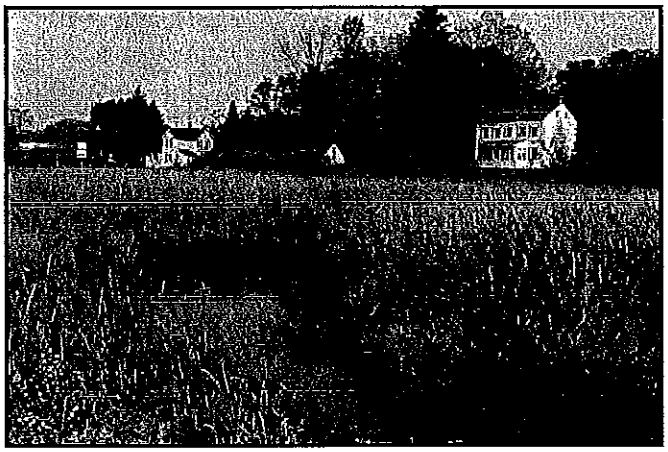
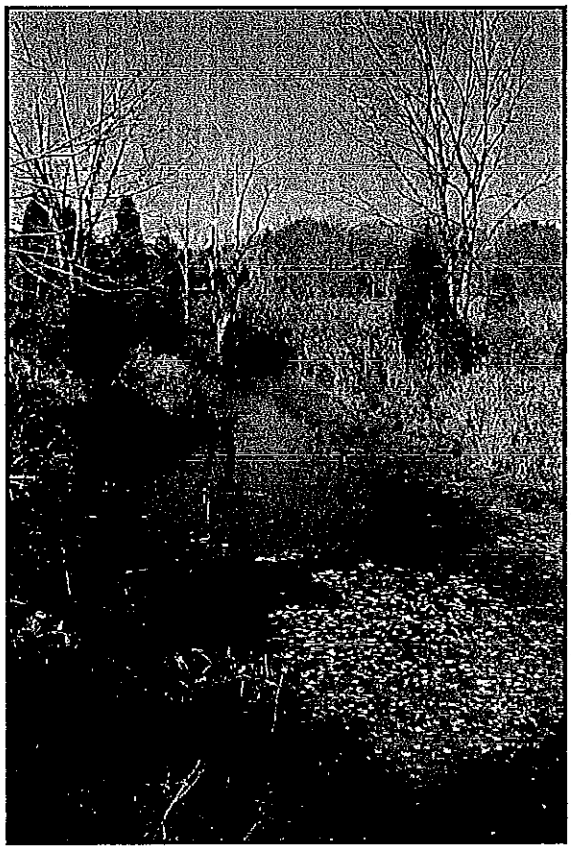
ANDOVER TOWNSHIP

NATURAL RESOURCE INVENTORY





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Andover Township Environmental Commission
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Andover Township

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Introduction

Andover Township is located in the Southern portion of Sussex County (Figure 1). The Township has a diverse landscape and is enriched with an abundance of natural resources and scenic qualities. Treasured for its rugged hilly terrain, water resources and unique geologic conditions, Andover Township provides critical habitat areas for State Endangered species, and a rich forest ecosystem. The natural systems that reflect the overall health and functioning of the environment transcend political boundaries. Effective protection of the Township's natural resources and regional ecological systems will require both local and regional planning efforts. Identifying natural resources and systems is the first step in protecting shared natural resources and ecosystems within the Township, County and State.

This Natural Resource Inventory (NRI) documents and characterizes Andover's natural resource base. The NRI, which will form the basis for strategies to protect the Township's natural resources base, is a building block upon which resource protection regulations will be developed.

Purpose and Objectives

A Natural Resource Inventory (NRI) identifies, quantifies and describes the environmental resources present in the community. Through mapping and description, critical factors can be identified and highlighted; this process forms the basis for determining relative importance for future planning efforts.

GIS digital data has simplified the quantification and description of resource factors. The ease with which data can be analyzed and displayed allows detailed studies to be undertaken for a large area. The inter-relationship of physical features and their relative importance can be identified. In this fashion, both competing and synergistic relationships among natural resources can be defined and explored.

An NRI is particularly useful in identifying and describing many of the natural resources and factors that play a unique role in planning and community development. It is often the basis for future efforts to establish land use and preservation policies in community planning documents; these documents will shape the future of the Township.

The purpose of this Natural Resource Inventory is to document in detail the resources and importance of what most people intuitively view as an extremely fragile ecosystem. The objective is to provide a firm basis for the establishment of sustainable policy and land use regulation by the Township.

Processes and Sources

Digital datasets from the Andover Township Geographic Information System (GIS) have been used extensively in the preparation of this NRI. The source and original scale of individual datasets utilized in map generation are noted on each map. The scale and resulting level of accuracy of available data should always be considered and verified when making specific land use decisions.

National Map Accuracy Standards (NMAS) govern production of datasets; when digitized, source data with a scale of 1:20,000 or smaller must have 90% of tested points within 1/50 of an inch of their location on the map and data presented at a scale greater than 1:20,000 must have 90% of tested points within 1/30 of an inch of their location on the map. Provided a data set meets NMAS, its scale can be translated into ground accuracy. As an example, a map at 1:100,000 scale requires that 90% of tested points fall within 1/30 of an inch of their location on the map from which they were digitized. This translates to roughly 166 feet on the ground, as noted in the table to the right. This implies that a feature or line can be depicted 166 feet from its actual location on the ground and still meet NMAS. Source data scale and subsequent ground accuracy must therefore be considered in decision-making.

National Map Accuracy Standards

Map Scale	Ground Meters	Ground Feet
1:12,000	10.2	33.5
1:24,000	12.2	40.0
1:100,000	50.8	166.7
1:250,000	127	416.7
1:500,000	254	833.4
1:2,000,000	1,016	3,333.5

GIS digital data has simplified the tasks of identifying, quantifying and describing the resource base of the community. Multiple layers of data can be viewed together within the geo-referenced framework of a digital base map, providing the means to analyze individual resources, along with their role and importance in the overall ecosystem. In this fashion, both competing and synergistic relationships among natural resources can be defined and explored. Given difficulty in viewing maps at the scale necessary for reproduction, readers wishing to view maps at an enlarged scale should refer to the CD data sets available through the Township that can be viewed through the use of Adobe software.

Identification, quantification and description are the beginning phases of analysis for the preparation of the NRI. Many of the natural resources and factors that are present play a unique role in planning and community development. The NRI is particularly useful in preparing a land use plan or conservation plan, key policy documents that spell out goals, objectives and recommendations to protect the natural resources found in a community.

Historic and Cultural Resources

Andover Township has a long and illustrative history that has defined its current natural and man-made resources. The Township was first settled by the Lenni Lenape Indians several centuries before the first European settlers appeared in New Jersey. The Lenape used the western tip of Lake Iliff as overnight camping grounds on their way to the shore. Here they found abundant fish and game suitable for a comfortable "summer" camp grounds. The rivers and streams of northern New Jersey also brought the first European settlers to the regions as they navigated the area through waterways.

The discovery of available iron in the region brought the first permanent European settlers to the region. The use of the forest and rivers for fuel and power supply lent the region to be developed quickly as an iron manufacturing area. Andover iron was quickly sought after as being a higher grade and stronger amalgamation. Since 1674, this "Old Andover" had been supplying

Philadelphia with iron of superior quality. In 1760, Allen and Turner of Philadelphia built a blast furnace and forge on a branch of the Pequest River, in the present Andover Borough.

The process of mining and processing iron at the time required large quantities of wood for the forges. All of the iron ore was smelted with charcoal and all the forges burned it. Except for the steepest slopes and rockiest ledges, every acre of Sussex County was cut over at one time. It took skilled hands to make charcoal and not ashes. It was big business and the air of Sussex County was blue with smoke. The earliest forest was probably more attractive than our current forest. What we see now is probably the third growth, since the land was again cut over for lumber after the charcoal burners went away.

