wet and dry years. Compared to wet years, the annual groundwater (base flow) contribution to streamflow during a dry year may be increased or reduced depending on the initial soil water content and temporal distribution of precipitation over the year.

Geomorphological conditions in the watershed are deteriorating. Downcutting and widening of stream channels occur extensively in the watershed. Stream bank erosion results in substantial water quality degradation in some parts of the watershed. There are accumulated sediments in the bottom of the streams especially in the main branch of the Neshanic River, which is a significant water pollution source, especially during high flow events. Although there is no comprehensive morphological assessment for the watershed, the general morphological conditions were assessed using the Rosgen stream classification system, Schumm's Channel Evolution Model (CEM) and the USDA Stream Visual Assessment Protocol (SVAP), which are summarized in next chapter and can also be found in separate project task reports.

4.1.12. Sewer Service Area (SSA) and Onsite Disposal Systems (OSDSs)

The NJDEP maintains a statewide SSA map that shows the planned method of wastewater disposal for specific areas (i.e., whether the wastewater will be collected at a regional treatment facility or treated onsite and disposed of through a surface water discharge or a groundwater discharge). However, SSA maps do not indicate where actual infrastructure is present. The areas that are not specifically mapped represent either water features where no construction can occur or land areas that default to individual subsurface disposal systems discharging less than 2,000 gallons per day where site conditions and existing regulations allow. Based on the 2010 updated SSA map maintained by NJDEP, 7,026 acres of the watershed are in SSAs. There are three types of SSAs in the watershed: GW < 20,000; SW; and GWIND. In terms of the size of the SSAs: 4,073 acres of SSAs are in GW < 20,000, which indicates a groundwater discharge less than 20,000 gallons per day; and 2,699 acres of SSA are in SW, which implies that the discharge goes to surface water. The most developed areas in the watershed are in SSAs with surface water discharge. The remaining 254 acres of SSAs are in GWIND, which indicates that the discharge goes to groundwater through an individual New Jersey Pollution Discharge Elimination System (NJPDES) permitted facility. The GWIND SSAs include Cooper Hill County Club, Copper Hill School and Verduccis Specialty Market. Figure 4.6 illustrates the spatial distribution of SSAs in the Neshanic River Watershed. All SSAs are within Raritan Township.

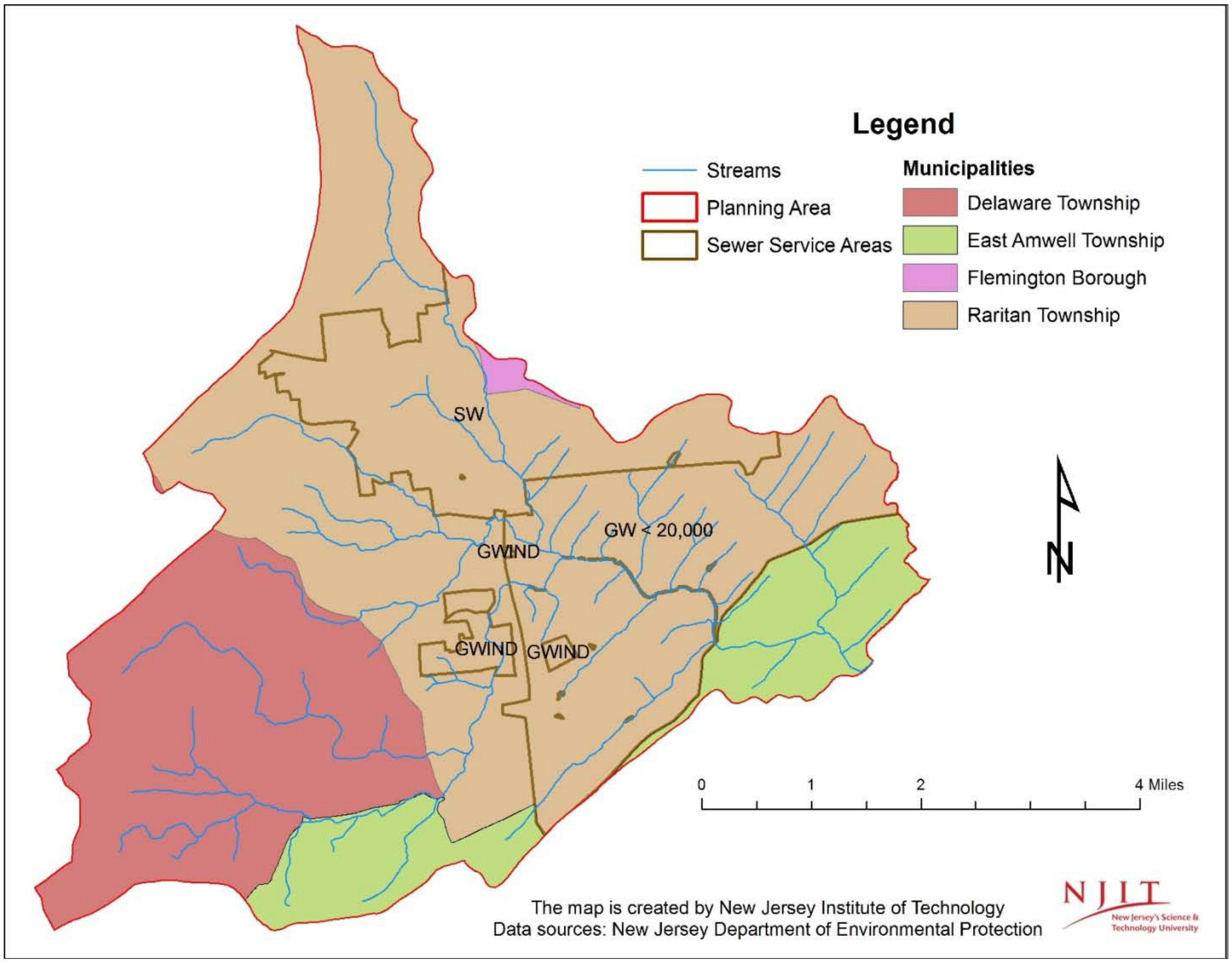


Figure 4.6: Spatial distribution of SSAs in the Neshanic River Watershed

The Raritan Township Municipal Utilities Authority (RTMUA) operates and maintains a 3.8 MGD conventional activated sludge wastewater treatment plant located at 365 Old York Road in Raritan Township which discharges treated effluent into the South Branch of the Raritan River at Three Bridges (RTMUA Main Treatment Plant). The portion of the RTMUA SSA that falls within the Neshanic River Watershed comprises the sewered areas south of Reaville Avenue/Road in Raritan Township and sewered areas south of Route 12 and the Hunterdon County Complex. These areas are tributary to the RTMUA Main Treatment Plant via sewers that lead to the RTMUA Pump Station No. 1, which was rehabilitated in 1999 and 2000. Sewered areas may improve water quality within the watershed because the sewage is conveyed to a central treatment facility that is regulated under the Clean Water Act and NJPDES. This arrangement may eliminate the alternative of sewage discharge to septic systems, which can malfunction.

Some homes in the SSAs and almost all homes outside the SSAs rely on OSDS to treat sewage and other waste water. There is no inventory on OSDSs in the watershed and municipalities. For planning purposes, the number of OSDSs is estimated based on the distribution of SSAs and parcel and land use maps. There are 2,696 homes in the low density and rural residential areas of the watershed according to the 2007 NJDEP land use data. Among those homes, 1,508 are in SSAs delineated by NJDEP and 1,188 are in the non-SSA. Assuming one fifth of these households are in SSAs and all households in the non-SSA rely on OSDSs, about 1,490 households are likely to rely on septic systems.

4.1.13. Water Supply and Availability

Neshanic streams drain to the South Branch of the Raritan River, which is a source of drinking water supply for 1.75 million people in Central New Jersey. Water availability in the Neshanic River Watershed can be measured by the streamflow at the watershed outlet. The streamflow includes surface runoff plus lateral flow plus groundwater recharge (i.e., water from the shallow aquifer that returns to the reach) minus transmission losses ((i.e., water lost from tributary channels via transmission through the bed that becomes recharge for the shallow aquifer). Since there is no streamflow monitoring station at the watershed outlet, water availability was estimated using the SWAT watershed hydrological model.