During the Revolutionary War, the Andover furnace was brought under military control and the iron produced there was used to manufacture cannons and artillery for the Continental Army. It is said that the iron from Andover was part of the "Great Chain" or "West Point Chain", which kept the British from coming up the Hudson River during the Revolution. After the war drew to a close, the work at the Andover Iron Works discontinued, around 1783.

The Andover Mine lay idle from about 1800 to 1848. In that year, Cooper & Hewitt acquired the property in the name of the Andover Iron Company. Under Edward Cooper and Abram S Hewitt, the mine produced at the rate of 50,000 tons of ore annually, at a time when all production of Sussex and Warren mines was only 143,000 tons. To transport this load they "steel-shod" the old mule road to the Morris Canal at Waterloo, and this became the first "rail" road in Sussex Co. It later became known as the Sussex Mine Railroad. Abe Hewitt built, at Phillipsburg, the largest blast furnace seen in America at the time. He roamed the hills of north Jersey, visiting old forges and furnaces, testing and sampling. In 1847, he found what he wanted at the old Andover Mine. When he tested some fragments of pigs he found in the underbrush, his eyes shown. In his hands, he held the whole railroad rail business of the United States. Early rails would split frequently, and Hewitt knew if he could get good quality ore, he could make rails that wouldn't split. From this Andover ore, he was able to make not only his rails, but also the first structural steel. In 1855, Nassau Hall at Princeton University was gutted by fire. It was rebuilt inside with Hewitt's railroad rails for I-beams. They are still there today.

Mining in Andover continued to a lesser extent throughout the 1800's, with an increase during the civil war when the iron was used for the production of rifles. Several large homes and smaller village settlements appeared in Andover throughout this time. The larger homes, built by the wealthier and more established families of the region can still be seen today. Smaller historical hamlets, built to service and house the working class are still present in their historic locations. Germany Flats, one of the earlier settlements in Andover Township, in the northeastern section of the Township, got its name due to the nationality of the settlers farming here before and after the revolution.

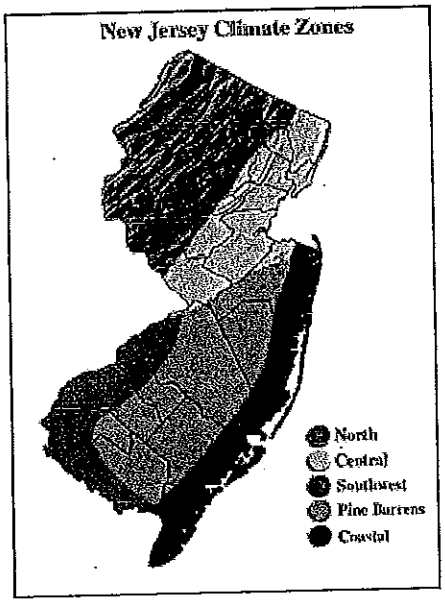
The history of the Andover Township goes beyond what is demonstrated here. For more information on historic events, areas, and structures in the Township, the following resources offer an intriguing and in-depth look:

"History of Sussex & Warren Counties", J. P. Snell, 1881, Everts & Peck, Philadelphia
Edsall's "Centennial Address", 1853
Swayze's "Historical Address", 1903
"Early Forges & Furnaces in New Jersey", Boyer
"300 Years of Mining in Sussex County, New Jersey", John L. Baum, 1973, Sussex Co. Historical Society
"Historical Sketch of the County", 1872
"Gazetteer and History of New Jersey", Cordon, 1834"
"The New Jersey Herald"
"The Sussex Register"
"Archives of the State of New Jersey"

Climate[1]

When viewed on a global scale, Andover Township is situated in the North Temperate Zone, the part of the Earth's surface between the Arctic Circle and the Tropic of Cancer. Temperate forests occur in eastern North America and central Europe. This forest biome has well defined seasons with distinct winters, but also has moderate climate and a growing season of 140-200 days during 4-6 months frost-free months. Fertile soils support temperate forests and moderately dense forest canopy, which allows light penetration, promotes a well-developed and richly diversified understory, and animal life.

At a local level, the Township is in the northern climate zone of New Jersey, comprised mainly of the counties stretching northeast from the southern boundary of Hunterdon County to the New York State Border. Sussex County is generally not influenced by the Atlantic Ocean and therefore has a continental type of climate. Prevailing winds are from the southwest in summer and from the northwest in winter. Generally, January is the coldest month with a mean temperature of 24.4 degrees while July is the warmest with a mean temperature of 71.2 degrees Fahrenheit. The annual average temperature is 48.4 degrees Fahrenheit.



The continental type of climate means that Andover generally has colder temperatures and greater snowfall in winter, with a greater average annual precipitation overall as compared to areas in central and southern New Jersey. Snowfall amounts average 48.3 inches.

The length of growing season, characterized by the dates of first and last killing frost, varies within the climate zone as well as from year to year. However, the growing season averages 155 days. The average date of the last killing frost is May 4 and the

1 "Divisional Normals and Standard Deviations of Temperature, Precipitation, and Heating and Cooling Degree Days", Climatography of the United States No. 85. National Oceanic and Atmospheric. "New Jersey Climate Overview", Office of the New Jersey State Climatologist web site, URL http://climate.rutgers.edu/

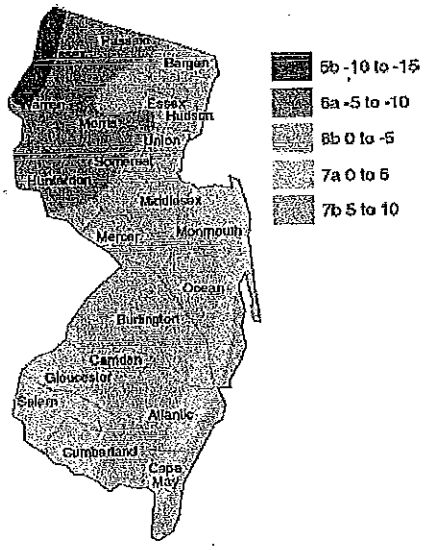
average date of the first killing frost is October 7. Areas within the northern climate zone have, however, experienced killing frosts as early as mid-September and as late as mid-June.

Another climate indicator is the hardiness zones established by the United States Department of Agriculture. As depicted on the adjacent map, Andover Township falls within Zone 6a, with an average annual minimum temperature range of -5 to -10 degrees Fahrenheit. The Indicator Plant Examples for Zone 6 that are native to the region include:

Quercus rubra (Red Oak)
Acer saccharum (Sugar Maple)
Betula lenta (Sweet Birch)
Lindera Benzoin (Spice Bush)

Hardiness zones are critical for successful cultivation or maintenance of landscape plant material. Landscape plants are rated by the minimum zone that can be tolerated. As an example, if a shrub is rated as hardy in Zone 7a, it will tolerate an average annual minimum temperature of 0 to 5 degrees Fahrenheit, and can survive in any Zone above 7a. It would likely not survive winters in Andover Township, however, as it is rated within Zone 6a. Aside from cold hardiness, a number of other factors affect plant growth. These include soil pH, sun exposure, rainfall and artificial micro-climate factors. Artificial micro-climate factors are those which can be altered by the nature of the built environment; proximity of buildings, artificial landform (severe grading), adjacency to a highway or parking lot and planting of material in planters or other elevated structures can all affect plant growth.

New Jersey Hardiness Zones



Source: *Purdue University Center for New Crops and Plant Products*

Land Use/Land Cover

According to 2002 data on land use/land cover published by the New Jersey Department of Environmental Protection (NJDEP), Andover Township is primarily characterized by forested (49.7%) land cover. Urban land cover accounts for 19.9% of the Township while wetlands account for 14.4%. The remaining land cover includes agriculture (11%), water (4.3%) and barren land (0.7%). Figure 2 depicts a Level I (generalized) Land Use/Land Cover classification for the Township based on the Anderson classification scheme, which was developed in the late 1970's as a standard for land use/land cover interpretation. The Anderson scheme classifies all land uses first on a general level (urban, agriculture, forest, wetland, barren and water), then provides further general distinction along with detailed distinctions. There are three levels of classification possible, Level III being the most detailed.

Table 1: Level I 2002 Land Use/Land Cover

Land Cover Type	Acres	%
Forest	6,594.54	49.7
Urban	2,633.56	19.9
Wetlands	1,906.06	14.4
Agriculture	1,452.55	11
Water	573.22	4.3
Barren Land	97.36	.7
Total	13,257.28	100

The forested areas in Andover are widespread, covering most of the Township. These relatively large tracts of woodlands are interrupted mainly by the lakes and urban land uses. Urban land uses are primarily located along the road networks in the central and northern portions of the Township, often located near lakes such as Lake Lenape, Lake Iliff and others. Wetlands are generally wooded and are scattered throughout the Township. Larger pockets of wetlands are found in the southwestern and northern portions of the Township. Agricultural areas account for 11% of the land area in the Township and are located primarily along the perimeter of the Township in the northern, western and southern areas. The remaining 5% of the Township is deemed water or barren land. Barren Land is primarily comprised of extractive mining areas and transition areas under development when the data was interpreted. The only pockets of barren land are located along Limecrest Road. Agricultural lands represent a small portion of the Township's land use. Due to environmental features such as steep slopes and rocky terrain, agricultural uses do not play a significant role in the Township's sense of place. However, it is interesting to note that the few locations of agricultural areas in the Township are being rapidly replaced to urban areas over the years with a loss of 2.2% or just over 300 acres.

Figure 3 depicts the 2002 land use/land cover of the Township in a more detailed fashion, expanding on the 6 general categories contained in the Level I Anderson classification. This breakdown, generally representative of a Level III classification scheme (although terms are slightly modified) details the types of forest, wetland, urban and agricultural land detailed in Figure 2 (barren and water are not further enumerated). Table 2 summarizes the acreage and percentage each land use/land cover category represents.

Table 2 – Detailed 2002 Land Use/Land Cover

Land Cover Type	Acres	%
Deciduous Forest	5,330	39
Wetlands	1,906	14
Cropland and Pastureland	1,261	9
Rural Residential	939	7
Mixed Forest	921	7
Other Urban	816	6
Water	573	4
Low Density Residential	386	3
Coniferous Forest	355	3
Medium Density Residential	249	2
Other Forest	211	2
Commercial	169	1
Orchards	104	.8
Other Agriculture	87	.5
Extractive Mining	59	.4
Plantations	52	.4
Other Barren	38	.3
High Density Residential	34	.3
Transportation/Utilities	22	.2
Industrial	14	.1
TOTAL	13,526	100

This detailed analysis highlights some more sensitive environmental features, such as wooded wetland areas. This also allows for a highlighting of the type of development found near some of the more sensitive environmental features, such as industrial and residential areas located near wetlands and exposed rock outcroppings.

Table 3– Population Change (1970 to 2000)[2]

	1970	1980	1990	2000	Change 1970-2000	% Change 1970-2000	% Change 1990-2000
Andover Township	3,040	4,506	5,438	6,033	2,993	98	11

In recent decades, the growth in Andover was most significant between 1970 and 1980 (see Table 3), when the population rose from 3,040 to 4,506 (32.5%), it is clear from comparison of

[2] Population data as reported by the United States Census Bureau

land use/land cover data (Figure 4) for roughly the same period that this growth occurred as an expansion of previously settled areas and along the more major road networks such as State Route 206. Areas near the Yates Avenue and Mulford Road show significant increases in urban development with scattered new residential areas throughout the Township. Historical land cover interpreted from remotely sensed data, seen in Figure 4, reveals that in 1986 Andover Township was dominated by forest land cover, representing 50.6% of the Township's acreage. Wetlands comprised 14.6% of the Township's land cover and urban land uses represented 14.5%. In 1995, more developed land uses began to appear. Land dedicated to agriculture decreased by 244 acres, forested land declined by more 10 acres and roughly 77 acres of wetlands were converted to other land uses. Simultaneously, urban land uses increased by 278 acres.

Table 4 – Land Use/Land Cover Change (1986, 1995 and 2002)

Land Use/Land Cover Type	1986		1995		2002		Change (1986 – 2002)	
	Acres	*%*	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
Agriculture	1,969.76	14.9	1,752.67	13.2	1,452.55	11	(517.2)	(30)
Barren Land	128.5	1	85.25	.6	97.36	.7	(31.1)	(24.2)
Forest	6,713.75	50.6	6,703.40	50.6	6,594.54	49.7	(119.2)	(1.8)
Urban	1,927.39	14.5	2,205.08	16.6	2,633.56	19.9	706	37
Water	579.41	4.4	649.48	4.9	573.22	4.3	(6.2)	(1)
Wetlands	1,938.19	14.6	1,861.12	14	1,906.06	14.4	(32.1)	(1.7)

The Township was marked by a decline in agricultural land uses (30%) and forested areas (1.8%) and a precipitous increase in urban land uses (37%) from 1986 to 2002. Roughly 517 acres of agricultural land and 119 acres of forested land was converted to other uses while urban land cover increased by 706 acres.

When considering changes in land use/land cover, it is important to consider factors that may not be apparent in the raw data; these factors are closely linked to the methods by which the data is compiled. As an example, what the data does not readily quantify is the replacement of old-growth forest with old fields in the forest category. Both are classified the same in a Level I land use/land cover scheme. Gross comparison of land cover characteristics, such as above, must be tempered with an understanding of their general nature. While useful for broad comparison, they do not detail the true nature of change occurring at finer levels.

Open Space

Preservation of open space protects not only the Township's natural resources, but also its defining rural and historic character. Andover Township is fortunate to have a large portion of preserved land, as seen in Figure 5. The majority of open space in the Township is state owned. The most visible is Kittatinny Valley State Park, extending north from the boundary with Andover Borough in the south central portion of the Township. The park contains a wide variety of recreational opportunities including nature trails, bird watching and other educational passive recreation. Other parks include Hillside Park, which is owned by the Township, located to the north of Kittatinny Valley State Park.

The acquisition of open space in the Township should be encouraged where preservation and conservation will contribute to the health of the ecosystem. Large contiguous areas of open space allow for undisturbed and non-fragmented areas. These areas create a natural "greenway" area that contribute to the protection of biological diversity by allowing whole and unfragmented areas of open space for plant and animal communities to thrive.

Forested Areas[3]

The Township has 8,064 acres of forest cover including wooded wetlands, which are part of the wetlands category in the Anderson Level I description. This represents 61% of the total acreage of the Township and a significant portion of land cover. Almost all of the Township (61.7%) is deciduous forest, which when combined with deciduous wooded wetlands, makes over 78.9% of the forested areas in the Township deciduous in nature. Table 5 below lists the forest types depicted on Figure 6 and the percentage each type represents.