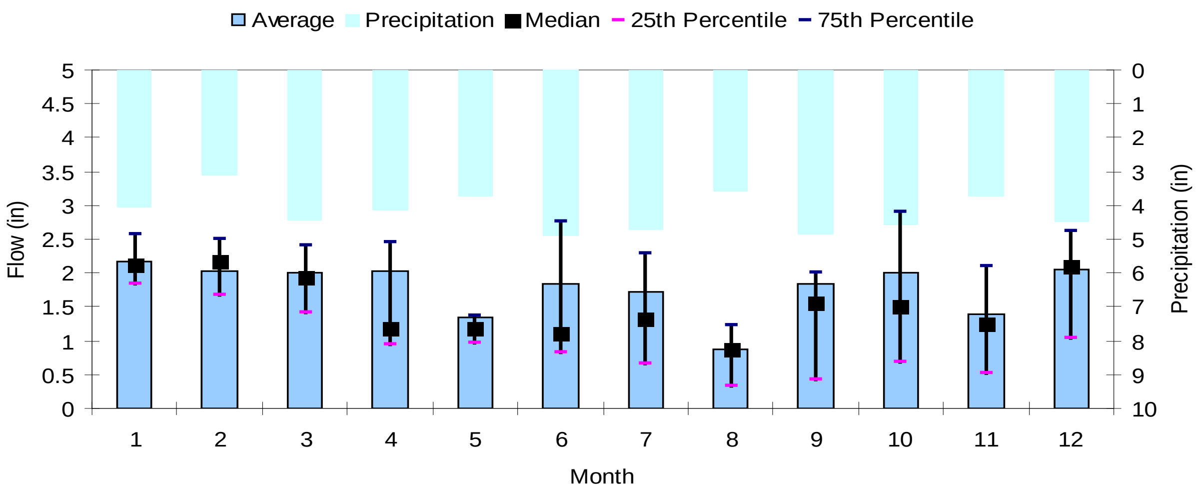


Figure 4.7: Average monthly precipitation in watershed and streamflow at watershed outlet, 1997-2008

The SWAT simulation results indicate that the average annual water yield at the outlet of the Neshanic River Watershed is 1.51E+09 cubic feet per year, or equivalently 21.32 inches of precipitation. Figure 4.7 illustrates average monthly precipitation in the watershed and median, 25th percentile and 75th percentile monthly streamflow at the outlet of the watershed. The average monthly precipitation varies from 3.11 to 4.88 inches with the highest precipitation in June and the lowest in February. The average monthly streamflows vary from 0.88 inches in August to 2.17 inches in January, which are equivalent to 24 to 66 percent of the monthly precipitation, respectively. The seasonal variations in average monthly precipitation and average monthly streamflows are similar. Average monthly streamflows are greater than two inches in January to April and October to December, two inches in May to July and September to November, and less than one inch in August. There are annual variations in the monthly streamflow due to changes in weather and climate patterns. Annual variations in the monthly streamflows are measured by the spans between the 25th and 75th percentiles. This variation is the largest in October and smallest in May. Variations in April, June, July, September, November and December are generally larger than in other months. The SWAT results also reflect the impacts of annual variation in land cover on the streamflow. Higher vegetative cover generally results in greater interception of water and therefore, lower streamflow. For example, even though the highest precipitation occurs in June, streamflow in June is lower than some months in fall, winter and spring because of the impacts of vegetation.

4.2. **Critical Environmental Areas**

4.2.1. Hydric Soils

The NRCS defines a hydric soil as a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper soil layer. Hydric soils are commonly associated with wetland areas and are strongly influenced by the presence of water. However, hydric soils and wetlands are not the same thing. An area must have hydric soils, wetland-adapted plants, and the presence of water for some time during the year to be considered a wetland. There are five different hydric soil types in the watershed with a total area of 847.69 acres as listed in Table 4.6. The Reaville wet variant silt loam is the predominant hydric soil in the watershed. The spatial distribution of the hydric soils in the watershed is also presented in Figure 4.8. Like the linear wetlands, most of the hydric soils are also found along the streams the streams.

Table 4.6: Hydric soil type and their acreages in the Neshanic River Watershed

Hydric Soil Name	MUSYM	Acres
Bowmansville silt loam, 0 to 2 percent slopes, frequently flooded	BoyAt	153.06
Croton silt loam, 0 to 2 percent slopes	CoxA	24.84
Croton silt loam, 0 to 6 percent slopes, very stony	CoxBb	35.11
Reaville wet variant silt loam, 0 to 2 percent slopes	RepwA	304.02
Reaville wet variant silt loam, 2 to 6 percent slopes	RepwB	330.66
Total		847.69

4.2.2. Wetlands

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin, 1979). For regulatory purposes under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas (the EPA Regulations listed at 40 CFR 230.3(t))." Wetlands provide important functions such as filtering pollutants from stormwater runoff, acting as storage areas for flood waters, protecting streambanks from erosion, providing wildlife habitat, and providing recreational opportunities for communities. The major concern related to wetlands in the watershed is losses due to agriculture and urban development. The loss of wetlands significantly alters the watershed hydrology and contributes to many of the water quality and quantity problems observed today.

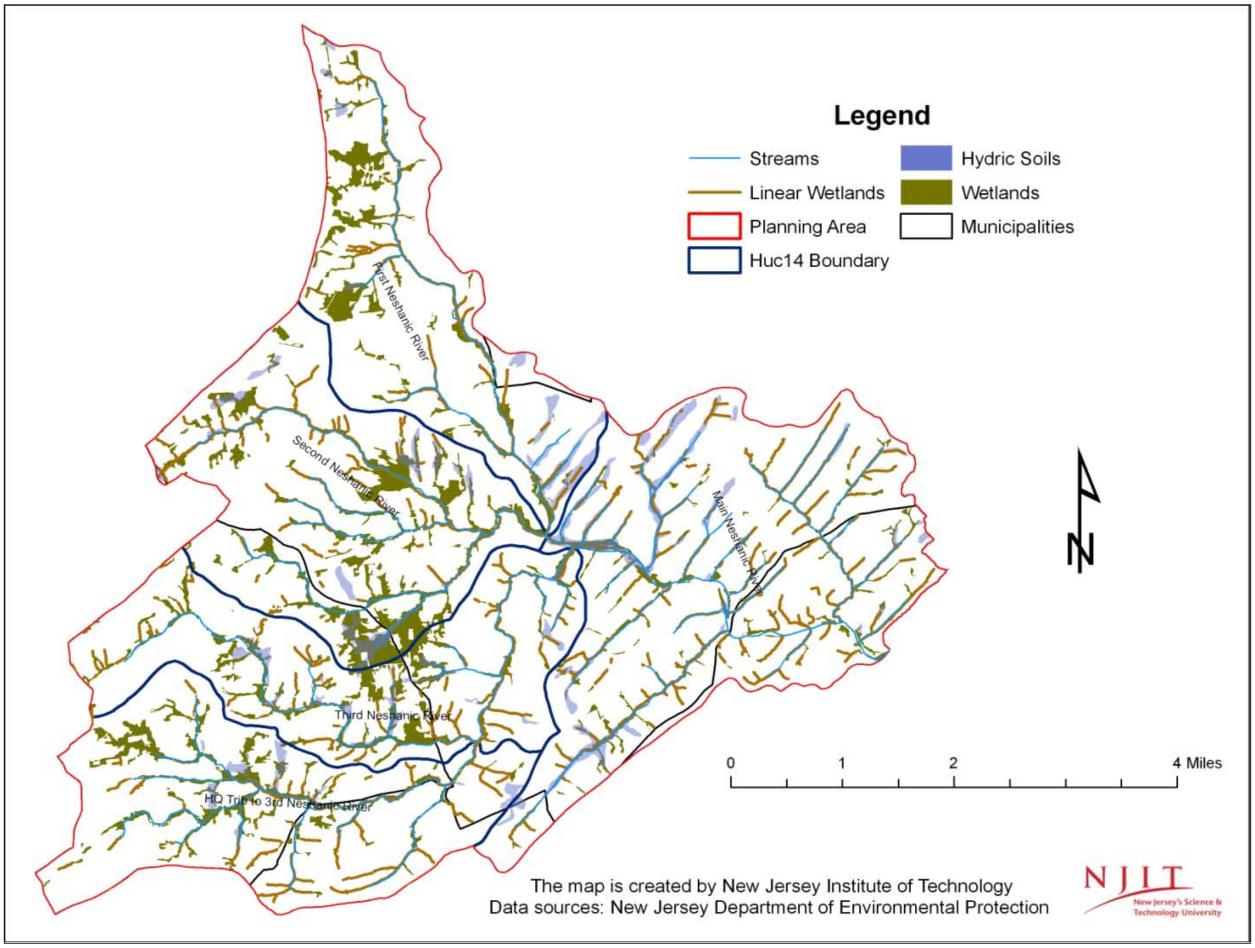


Figure 4.8: Spatial distribution of hydric soils, linear wetlands and wetlands in the Neshanic River Watershed