Table 5 – 2002 Forest Types

Forest Type	Acres	Percentage
Brush/Shrubland	714.13	8.9
Coniferous Forest	211.03	2.6
Coniferous Wooded Wetlands	8.24	.1
Deciduous Forest	4,973.57	61.7
Deciduous Wooded Wetlands	1,384.88	17.2
Mixed Forest	695.79	8.6
Mixed Wooded Wetlands	76.32	.9
Total	8,063.96	100

Forested areas in Andover Township perform many vital ecosystem functions, including:

- Habitat for threatened and endangered species;
- Regulation of stream temperatures to support stability of streams and rivers;
- Provision of nutrients and woody debris to streams and rivers;
- Stabilization of steep slopes and reduction of erosion and sedimentation;
- Conversion of carbon dioxide to oxygen;
- Dissipation of heat and provision of shade;
- Provision of riparian buffers;
- Reduction of pollution;
- Reduction of noise pollution;
- Provision of privacy and screening;
- Enhancement of groundwater recharge capacities.

[3] Forested areas data is taken from the New Jersey Department of Environmental. Protection 1995 Land Use/Land Cover data

Comparison of land use/land cover data from 1986 and 2002 shows that 119 acres of forest were converted to other (primarily residential) land uses during this 16 year period. Typically, forested areas converted to other land uses (except agriculture) rarely revert to forest, especially when converted to residential uses.

Forested areas in Andover are typical of the Mesic Upland habitat of northern New Jersey (i.e. the Highlands and Ridge and Valley regions). The predominant type of forest is the Chestnut Oak forest. The combination of tree stands in the Chestnut Oak forest consist of a variety of oak trees including, chestnut, red, white and scarlet oaks (Buell 1973). Other dominant trees, including sweet birch and pitch pine, are more adapted to reproduce and grow on rockier soils and slopes, but under the conditions present in the Uplands, often do not grow as tall and have less chance of producing a closed canopy, thus allowing for more light penetration to the forest floor. Understory trees include some dogwood and sassafras, but often do not form a contiguous understory. Finally, the dominant shrubs within the Uplands, blueberry, huckleberry and laurel, are able to cope with acidic soils often seen in the Township.

Rock outcrops pose another level of forested types in the Township. The production of soils and vegetation on exposed rock takes significant time, with the initial invaders consisting of mosses and lichens. Eventually, enough soil forms to allow for the growth of shrubs and trees. Usually, these areas of thin soil are dominated by pitch pine-scrub oak or chestnut oak.

Geology

Geologic History[4]

The geologic history of Andover Township has its beginnings more than 1.5 billion years ago, during the Precambrian Era. The resistant bedrock that forms the ridge east of Lime Crest Road, consists of igneous and metamorphic rocks with a long and complex geologic history. These Precambrian rocks were once sandstones, shales, limestones and volcanic rocks, that became buried deep within the earth. As they were buried these ancestors to our present granitic rocks were subjected to immense heat and pressure. These extreme forces melted and altered the rocks, resulting in the present day granite and gneiss that make up the eastern side of the Township in a series of ridges from 600 to 900 feet high. These crystalline rocks were later exposed during subsequent mountain building events, creating the ridge we see today.

The next period of geologic activity in the region resulted in the formation of a major ocean basin. The history of the ocean basin started with the formation of shallow, warm tropical seas in which limestone reefs and lagoon-like mudflats predominated. In other parts of this ocean basin, deep trenches formed in which large amounts of sediment rapidly accumulated.

This warm tropical sea was the origin of the rocks we now call the Kittatinny Limestone. A period of sea level lowering and uplifting of the sea floor marked the end of the formation of the Kittatinny. The exposed coral reefs and underlying limestone deposits were subjected to an

[4] Geologic History section taken in its entirety from the 1992 "Natural Resource Inventory, Environmental Characteristics. Andover Township, Sussex County, New Jersey." Prepared by Eco Systems Environmental Consultants.

interval of significant erosion. Deposition of the Martinsburg Shales tells of the rapid deepening of the ocean basin, when shallow conditions favorable to the continued formation of the limestones no longer prevailed in what is now New Jersey.

The immense thickness of the Martinsburg Shale, greater than 20,000 feet, records a period of rapid deposition in a deepening ocean. Near the end of this deposition, more than 400 million years ago, the ocean basin occupied a place where the great plates that make up segments of the earth's crust were beginning to converge. The wide ancient ocean basin, piled thick with the limestone of the Kittatinny and the shale of the Martinsburg, was caught up in the collision between the plates. The sediments that were formed in the ocean were then raised up above sea level.

This mountain building episode squeezed the thick accumulation of shale and limestone folding and lifting them. The folding process created weakened areas in the semi-brittle sediment, reflected in the joints and fractures we see today.

Bedrock Geology

Andover Township is split between the Highlands and Valley and Ridge Physiographic Provinces (Figure 7). The Highlands Province is part of the larger New England Uplands and includes the Green Mountains in Vermont, extends through New Jersey and southward into Pennsylvania[5]. In New Jersey, the Highlands region covers 900 square miles, or 12% of the State's total land mass (Buell 1973). Its parallel narrow steep ridges often characterize the Highlands. The oldest rock formations in the State are located in the ridges of the Highlands, which have resisted erosion do to their gneiss (very hard rock material) properties. The valley areas of the Highlands are often comprised of soft limestone or shale. The soils of the Highlands and the gneiss parent rock differ according to glacial drift, but are often stony with varying drainage.

The eastern portion of the township lies within the Highlands, and is represented by the series of ridges east of Limecrest Road. These ridge lines are underlain by granitic rocks and are characterized by a rocky terrain, steep slopes, marshy depressions and generally poorly drained soils. Since soil formation is a function of the underlying parent rock, soil types associated with these granitic formations are not found elsewhere in the township[6].

This crystalline upland (the Highlands) is a source of runoff for the Hidden Valley and Lenape Lake watershed, and, therefore, the quality of the water draining from the mountain affects water quality within the south eastern part of the township. Subsurface and ground-water that originates in this granitic terrain is generally moderately soft, with a moderate pH (6-7), low dissolved solids and often moderate to high concentrations of iron and/or manganese[7].

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[5] Tedrow, J.C.F. Soils of New Jersey. Robert E. Krieger Publishing Company, Inc. Malabar, FL. 1986

[6] "Natural Resource Inventory, Environmental Characteristics. Andover Township, Sussex County, New Jersey." Prepared by Eco Systems Environmental Consultants.

[7] Ibid

The Valley and Ridge province is part of a larger province that extends from Canada to the Southern United States. It is characterized by narrow belts of ridges and interconnected valleys arranged in a northeast-southwest orientation. Kittatinny Mountain, the highest point in New Jersey at 1,803 feet, is located in the Valley and Ridge Province. The Valley and Ridge province in New Jersey consists of 635 square miles and comprises about 7 percent of the total land mass in the state. The underlying bedrock in this province accounts for the variations of ridge and valley. Softer shale and limestone located in the valleys weather faster than the more resistant sandstone and conglomerates that attribute to the ridges. These variations also have a large effect on soil in the region. Soil covering the ridges is often thin and exposed in many places revealing an acidic, stony and low fertility soil coverage. Soils in the valley, derived from limestone, are deeper and more fertile and can be well drained. Peat or large muck deposits may also be found in this area.

The majority of the township (everything west of Limecrest Road) lies within the Ridge and Valley Province. This Province is underlain by sedimentary rocks including limestone, sandstone, and shale. Geologic structures and the resistance of the various sedimentary rocks to weathering and erosion have formed a landscape in this Province consisting of alternating linear valleys and ridges. Those rocks that are more resistant to erosion, such as sandstone and shale form the ridges; while rocks more easily eroded, such as limestone and dolomite, occupy the valleys. Soil cover being a function of the topography, is usually thin on ridges and deeper in valleys.

Within Andover Township two bedrock units make up the Ridge and Valley Province; these are the Kittatinny Limestone and the Martinsburg Shale. The limestone underlies the lower elevations while shale and sandstone, form the higher elevations.