The NJDEP developed and maintains two types of wetlands information for general planning and regulatory purposes. The first type is delineated wetlands listed in the NJDEP land use/cover change database. These wetlands are primarily located along interior stream systems as well as wetlands that have been modified for recreational, agricultural or industrial uses. There are a total of 1,877 acres of delineated wetlands based on the NJDEP 2007 land use/cover database. Table 4.7 lists the types of wetlands and their NJDEP class codes and acreages. The dominant types of wetlands in the watershed are deciduous wooded wetlands (class code 6210) and modified agricultural wetlands (2140), which comprise 53 and 30 percent of the total wetlands in the watershed, respectively.

The second type of wetlands is the linear wetlands derived from the freshwater wetlands data developed by the New Jersey Freshwater Wetlands Mapping Program of NJDEP, which fulfills a requirement of the 1987 Freshwater Wetlands Act. This program mapped all freshwater wetland polygons greater than one acre in area and all linear freshwater wetland features greater than 10 feet in width. There are about 70.68 miles of linear wetlands in the watersheds.

Figure 4.8 shows the spatial distribution of both delineated wetlands and linear wetlands in the watershed. Delineated wetlands are primarily located in the upper part of the watershed (i.e., the First, Second, and Third Neshanic Rivers, and HQ tributary to the Third Neshanic River

HUC14s (02030105030010, 02030105030020, 02030105030030, and 02030105030040)). There are very few wetlands in the lower main Neshanic River HUC14 (02030105030060). Linear wetlands are generally located along streams.

Table 4.7: The types and areas of wetlands in the Neshanic River Watershed, 2007

Types of Wetlands	NJDEP Land Use Class Code	Acres	Percent
Agricultural wetlands (modified)	2140	558.68	29.77
Cemetery on wetland	1711	0.30	0.02
Coniferous scrub/shrub wetlands	6232	4.82	0.26
Deciduous scrub/shrub wetlands	6231	44.33	2.36
Deciduous wooded wetlands	6210	1,001.23	53.35
Disturbed wetlands (modified)	7430	10.28	0.55
Former agricultural wetland (becoming shrubby, not built-up)	2150	23.08	1.23
Herbaceous wetlands	6240	104.11	5.55
Managed wetland in built-up maintained recreational area	1850	18.24	0.97
Managed wetland in maintained lawn green space	1750	26.72	1.42
Mixed scrub/shrub wetlands (coniferous dom.)	6234	20.88	1.11
Mixed scrub/shrub wetlands (deciduous dom.)	6233	56.28	3.00
Mixed wooded wetlands (deciduous dom.)	6251	0.67	0.04
Wetland rights-of-way	1461	7.17	0.38
Total		1,876.79	100.00

Sources: NJDEP 2007 land use/cove database

4.2.3. Hydrologically Sensitive Areas

Hydrologically sensitive areas (HSAs) refer to watershed areas that are especially prone to generating runoff and, as such, are potentially susceptible to transporting contaminants to perennial surface water bodies (Walter et al., 2000). If HSAs are disturbed, significant changes in the movement of water, nutrients and biota within landscapes may occur (Clark et al., 2009).

Figure 4.9 shows the spatial distribution of HSAs in the watershed. The pattern of HSAs can be explained by the concept of variable source area (VSA) hydrology developed in the 1960s and has modified over the last forty years (Walter et al., 2002; Qiu et al., 2007). The detailed procedure for identifying the pattern of HSAs in the Neshanic River Watershed can be found in Qiu (2009). Specifically, HSAs are derived using a modified topographic index approach based on VSA hydrology that involves two steps. First, a digital elevation model (DEM) and the NRCS SSURGO soil database are used to generate the topographic index for each grid of the watershed; grid size is determined by the DEM resolution. The measured values of the topographic index in the Neshanic River Watershed range from 1 to 28. A higher topographic index value indicates a greater likelihood of saturation and runoff during a storm event. Second, HSAs can be defined as areas where the topographic index exceeds a specific threshold level. In this project, a threshold value of 11 was arbitrarily selected. Areas with a topographic index of 11 or higher were considered to be HSAs. Such areas cover about 2,642 acres (i.e., 13.7 percent of the watershed). A value of 13.7 percent is considered more practical than the 20 percent value suggested by Herron and Hairsine (1998). HSAs are mostly distributed in the upper part of the watershed. HUC14 02030105030010 (the First Neshanic River) has the most HSAs as shown in Figure 4.9. Although there are some HSAs distributed along the streams, most HSAs are located in the upland areas outside the immediate riparian areas of the streams.