Limestone and Shale Formations

Limestone and Shale are prevalent in Andover Township, as seen in Figure 8. Development on limestone and shale areas poses limitations. Shallow depth to bedrock and seasonal high water tables pose on-site septic challenges. Kittatinny Limestone, like many limestone formations, contains sink holes, outcropping and caves. Development on limestone and shale rich sites should be carefully weighed.

Bedrock geology is important in terms of land use, as it controls where ground water occurs and determines the stability of the environment. There are many unstable features associated with the Kittatinny Limestone, such as sinkholes and caves, that are the result of chemical and physical weathering. Bedrock geology helps us plan where to locate wells for water supply and where to exercise caution in undertaking construction.

Kittatinny Limestone[8]

The former Kittatinny Limestone is now subdivided into five separate formations, all of which are found in the section of the township west of Limecrest Road (see Bedrock Geology map - Limestone). The individual formations within the Kittatinny Group include the Leithsville, Allentown, Rickenbach, Epler and Ontelaunee Formations. Underlying the Kittatinny are the resistant Precambrian crystalline rocks and Hardyston Sandstone, while on the top of the Kittatinny is another limestone, the Jacksonburg Limestone (formed during that second reef building period).

The Kittatinny Limestone formations consist mostly of dolomite, which is a more resistant form of limestone, containing magnesium as well as calcium carbonate. Even though this dolomitic limestone is harder and more resistant than pure limestone, it exhibits hydrogeologic traits found in areas underlain by limestone. Caverns, sinkholes, undrained depressions, disappearing streams and springs are common in the Kittatinny terrain.

Within the Kittatinny, formations that contain the coarsest dolomite grains have undergone the most severe weathering. The formations most susceptible to weathering include the Leithsville, the Mentown (lower part), and the Rickenbach Formations. These formations constitute the most prolific carbonate aquifers and have the greatest amount of caverns, sinkholes, springs, bedrock pinnacles and other "karst" features thereby making these limestone valleys a very sensitive environment.

The carbonate formations that are less susceptible to weathering include the upper Allentown, Epler, and Ontelaunee Formations. While sinkholes, caves and other karst features are found with these formations, environmental limitations associated with more resistant carbonate formations include steep slopes, small sinkholes, thin rocky soil and poor ground-water yields. Within the Kittatinny Valley the Leithsville, lower Allentown and Rickenbach Formations tend to underlie stream valleys, marshes and floodplains, while the upper Allentown, Epler, Onteluanee and Jacksonburg Formations make up the more elevated terrain.

The topography, ground-water yield characteristics, and environmental limitations associated with the carbonate formations within the township are outlined in the Bedrock Hydrology Section. These geologic traits help us to understand the potential for development above these formations and associated risks to the environment.

Martinsburg Shale

The Martinsburg Shale is found predominantly in the northwestern part of township west of Goodale/Lawrence Road, from the Lafayette border down to Twin Lakes. It forms the rolling, hilly terrain that underlies the Newton Country Club. The Martinsburg terrain is characterized by moderate to steep slopes, frequent bedrock outcrops, thin soils and shallow, sometimes marshy valleys.

[8]Kittatinny Limestone and Martinsburg Shale section taken in its entirety from the 1992 "Natural Resource Inventory, Environmental Characteristics. Andover Township, Sussex County, New Jersey." Prepared by Eco Systems Environmental Consultants.

The Martinsburg Shale can be divided into two units, or members, known as the Bushkill and the Ramseyburg members. The Bushkill Member consists mainly of claystone slate, a shale-like rock. The Ramseyburg Member contains mostly siltstone and sandstone. The Ramseyburg is the more resistant of the two members and, therefore, occupies the highest elevations in the township.

The shale does not normally provide exceptional ground-water yields to wells, although there have been prolific wells finished *in* the Martinsburg where geologic structure has caused extensive fracturing of the rock, such as near faults and folds. However, due to recent requirements for longer well casings to protect wells from the possibility of contamination and due to modern well drilling methods; well yields for recently drilled wells may be lower than those reported several years ago. Deeper well casings prohibit water within the upper, weathered portions of the bedrock from entering the well. Current practice requires that water be obtained from fractures deeper within the rock aquifer; but fractures tend to decrease with depth.

Hydrogeology[9]

In Andover Township, nearly 100% of the residents currently rely on and will continue to rely on groundwater for their water supplies. The township's largest aquifers extend for the entire length of the township under the central limestone valleys.

The Shale to the west and the Crystalline rock to the east of this area are much poorer aquifers. The shale has no primary porosity or permeability except for some included sandstones. Almost all of its water is contained in fractures. The fractures in the Martinsburg Shale are considered to be tight and generally create very poor aquifer conditions. Exceptions include areas that are faulted or tightly folded. Waters from this formation may contain hydrogen sulfide (rotten egg odor) to a degree that renders it unpotable. Water from this formation is also low in hardness.

Precambrian Crystalline rocks form the township's eastern boundary. Practically all groundwater in these formations occurs in joints and fractures along faults. In areas where the joints are far apart, there is no distinct water table, each system of joints having its own flow system. Only where weathering has occurred at depths less than 150 feet and fractures are most abundant, can you find water in sufficient quantities for domestic use. Well data show this formation as being the poorest supplier of water in the township. Water found in this rock is generally high in iron and of low hardness.

The importance of the township's limestone aquifers cannot be overstated. These are the areas that we can depend on for our future water supplies. However, the same process that makes the limestone our best aquifer, also makes it highly susceptible to contamination. Where the limestone is at a shallow depth, sinkholes, cracks, fissures and joints allow rapid flow of surface

[9] Hydrogeology section taken in its entirety from the 1992 "Natural Resource Inventory, Environmental Characteristics. Andover Township, Sussex County, New Jersey." Prepared by Eco Systems Environmental Consultants.

water into the system. These areas must be carefully protected from surface contamination. Only our prudent planning of cautious and considerate development, will insure the safety of our drinking water. Numerous townships that are also underlain by limestone, have adopted limestone ordinances to help protect this precious water supply.

History of Groundwater Table in the Limestone Valley

The Limestone Valley in the Township has been altered over the past 100 years by the operation of the Limestone Quarry. In order to keep water out of the quarry's 145 foot deep pit, the quarry was permitted to pump millions of gallons of water out of the ground and to discharge it into the Paulinkskill River. In 2005, the Limestone Quarry ceased its mining operations. As a result, beginning in early 2005, and continuing throughout the summer and fall, the groundwater table throughout the Limestone Valley of Andover Township and adjacent towns began to rise to historically natural levels (see Appendix 1 for historic aerial photos of Howell's Pond area).

During the years that the quarry had been pumping water, developments in the Limestone Valley continued. With the recent cessation of operations and rise of the water table, flood conditions in the Valley have become evident. A stabilization of the water table is beginning, however, at current levels, developments and sewage treatment plants are facing flooding and critical failures. While there is no immediate solution to the existing developments in the area, any proposed construction in the limestone valley, now or in the future, needs to be carefully evaluated, with prudent steps being taken for appropriate field investigations.

Stratified Drift[10]

The most recent geologic episode that shaped the township was a period of glaciation. During the past two million years New Jersey has undergone thee advances of glacial ice sheets. The last glacier to occupy New Jersey, the Wisconsin glacier, reached its maximum extent just 20,000 years ago.

The advance and subsequent retreat of the Wisconsin glacier, left a variety of unconsolidated sediments over the landscape. These surficial deposits are shown on the Stratified Drift map. The physical properties of these glacial deposits are a function of how the sediments were released from the ice during its advancement and retreat.

At the end of the Wisconsin glaciation large glacial lakes were formed by glacial meltwater that became trapped behind ice dams and glacial debris. The remains of these glacial lakes consist of silt, clay and fine sand and are often found under the larger swamps in the area, such as Great Meadows.