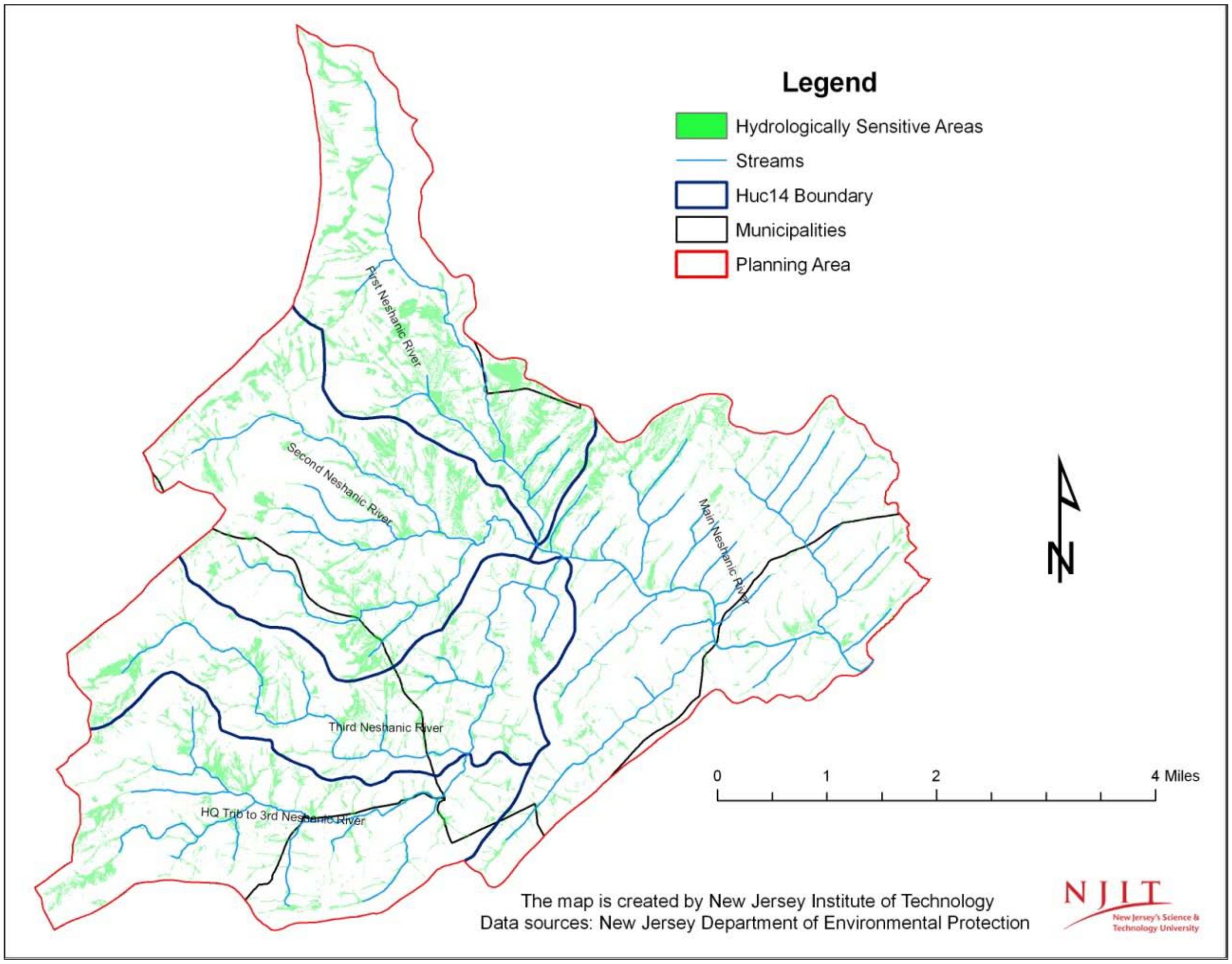
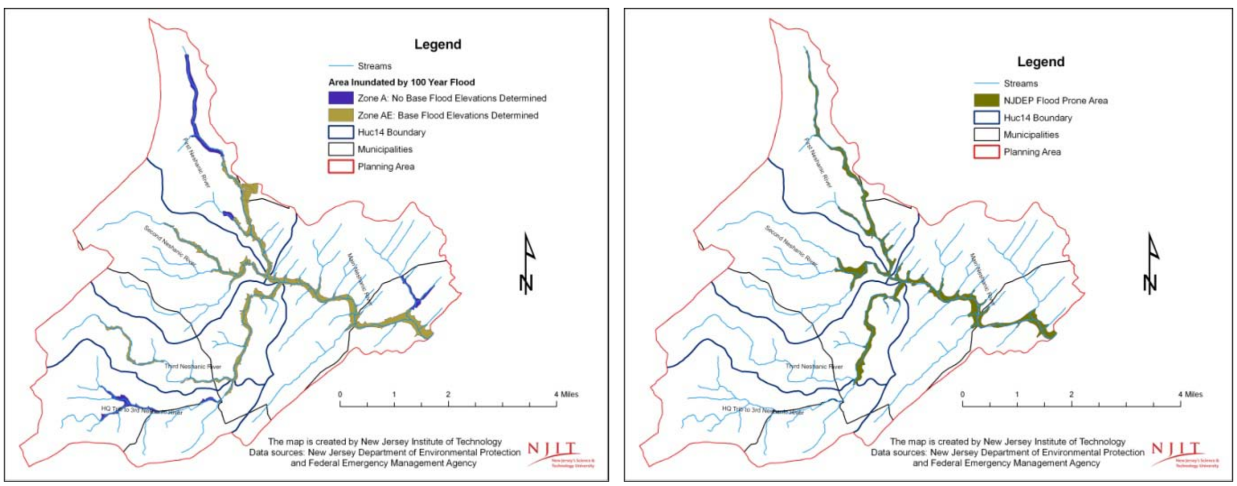


Figure 4.9: Spatial distribution of HSAs in the Neshanic River Watershed

Information on the HSAs is valuable for water resource management. Qiu (2003, 2009) demonstrated how such information can be used to prioritize conservation buffer placement in watersheds. Because of the profound impacts of runoff on environmental quality, the spatial pattern of HSAs can be used as a basis for prioritizing other conservation efforts in a watershed, such as conservation easements, open space and farmland preservation that target HSAs for achieving higher environmental benefits. Various land use planning tools and ordinances can be used to protect and preserve HSAs from urban development. Since the HSAs can be spatially displayed at high resolution, they can be valuable for designing onsite BMPs that mitigate the negative environmental impacts of runoff.

4.2.4. Floodplains

A floodplain is flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. The extent of floodplain inundation depends in part on the flood magnitude, defined by the return period. For example, the commonly used flood insurance rate maps typically depict both the 100-year and the 500-year floodplains. In addition to the flood magnitude, the extent of the floodplain is influenced primarily by topography as well as land use conditions in upland areas of the watershed. For example, increases in urban lands and roads have dramatic impacts on where the floods are likely to occur during a storm. Two sets of floodplain related spatial data are available for the Neshanic River Watershed: the flood hazard zones from the Federal Emergency Management Agency (FEMA) based on flood model projections; and the flood prone areas from NJDEP based on historical flooding. Figure 4.10 compares the FEMA's flood hazard map and NJDEP's flood prone area map.



(a) FEMA flood hazard map (b) NJDEP flood prone area

Figure 4.10: Comparison between (a) FEMA flood hazard map and (b) NJDEP flood prone area map in the Neshanic River Watershed

FEMA identifies five flood hazard zones two of which are relevant to the watershed as described below:

- Zone A – an area inundated by 1 percent annual chance of flooding for which no Base Flood Elevations (BFEs) have been determined.
- Zone AE – an area inundated by 1 percent annual chance of flooding for which BFEs have been determined.

BFE is defined as the elevation associated with the flood that has a 1 percent annual chance of being equal to or exceeded in any given year. FEMA identified 989 acres of flood hazard area of which 218 acres are in Zone A and 771 acres are in Zone AE. NJDEP identified 695 acres of flood prone areas in the watershed.

4.2.5. Riparian Areas

Riparian areas are the land areas adjacent to the stream bank. Riparian areas connect the terrestrial landscape with the aquatic environment and play a critical role in mediating the effects of landscape disturbance on streams; therefore, human disturbances in the riparian areas tend to exert a stronger influence on stream condition than areas further away from the streams (Gregory et al., 1991; NRC, 2002). They are CSAs like the floodplain, but are generally more extensive. Protection of riparian areas has become an important water resource management goal in many watersheds. The Raritan Basin Watershed Management Plan (NJWSA, 2002a) identified the damage to streams and their riparian areas as one of six critical issues in the basin. The restoration, protection and preservation of riparian areas of the Raritan Basin are among the key strategies for improving water quality and enhance aquatic and wildlife habitats. NJWSA (2002a) defined riparian areas as areas adjacent to streams that are either within the 100-year floodplain, contain hydric soils, contain streamside wetlands and associated transition areas or are within a 150-foot or 300-foot wildlife corridor on both sides of a stream.