[10] Stratified Drift section taken in its entirety from the 1992 "Natural Resource Inventory, Environmental Characteristics. Andover Township, Sussex County, New Jersey." Prepared by Eco Systems Environmental Consultants.

Upland areas were draped with glacial till, an unsorted mixture of sand, clay and stones deposited directly from glacial ice. Valleys -were filled with thick accumulations of sand and gravel released and sorted by streams flowing from the melting glacier. These sand and gravel outwash deposits when thick, form productive aquifers and serve as important recharge areas for underlying bedrock aquifers.

The various geologic processes described above left their mark on the landscape of Andover Township. Mountain building and differences in the resistance of the bedrock to erosion have controlled the location of valleys, hills and mountains. Glacial advances have modified the contours on the bedrock surface, stripping it of soil in places and piling up thick accumulations of sediment in other places.

The various forces, that have broken and subsequently weathered the bedrock, control the movement of water through the rock formations and the availability of water to wells. The glacial processes have determined whether the unconsolidated overburden on top of the bedrock permits rapid infiltration of precipitation or retards infiltration. The resultant topography has shaped the network of streams and rivers that drain the landscape.

These geologic processes that formed the rocks have produced an environment with great variety, and shaped human habitation of the region. Deep, rich limestone soils; steep, rocky, cavernous limestone outcrops; cool springs and perennial swamps; and rolling, thinly veneered hills of shale are all the product of the township's unique geologic history. Each one of these environments presents its own planning challenges and development limitations.

The underlying geology is the basis for a variety of environmental factors that affect vegetation, groundwater, erodibility and many other influences. These will be further outlined in the following sections.

Soils

Soils are formed by the weathering and break up of parent material (rock). They bear a strong relationship to the rock from which they are formed and are often times greatly influenced by this relationship. A variety of factors related to community development are limited by the soils present in the Township. With their shallow depth to hard bedrock and presence of layers which restrict infiltration of precipitation, their properties must be considered carefully.

The soils in Andover Township have significant limitations in terms of depth to bedrock and seasonal high water and suitability for on-site disposal of effluent. All of these characteristics are related by way of soil associations, as mapped in the Soil Surveys published by the United States Department of Agriculture (USDA) Soil Conservation Service. In addition to Soil Surveys, the USDA Natural Resources Conservation Service published digital soil surveys and supporting data tables known as Soil Survey Geographic (SSURGO) databases. This digital data, used to create the maps depicted in Figures 9 through 14, is based on the Soil Surveys of Sussex County, published in 1975 and the USDA Natural Resources Conservation Service.

There are five major soil associations identified in Andover Township. The following is a description of each soil component found in this association[11]:

Hazen (H)-Palmyra (Pa)-Fredon (Fr) Association
This soil association consists of level to very steep, deep and well-drained and poorly drained loamy soils often located on terraces, Kames and outwash plains. Hazen Soils are often well-drained and found on nearly level to very steep areas and have a gravelly loam surface layer, while Palmyra soils are often located on side slopes. Fredon soils are poorly drained and located on nearly level to slightly sloping areas and have a loamy surface layer.

Carlisle (Ca)-Swamp Association
These soils are located in nearly level areas are deep and very poorly drained organic and mineral soils. Carlisle soils are formed in organic material, while the Swamp soils are mineral in composition and often covered by water. Most soils in this association are located in woodland areas.

Washington (W)-Wassiac (WM)-Rock Outcrop Association
This association is often located on hillsides and lower valley slopes between ridges. Washington soils are deep, well drained and gently sloping to steep areas. The surface layer of Washington soils is silt loam. Rock outcrops are predominately limestone. This association is often used for farming and less intensive uses. Due to the occurrence of sinkholes associated with these soil types, more intensive uses are discouraged.

Nassau (N)-Bath (B)-Norwich (N) Association
This association is located often on hilltops and hillsides in the interior valleys. Nassau soils are often shallow and located over shale or slate. They tend to be excessively drained and have a surface layer of shaly silt loam. Bath soils are deep, well drained and have a surface layer of loam, gravelly loam or very stony loam. Norwich soils are deep, poorly drained and have a surface layer of silt loam or stony loam. These soils are often converted to farming areas, however they tend to deter farming unless irrigation occurs. The shallowness of the soils limit development.

Rockaway (R)-Hibernia (Hn)-Whitman (W) Association
This association is found on hillsides and hillsides in valleys. The Rockaway soils are well drained and have a surface layer of gravelly loam or very stony loam. Hibernia soils are somewhat poorly drained with a similar surface of the Rockaway soils. Whitman soils are very poorly drained and have a surface layer of extremely stony sandy loam.

Rockaway (R)-Rock Outcrop-Whitman (W) Association
This association is found on steep and very steep slopes. The soils tend to be well-drained since it consists primarily of gravelly to very stony loamy soils or on rock outcrops. In the upland areas the soil can be poorly drained if the area is level, despite stony soils.

[11] Soil Survey of Sussex County, New Jersey. USDA Soil Conservation Service. August 1975.

Soil Characteristics

On-Site Disposal of Effluent

With the adoption of *N.J.A.C.* 7:9A "Standards for Individual Subsurface Sewage Disposal Systems" in 1999, the New Jersey Department of Environmental Protection (NJDEP) revised their methods for classifying soils based on their suitability to dispose of effluent via a septic system and the appropriate type of system to be used given certain limitations. The soil suitability classification consists of Roman numerals from I to III. These indicate the severity of the septic limitation using the higher numerals to indicate more severe limitation with lower numerals to indicate less severe limitations. In the absence of detailed on-site soil investigation, the Soil Survey mapping is used to determine the location of soil series, and the standards specify the types of limiting zones that may be present and the type of system to be used, if any. Figure 9 shows the soils of Township as classified by Appendix D of *N.J.A.C.* 7:9A; Table 6, on the following page, lists the type of septic system permitted given the suitability class. Septic system types include conventional systems, soil replacement bottom-lined systems, soil replacement fill-enclosed systems, mound systems and mounded soil replacement systems.

Table 6 – N.J.A.C. 7:9A Limiting Zones

Type of Limiting Zone	Depth[2], ft.	Suitability Class	Type of Installation Permitted[3]
Fracture Rock or Excessively Coarse Substrata	>5 0-5	I IISc	C, (SRB, SRE, M, MSR) SRE, M, (MSR)
Massive Rock Hydraulically Restrictive Substratum	>9 4-9 <4	I IISr IIISr	C, (SRB, SRE, M, MSR) M, (MSR) UNSUITABLE
Hydraulically Restrictive Horizon, Permeable Substratum	>9 4-9 <4	I IIHr IIIHr	C, (SRB, SRE, M, MSR) SRB, SRE, M, (MSR) SRB, SRE, (MSR)
Excessively Coarse Horizon	>5 0-5	I IIHc	C, (SRB, SRE, M, MSR) SRE, M, (MSR)
Zone of Saturation, Regional	>5 2-5 <5	I IIWr IIIWr	C, (SRB, SRE, M, MSR) M, (MSR) UNSUITABLE
Zone of Saturation, Perched	>5 2-5 <5	I IIWp IIIWp	C, (SRB, SRE, M, MSR) C[4], (SRB, SRE, M, MSR) C[4], (SRB, SRE, M, MSR)

C = Conventional Installation
SRB = Soil Replacement, Bottom-lined Installation
SRE = Soil Replacement, Fill-enclosed Installation
M = Mound Installation
MSR = Mounded Soil Replacement Installation1
(1) Mounded soil replacement systems are generally required only in cases where several limiting zones are present as, for example, in compound soil suitability classes such as IIScWr, IIIHr (IISr) or IIIHr(IIWr).
(2) Depth is measured from the existing ground surface to the top of the limiting zone. In the case of disturbed ground, the depth to the limiting zone shall be measured from the pre-existing natural ground surface, identified as prescribed in N.J.A.C. 7:9A-5.10(c), or the existing ground surface, whichever is lowest.
(3) Installations shown in parentheses are allowed but are generally not the most cost-effective type of installation for the soil suitability class unless other soil limitations are present.
(4) An interceptor drain or other means of removing the perched zone of saturation is required. Note: In soils with a compound soil suitability class, where more than one limiting zone is present in the soil, a disposal field installation shall not be approved unless the type of installation proposed is listed in Table 10.1 as an acceptable option for each of the soil suitability classes which apply.