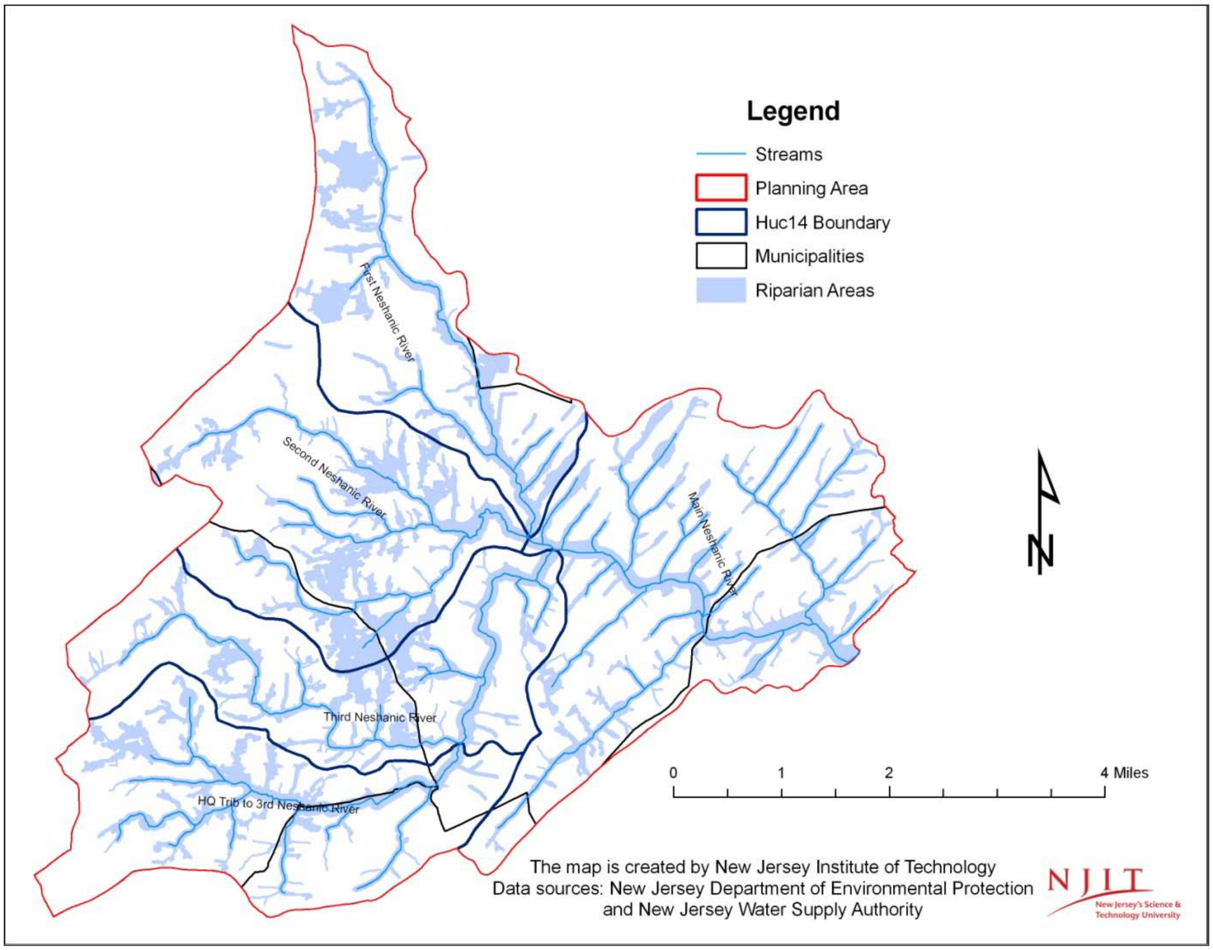


Figure 4.11: Spatial distribution of the riparian areas in the Neshanic River Watershed

The width of the riparian areas varies along the stream corridors depending on site-specific conditions. The NJWSA derived the riparian areas using the 1995 NJDEP stream network data for the Raritan Basin. Since then, updated 2002 stream network data has been released by NJDEP. Compared to the 1995 stream network data, the 2002 stream network data contain more stream miles, especially the headwater streams in Raritan Basin. In this project, riparian areas are redefined to include the NJWSA's original riparian areas plus the 100-foot buffer areas of the additional streams in the 2002 stream network data. The total area of the delineated riparian areas in the watershed is 5,714 acres. Figure 4.11 shows the spatial distribution of the riparian areas in the Neshanic River Watershed.

4.3. **Land Use**

4.3.1. Settlement and Historical Changes

The land in the watershed was originally the territory of the Lenni Lenape Native Americans, as was all of Hunterdon County. The area was first settled in the early 18th century by Colonel John Reading (1657-1717), who was instrumental in the creation of Amwell Township in 1708 and also worked for the creation of Hunterdon County in 1714. Amwell Township was established by a royal patent from Queen Anne in 1708. The territory of the original Amwell Township comprised 200 mi^2 and included present day Delaware Township, Raritan Township, Readington Township, East and West Amwell Townships and portions of Clinton, Lebanon and Tewksbury Townships. Raritan, East Amwell and Delaware Townships were incorporated as independent townships by an Act of the New Jersey Legislature on April 2, 1838, from portions of the now-defunct Amwell Township. Flemington town was formed within Raritan Township on March 14, 1870, and became an independent borough on April 7, 1910 following an Act of the New Jersey Legislature (Snyder, 1969).

Row crop agriculture was essentially the primary land use in the watershed because of its fertile farmland during the early settlement. However, as early German and English settlers engaged in industries in the surrounding urban centers, their dependence and demand for farm products increased. Poultry and dairy farms gradually superseded crops and became an important part of agriculture. The watershed and surrounding communities remained agricultural until the 1970s when urbanization and suburbanization started to significantly affect land uses. Like the rest of Hunterdon County, land use patterns were first driven by the high-density residential development around the existing urban centers in the 1970s to accommodate low-income housing needs, followed by corporate and industrial expansion into rural communities in the 1980s. The presence and employment of the corporations and industries spurred a new round of urban development starting in the 1990s, characterized by the medium and low density residential development. In the 2000s, residents from the city and/or suburbs moved into exurban areas that have very low density residential development. Suburbanization and exurbanization in the last two decades blurs the traditional rural and urban interfaces and creates the communities that exist today.

4.3.2. Historical Land Use Change

The NJDEP maintains a detailed land use/cover change database. The land uses in this watershed are classified into six broad land use categories, including agriculture, barren, forest, urban, water and wetlands, and around 50 subcategories following a 4-digital land use classification code based on a modified Anderson Land Classification system (NJDEP, 2010). Figure 4.12 depicts the spatial distribution of land uses in the Neshanic River Watershed in 1986, 1995, 2002 and 2007. Figure 4.12 shows the expansion of urban lands and the loss of agricultural lands through the watershed over the past two decades.

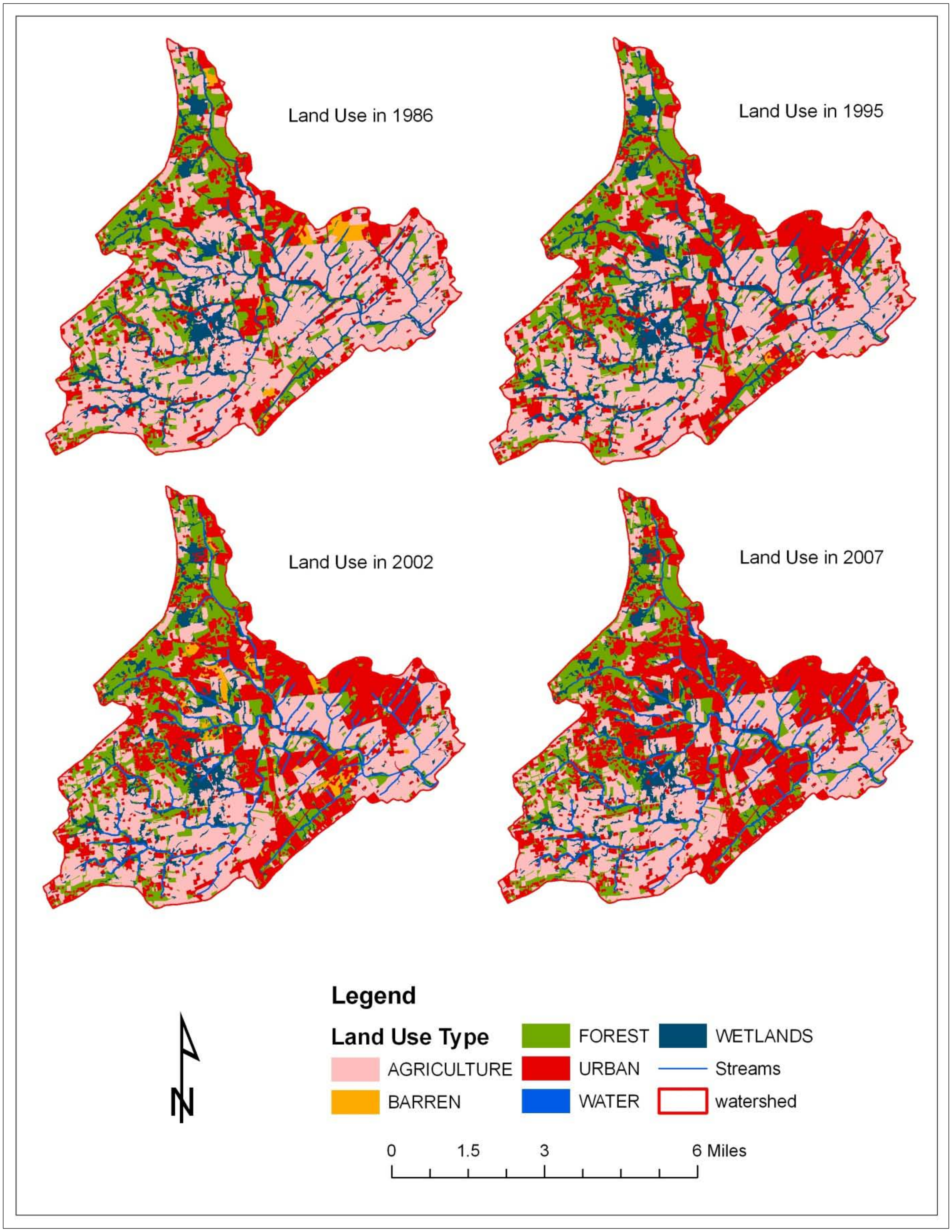


Figure 4.12: Spatial distribution of land uses in the Neshanic River Watershed, 1986, 1995, 2002 and 2007

Table 4.8 gives the area distribution in various land uses in 1986, 1995, 2002 and 2007. The percentage of urban land in the watershed increased from 17 percent in 1986 to 25 percent in 1995, 31 percent in 2002 and 35 percent in 2007. The increases in urban land are accompanied by notable decreases in agricultural land in the watershed. Agricultural lands in the watershed decreased from 51 percent in 1986 to 43 percent in 1995, 36 percent in 2002 and 35 percent in 2007. Forest area increased from 1986 to 1995, but decreased from 1995 to 2007. Wetland areas declined continuously during the past two decades.

Table 4.8: Land uses in the Neshanic River Watershed, 1986, 1995, 2002 and 2007

Land Use Type	1986		1995		2002		2007	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	10189.2	51.4	8531.5	43.0	7220.9	36.4	6937.3	35.0
Barren	287.7	1.5	63.8	0.3	333.9	1.7	53.1	0.3
Forest	3897.5	19.6	4138.5	20.9	4069.7	20.5	3905.7	19.7
Urban	3284.2	16.6	4970.1	25.0	6199.7	31.2	6972.5	35.1
Water	40.8	0.2	52.7	0.3	93.6	0.5	95.9	0.5
Wetlands	2141.9	10.8	2084.7	10.5	1923.5	9.7	1876.8	9.5
Total	19841.3	100.0	19841.3	100.0	19841.3	100.0	19841.3	100.0

4.3.3. Preserved Farmlands

There are 2,975 acres of preserved farmland in the watershed. Figure 4.13 shows the spatial distribution of these preserved farmlands. Farmland is primarily located in HUC14s 02030105030 (the HQ tributary to the Third Neshanic River), 02030105040 (the Third Neshanic River) and 02030105060 (the Main Neshanic River). In addition to being essential for agricultural production, farmland provides scenic benefits to residents. Rapid development in New Jersey has stimulated the rise of farmland preservation as an important policy tool to combat urban sprawl and enhance the quality of life in local communities. In New Jersey, the Farmland Preservation Program is administered by the State Agriculture Development Committee (SADC). Farmland preservation was traditionally achieved by purchasing farmland. Recently, the purchase of the development rights or easements has become a popular tool to preserve farmlands. An example of the latter is the Municipal Planning Incentive Grant (PIG) Program that enables SADC to provide grants to eligible counties and municipalities to purchase development easements for permanent preservation of farmland in designated areas. Forty-three 43 percent of all agricultural lands in the watershed are preserved through various programs. Of the preserved farmlands, 1,765 acres are preserved through the traditional farmland preservation programs and the remaining 1,210 acres through the PIG program.

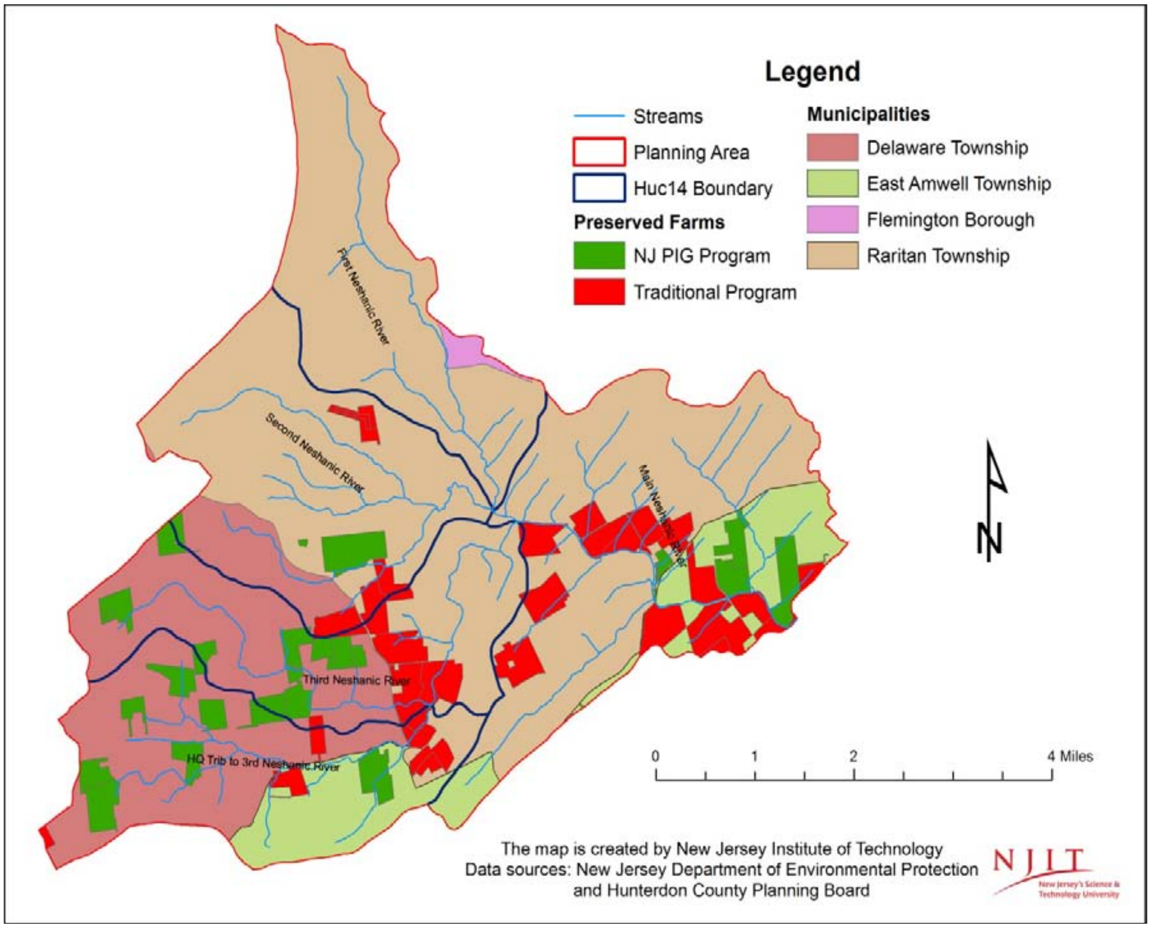


Figure 4.13: Spatial distribution of the preserved farmlands in the Neshanic River Watershed

4.3.4. Preserved Open Space

Open space generally refers to a tract of land that is protected from further development. While preserved farmlands are used to protect agriculture, preserved open space has various uses, including recreational parks, natural preserves and schools. Open space offers aesthetic view, recreational opportunities, and ecological benefits and are important assets to the local communities. Many different preservation programs have been developed by state, county and municipal governments, private organizations and individuals. The open space preservation programs in this watershed include the Green Acres programs operated by the state of New Jersey, the Hunterdon County Parks Service and individual municipalities and organizations.