The 1999 standards adopted by the Department indicate certain soils with limiting zones that are unsuitable for any type of septic system installation. A number of these soil types are present in the Township and are mapped in Figure 9. According to *N.J.A.C* 7:9A most of the Township has limiting factors for septic installation. Figure 10 identifies a generalized picture of soil limitations in the Township. The limitations are primarily due to the large portion of steep slopes and rocky soil and rock outcropping. As seen in the previous section, the characteristics of the major soil associations in the Township pose significant development limitations due to the stony, steeply sloping nature of the soils along with the lateral movement of excess water which can impact septic systems and nearby water resources.

Depth to Bedrock

Depth to bedrock is one factor which affects a soils' ability to process septic effluent via a septic system. Generally the shallower the depth to bedrock (less than four feet), the less soil is present to properly treat human waste. Excluding mounded systems, a four foot zone of treatment is required to properly treat septic effluent.

Figure 11 depicts the depth to bedrock for soils in the Township, as classified in the SSURGO database from the USDA NRCS (see table in Appendix 2 for Geologic Characteristics). The majority (67%) of soils in the Township have a depth to bedrock between 6 and 10 feet, while 18% are rock outcrops and 2.6% having depths greater than 10 feet. Many of the categorizations in the SSURGO database exhibit great variety, where the range presented could be part of another range based on site specific investigation.

Depth to bedrock is one of the factors used to determine suitability for septic disposal of effluent. Soils remove nitrates and other organic compounds present in human waste, the depth of the soil has a direct relationship to its ability to process effluent effectively. Generally, the more soil present, the better its processing capabilities. This is, of course, dependent on the type of soil and its permeability; sandy soils generally drain rapidly and heavy clay soils generally drain slowly, affecting their ability to filter human waste. Areas of shallow depth to bedrock can result in an increase of groundwater pollution since the soil is unable to filter out effluents. Additionally, a shallow depth to bedrock can also increase the amount of soil erosion at site of soil disturbance.

Depth to bedrock influences other community development factors such as septic system installation, road construction, basement and foundation construction, landscaping, seeding and drainage. Soils with a depth to bedrock greater than 6 feet are generally unconstrained with respect to the above factors, whereas moderate and shallow depths to bedrock experience varying degrees of limitation, the latter with a tendency towards severe limitations.

Depth to Seasonal High Water

Shallow depth to seasonal high water (DSHW) presents numerous limitations for development, most notably installation and maintenance of septic systems. Even with soil replacement and other engineering measures, septic systems placed in high water tables have the potential to pollute groundwater. When soils exhibiting shallow DSHW are located adjacent to streams, there is also the potential for surface water contamination in periods of flooding. If a system is maintained improperly and ceases to function, effluent from the leach field that rises to the surface can be carried off in surface water. Even in periods when flooding is not prevalent; a failing septic system can introduce surface contamination into surface waters.

Shallow seasonal high water tables (typically less than 6 feet), while presenting limitations for development, also support diverse plant and wildlife communities. A majority of the soils with depths to seasonal high water less than 5 feet (60 inches), are seen throughout the Township. Soils with seasonal high water table under 2 feet often coincide with stream corridors and areas with rock outcrops and other constraints. Moderate or shallow DSHW are good indicators of lands which deserve further study, perhaps warranting protection to limit destruction of private

property and fostering of diverse plant and animal communities that may support critical habitat for threatened and endangered species.

Figure 12 depicts DSHW for the soils found in the Township. DSHW indicates the highest level below the surface that groundwater reaches in most years, typically occurring between October and June, with variations in the length of time dependent on soil type. The majority (72%) of the soils in the Township have generally shallow DSHW, just over 5 feet. The soils in this category are least susceptible in the Township to potential problems related to development and any of the minor limitations that may be present can be overcome, however, soils under 6 feet DSHW are generally considered limited for development. Soil types with generally shallow DSHW are almost exclusively located near stream corridors and along areas of rock outcrops. In Andover Township, these very limited soils are primarily located in the southeastern portion of the Township. Soils in this region have a DSHW of less than 33 inches. A number of these seasonally high water tables support wetland systems associated with river and stream systems, deciduous wooded wetlands which act as headwaters for numerous streams and diverse vernal or emergent ecosystems present in the Township and along rivers and streams.

Highly Erodible Lands

The United States Department of Agriculture, Natural Resources Conservation Service rates soils based on their potential for erosion by wind and water, with those most susceptible to erosion, referred to as the "Highly Erodible Lands" class. While none of the soils in the Township are susceptible to erosion by wind, there are soils in the Township rated for erodibility by water, as depicted in Figure 13. These soil types are discussed in detail below.

Of the soils in the Township, 59% are rated as "Highly Erodible Land Class" in the SSURGO database. This indicates that the soil will erode when exposed to water, such as heavy rain or surface water runoff. A comparison of the location of "Highly Erodible Lands" and the steep slope mapping in Figure 22 reveals that some of the "Highly Erodible Lands" are in areas of slope greater than 15%. There are a number of soils designated as "Highly Erodible Lands", however, that are not located in areas of slopes greater than 15% due to the rocky nature of the soil properties in the Township and shallow depth to bedrock and water.

Of the remaining soils in Andover, 21% are categorized as "Potentially Highly Erodible". While these soils do not have the component of slope that "Highly Erodible Lands" do, they possess similar texture and surface properties and will experience erosion from heavy rain and swiftly moving surface water. This class is comprised of the entire spectrum of soils in the Township and are scattered throughout the region. Only 17% are classified as "Not Highly Erodible", generally consisting of the soils and sediment making up the stream and reservoir beds.

Soils in the "Highly Erodible Lands" class require careful management in logging and development. In the course of permitted development, disturbance of highly erodible soils should be avoided unless adequate measures can be implemented to assure that erosion and soil loss will be minimized. Although some equate highly erodible lands with areas of steep slope, there are areas of highly erodible lands that do not coincide with slopes greater than 15%. These areas must be afforded protection, as minimizing soil loss will help eliminate potential surface water quality impairment while maximizing groundwater and aquifer recharge.

Farmland Capability

Figure 14 depicts farmland capability of the soils present in Andover Township. Farmland capability was mapped by applying designations contained in the State Agriculture Development Board's study entitled "New Jersey Important Farmlands Inventory", prepared in 1990 to the SSURGO digital soils database from the Andover Township GIS.

There are highly capable agricultural soils throughout the Township, which includes prime soils and soils of unique importance. The following descriptions of prime farmlands, soils of statewide importance and farmland of local importance are taken directly from the "New Jersey Important Farmlands Inventory", prepared by the State Agriculture Development Committee in 1990.

Prime Farmlands - Prime Farmlands include all those soils in Land Capability Class I and selected soils from Land Capability Class II. Prime Farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops and is also available for these uses. It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed according to acceptable farming methods. Prime Farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding.

Farmland of Unique Importance - Farmland of unique importance includes those soils that are not of prime or statewide importance and are used for the production of specialty crops.