The preserved open space by Board of Education includes Delaware Township Elementary School and Barley Sheaf School and Robert Hunter School in Raritan Township. The preserved open space by county is county parkland including 92 acres of Uplands Reserve and 241 acres of Hunterdon County Golf Course. Both are in Raritan Township. The preserved municipal open space are primarily municipal parks and open space. Except the Marion F. Clawson Memorial Park located along the south edge of the watershed in East Amwell Township, all other municipal open space is located in Raritan Township. There is also a piece of 38 acres of conservation lands located in Raritan Township in adjacent to Flemington Borugh preserved by a non-profit organization. There is also a tiny piece of common-owned open space along the east edge of the watershed in Raritan Township preserved by a private entity. The opens space preserved by the state is 59 acres of Abratiles' Pine Stand Preserve owned by New Jersey Natural Lands Trust.

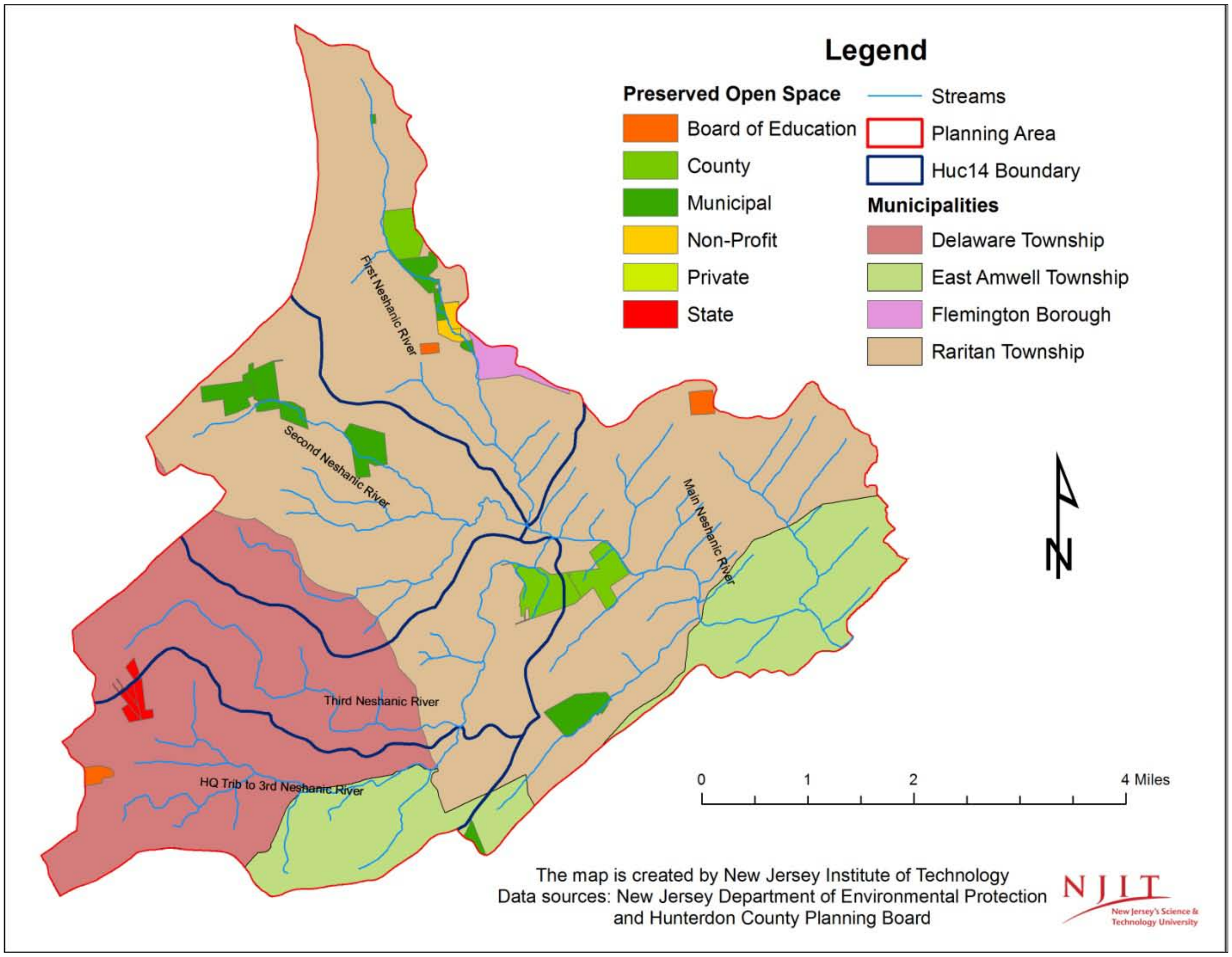


Figure 4.14: Spatial distribution of the preserved open space in the Neshanic River Watershed

4.3.5. Land Use Controls and Ordinances

In addition to farmland and open space preservation as discussed above, municipal master plans and various land use controls and ordinances are also used to dictate land use changes and protect water quality. Examples include stream corridor protection, steep slope restrictions, septic management and impervious restrictions.

Stream corridor protection is mandated by the NJDEP Stormwater Management Rule (NJAC 7:8), the NJDEP Flood Hazard Control Act (NJAC 7:13); and the state wetland protection and mitigation rules and implemented through municipal stream buffer ordinances to prevents urban development and other disturbance in the areas adjacent to the streams for water quality improvement. The purpose of stream corridor protection is to maintain or enhance the current functional value of the streams and overall condition of the stream corridor protection area. The NJDEP Stormwater Management Rule requires the stream corridor to include the stream buffer area that is at least 150 feet as measured perpendicular to the streams. The NJDEP Flood Hazard Control Act (NJAC 7:13) defines the riparian zone or corridor as the 75, 100, 150 or 300 foot along the streams depending on the type of the streams. The stream corridor protection area defined by municipalities often includes not only stream channels and their riparian areas, but also floodplains, and the sloping areas that are adjacent to the riparian areas of the streams and floodplains.

Steep slope restriction is required by the NJDEP Water Quality Management Planning Rules (NJAC 7:15) to control the land use changes and any disturbance in the areas with steep slope. Municipalities implement steep slope restriction through zoning regulations for development on and disturbance of steep slopes. The purpose of steep slope restriction is to prevent soil erosion and reduce the risk of landslides that endanger lives, damage property and infrastructure, harm water quality, and degrade wildlife habitat. Additional benefits include preservation of the aesthetic character of visually prominent hillsides by discouraging vegetative clearing and excessive earthwork to accommodate development. Steep slope restrictions vary by each slope tier (10 to 20 percent and 20 percent and greater) with a series of permitted, prohibited, and conditional uses. In general, development is prohibited in areas with slopes that are equal to or greater than 20 percent as measured over any minimum run of 10 feet.

Impervious surface restriction limits the rate of impervious surface in a municipality or watershed and helps to achieve the goals of stream protection. The rate of impervious surface in a municipality or watershed is measured by the percentage of the total area of impervious surface to the total area of the municipality or watershed. As urban land expands, so do the impervious surfaces such as roads, streets, parking lots, driveways and rooftops. With increased pavement, rainfall is less able to percolate into the ground. This raises the volume and velocity of runoff that carries pollutants and sediments into waterways. Groundwater recharge zones are diminished and water tables can be threatened (USEPA, 2000). Increases in impervious surface due to urban development are considered to be one of the largest threats to water quality. Much of the current literature indicates that once the rate of impervious cover exceeds the threshold level of about 10 percent in a watershed, streams typically show signs of declining stream health; at 25 percent impervious cover, streams will no longer support their designated uses in terms of hydrology, channel stability, habitat, water quality, or biological diversity (Schueler 1994).

The NJWSA (2008) assessed the status of stream corridor protection, steep slope restriction and impervious surface restriction in Delaware and Raritan Townships, the two largest municipalities in the watershed and made the following conclusions: both townships have a good stream corridor ordinance, but fair steep slope and impervious surface restriction. The NJWSA recommended that both townships revise the existing Steep Slope Provisions of the Land Use Code in conformance with the Water Quality Management Rules Planning (N.J.A.C.7:15) and reduce permitted impervious surface areas to 5% in areas zoned agricultural, rural or low density residential.

4.4. **Stormwater Infrastructure**

4.4.1. Stormwater Infrastructure Systems

As one of the first portions of Hunterdon County to urbanize, the Neshanic River Watershed possesses some of the County's oldest stormwater infrastructure. The watershed has mixed land uses and has three different types of stormwater infrastructure systems: urban; suburban subdivision; and ditch and pipe.

The urban systems are found along the highways and in commercial centers where there is a high percentage of impervious surfaces. These well-connected impervious surface areas generate much more stormwater then do the less developed parts of the watershed and therefore require a higher density of catch basins and/or other stormwater collectors. These areas have extensive subsurface pipe networks. Roof drains are commonly directly connected to the subsurface pipe system, which is interconnected so as to pass stormwater across maintenance jurisdictions. Detention basins are used in connection with commercial structures. These urban systems generally can effectively and quickly remove stormwater from private properties. However, these systems will generate large amounts of concentrated runoff, which contributes to flash flooding, causes significant distresses to the streams which leads to streambank erosion and water quality degradation. They are very expensive to build and maintain.

The largely autonomous suburban subdivision systems are located throughout the watershed. These systems typically include lot line swales that drain to catch basins located along residential roads, which in turn feed a subsurface pipe network. These pipes discharge stormwater to one or more detention basins usually located in the lowest portion of the development. Suburban subdivision systems tend to be well planned and extensively reviewed, and reflect design standards at or near the time of construction. Compared to the urban systems, the suburban subdivision systems might be cheaper to build and maintain. They are also effective in removing stormwater from properties, and therefore have the similar destructive effects on watershed hydrology and stream integrity.

The ditch and pipe system is a low cost stormwater infrastructure system found primarily in more rural areas located in the southern and western parts of the watershed. It is characterized by open roadside ditches, driveway culverts and an absence of detention basins. Maintenance is primarily the responsibility of the municipality and most of the stormwater infrastructure is confined to road right-of-ways. This portion of the stormwater system typically lacks modern designs or upgrades. Lack of modern design and poor maintenance makes these systems a source of water pollution.

4.4.2. Stormwater Infrastructure Inventory

Table 4.9 gives a brief description of the various types of stormwater infrastructure that were inventoried in the watershed. A stormwater infrastructure inventory was performed to map and assess the stormwater infrastructure in the watershed. The inventory effort is based on *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments* by Brown et al. (2004). This document provides excellent background information on mapping and understanding municipal stormwater systems. The general types of stormwater infrastructures inventoried include dams, culverts, swale and ditch, catch basin, and catch basin pipe inlet, discharge pipe and outfall, detention basin, detention basin inflows, detention basin discharge, and detention basin low flow channel. Their locations and general attributes were recorded using a Global Positioning System (GPS) following GPS Data Collection Standards by NJDEP (2002).

Table 4.9: Types and numbers of inventoried stormwater infrastructure

Name	Brief Description	Num
Catch Basins	The primary collection points where stormwater enters into the municipal stormwater system	4,482
Catch Basin Pipe Inlets	Serve the same purpose as catch basins or storm drains, but omit the grate, head and sump found in catch basins	115
Culverts Up Stream	A culvert is a conduit used to enclose a concentrated flow. The upstream portion of a culvert signifies the point at which water enters the conduit	714
Culverts Down Stream	The downstream portion of a culvert signifies the point at which water exits from the conduit	714
Dams	Stream structures that hold back, impound or restrict streamflow	8
Detention Basin Discharges	The point of discharge of a detention basin commonly located in low area adjacent to streams or wetlands	118
Detention Basins	Constructed impoundments that may include bermed stream corridors for reducing flooding, lowering the volume and velocity of stormwater flows and/or improving water quality	153
Detention Basin Outlet Structures	A structure that regulates stormwater flows exiting from a detention basin; ranges from simple concrete weirs regulating flows to complex multi-outlet cast concrete towers	151
Detention Basin Inflows	Pipes that carry stormwater into a detention basin	220
Detention Basin Low Flow Channels	Defined flow paths located on the floor of a detention basins. Some basins have multiple channels while others do not have a low flow channel.	196
Discharge Pipes and Outfalls	The discharge pipes or pipe outfalls located near streams, wetlands or other low lying areas where stormwater exits the stormwater system	409
Swales and Ditches	The defined flow paths that direct stormwater flows; most common in rural areas where piped drainage is less prevalent	853

4.4.3. Stormwater Infrastructure Assessment

A general assessment of infrastructure conditions is given for three major types of stormwater infrastructure. There are 853 (40.06 miles) mapped swale and ditch segments. Of the mapped segments, 185 (8.68 miles) are actively eroding, contributing sediment to stormwater which flows through them and in urgent need of repair. Of the 853 segments, 515 (25.81 miles) have exposed earth in at least portions of the conveyance and need some repair. Only 153 (5.57 miles of) swale and ditch segments are in good condition and consistent with the soil erosion standards for a grassed waterway or rip-rap channel. Swales in good condition help to improve water quality or at least do not further degrade water quality (Schueler, 1995). Properly vegetated swales with good maintenance regimes have been shown to promote recharge while reducing volume, velocity and peak flows (The Center for Neighborhood Technology, 2009).

Discharge structures are made up of detention basin inlets, detention basin discharges and discharge pipes and outfalls that denote locations where piped stormwater flows exit the covered (piped) system and re-enter the environment. As shown in Table 4.10, there are 747 mapped discharge structures including 220 detention basin inflows, 118 detention basin discharges and 409 discharge pipes and outfalls. Out of the 747 mapped discharge structures, 39 were found to be eroding and 158 were depositional. Eroding conditions indicate the frequent presence of stormwater flow with high velocity. Depositional conditions indicate the presence of accumulated sediments and debris. Also of interest is the fact that the number of direct discharge pipes and outfalls (409) is almost four times the number of detention basin discharge outfalls (118). The nearly 4:1 ratio of direct discharge pipes and outfalls to detention basin discharge outfalls implies that, when designing those detention basins, a large amount of the stormwater in the watershed is discharged without considering volume and velocity reductions. Retrofitting those discharge structures involves correcting eroding conditions by adding energy dissipaters (i.e., conduit outlet protection) and regularly removing the sediments and debris accumulated in depositional areas. Such retrofitting will decrease bank erosion, reduce siltation and decrease non-point source pollution (The Center for Neighborhood Technology, 2009).

Table 4.10: Status of stormwater discharge structures in the Neshanic River Watershed

Type	Detention Basin Outfalls	Detention Basin Inflows	Outfall pipes	Total
Total	118	220	409	747
Erosive	5	13	21	39
Depositional	34	*	124	158

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

There are 153 mapped detention basins in the Neshanic River Watershed that have a variety of designs, including wet ponds, infiltration basins, bio-retention basins, extended dry detention basins, and bermed-off stream corridors with flow control weirs. There are several maintenance levels ranging from heavily landscaped and manicured to benign neglect and outright abandonment. Virtually all detention basins in the watershed present an opportunity for upgrades or retrofits. Many detention basins have various bottom conditions that are suitable for retrofits: 106 of 153 basins were found to have mowed turf bottoms; eight basins had weeds or successional vegetation due to a lack of mowing; three basins were fully overgrown with trees and shrubs; and one basin lacked any vegetation and was covered with deposited material. Low flow channels were very common in the watershed's detention basins. Of the 196 mapped low flow channel segments, 156 were found to be concrete. Only one third of the detention basins have outlet structures with a three-inch water quality orifice required by NJDEP. The three-inch orifice outlet structure extends the water detention time in the basin to allow TSS and the attached nutrients to settle and therefore achieve certain water quality benefits. The remaining detention basins in the watershed were not constructed to achieve water quality benefits through extended water detention.

The assessment of the conditions of these stormwater infrastructure systems reveals infrastructure retrofitting opportunities. Detailed mapping of these stormwater infrastructures and assessment of their conditions shows the need for implementation of BMPs to manage stormwater runoff and mitigate its negative impacts on watershed hydrology and stream water quality.