Prime agricultural soils account for 12% and farmland of unique importance soils account for 4%. The reminder of the soil in the Township has no class distinction. A majority of the productive soils are located in the central and western portion of the Township. Other significant areas are located in the northern portion of the Township, where a contiguous area of unique soil is located. Highly productive soils are a finite resource. Once converted to developed uses it is unlikely they will be returned to agricultural uses.

Surface Waters and Subwatersheds

Watersheds and Subwatersheds

According to the New Jersey Department of Environmental Protection a watershed is:

> "The area of land that drains into a body of water such as a river, lake, stream or bay. It is separated from other systems by high points in the area such as hills or slopes. It includes not only the waterway itself but also the entire land area that drains to it. For example, the watershed of a lake would include not only the streams entering the lake but also the land area that drains into those streams and eventually the lake. Drainage basins generally refer to large watersheds that encompass the watersheds of many smaller rivers and streams."

The Township's major (or First Order) watershed is the Delaware River, where all of the water eventually flows. The secondary watersheds (Second Order) are the Paulins Kill and Pequest

Rivers (Figure 15). The subwatersheds are smaller drainage basins within larger hydrological units. Water quality impacts are often easier to track in subwatersheds, especially those related to nonpoint source pollution. Due to their smaller size, it is easier to assess the location of potential pollution sources and determine impacts they may have on water quality.

Accordingly, each subwatershed is subdivided into smaller areas, using a grouping called the Hydrologic Unit Code (HUC). The HUC is a code system developed by the U.S. Geological Service for delineating and identifying drainage areas. The system starts with the largest possible drainage areas and progressively subdivides the areas in a nested fashion. The HUC employs a series of numbers to describe the relationship of each smaller subwatershed to other subwatersheds with which it is associated.

According to data from the New Jersey Department of Environmental Protection, there are 8 HUC 14 (Hydrologic Unit Code) drainage areas within the Township that are part of the Delaware River drainage basin. Table 7 lists the HUC 14 subwatersheds within the Township and the HUC 14 acreage.

Table 7 – HUC14 Subwatersheds

HUC 14	Acres	%
2040105070020	4,934	37
2040105070030	2,629	20
2040105070010	2,576	19
2040105040060	1,991	15
2040105040050	1,060	8
2040105070040	58	0
2040105070050	9	0
2020007010010	1	0
Total	13,258	0

Surface Water Quality

Surface water is all water where the surface is exposed to the atmosphere. The surface water system is made up of rivers, steams, lakes, ponds, canals reservoirs, swamps, marshes, and the ocean. Water bodies serve as a kind of circulatory system providing nutrients and metabolizing waste materials. Wildlife and the aquatic community rely on waterways for these functions, as well as shelter and a place to rest and breed. Humans enjoy the added benefits of recreation, transportation and socio-economic opportunities.

Preserving and enhancing surface water quality is key to importance for preserving the environmental health of water bodies, as well as protecting the scenic and recreational opportunities that the Township's streams, rivers and lakes provide. Water quality for New Jersey streams and rivers are classified by the New Jersey Department of Environmental Protection (NJDEP), in the "Surface Water Quality Standards" (N.J.A.C 7:9B). Through these statewide standards, a regulatory framework is established and management policies are implemented based on the designation of streams as FW1 and FW2, Category 1 and 2 and either

trout-producing, trout-maintenance or non-trout waters. All of the Surface waters in Andover Township are designated as FW2.

According to NJDEP, all surface waters within the Township are currently classified as "FW2". "FW2" *means the general surface water classification applied to those fresh waters that are not designated as FW1 or Pinelands Waters.* As a frame of reference, "FW1" *means those fresh waters, as designated in N.J.A.C. 7:9B-1.15(h) Table 6, that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic or aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).*[12] Possible uses described for FW2 waters include:

1. Maintenance, migration and propagation of the natural and established biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation, and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and
5. Any other reasonable uses.

In addition to the above classification and for purposes of implementing regulatory policy, surface waters are further categorized by NJDEP as either "Category 1" or "Category 2". Category 1 waters "*means those waters designated in the tables in N.J.A.C. 7:9B-1.15(c) through (h), for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality characteristics because of their clarity, color, scenic setting, other characteristics of aesthetic value, exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s). These waters may include, but are not limited to:*

1. *Waters originating wholly within Federal, interstate, State, county, or municipal parks, forests, fish and wildlife lands, and other special holdings that have not been designated as FW1 at N.J.A.C. 7:9B-1.15(h) Table 6;*
2. *Waters classified at N.J.A.C. 7:9B-1.15(c) through (g) as FW2 trout production waters and their tributaries;*
3. *Surface waters classified in this subchapter as FW2 trout maintenance or FW2 nontrout that are upstream of waters classified in this subchapter as FW2 trout production;*
4. *Shellfish waters of exceptional resource value; or*
5. *Other waters and their tributaries that flow through, or border, Federal, State, county, or municipal parks, forests, fish and wildlife lands, and other special holdings."*[13]

[12] "Surface Water Quality Standards", N.J.A.C. 7:9B, New Jersey Department of Environmental Protection, pg. 4.
[13] Ibid, pgs. 2-3

Category 2 waters "*means those waters not designated as Outstanding National Resource Waters or Category One at N.J.A.C. 7:9B-1.15 for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d).*" [14]

Table 8 and Figure 15 identify the stream or river name, if it is designated as a C-1 stream and the length of each stream. Kymer Brook has the most length in the Township at 9.7 miles, due mainly in part to the number of tributaries found within the Township's boundaries. This is followed closely by the Pequest River at 7.9 miles and then Andover Junction Brook at 5.8 miles.

Table 8 – Streams and Rivers

Stream or River Name	Designated C-1	Length (miles)	%
Kymer Brook	No	9.7	29
Pequest River	No	7.9	24
Andover Junction Brook	No	5.8	17
West Branch Paulins Kills	No	4.2	13
Tar Hill Brook	No	2.5	7
Paulins Kill	Yes (portion)	2.3	7
Unnamed Tributaries	No	1.3	4
Total		**33.7**	

According to NJDEP, only portions of Paulins Kill are designated as a Category One stream. This means that portions of the stream are subject to the anti-degradation regulations set forth above. The remainder of the streams in the Township are designated as Category Two. General anti-degradation policies seek to protect waterways from decline in quality while protecting the designated uses set forth. In addition to general policies, where water quality exceeds levels necessary to support the designated uses, that level shall be maintained unless deterioration would accomplish important social or economic goals. Further categorization of surface water is accomplished through designation as trout producing, trout maintenance or non-trout waters; all three trout categories are found in the Township. Portions of the Paulins Kill are classified as a trout producing stream. Andover Junction Brook, Kymer Brook and Pequest River are Trout Maintenance waters. Trout production waters are those that are home to breeding populations of native trout while trout maintenance waters are those that are home to native populations of trout, although trout do not breed there.

The Surface Water Quality Standards (SWQS) adopted by NJDEP in 2003 also established strict guidelines for numerous man-made and naturally occurring contaminants including fecal coliform, enterococci, dissolved oxygen, floating colloidal solids, petroleum hydrocarbons, phosphorus, suspended solids, total dissolved solids, sulfates and taste and odor producing substances. Also important, especially to potential Category 1 waters, are alterations to temperature and the addition of toxic substances.

[14] Ibid, pg. 3

Lakes

The principal water bodies in Andover Township are the lakes (Figure 15). The Township's lakes provide an abundance of water bodies and are defining features of the Township's landscape. The largest lake, New Wawayanda Lake (Aeroflex Lake), which consists of 111 acres, followed by the Lake Lenape at 54 acres. Combined with the other lakes in the Township, almost 631 acres are covered by water. The lakes of Andover provide clean drinking water, recreational opportunities and important habitat areas.

Known Contaminated Sites

The New Jersey Department of Environmental Protection, Site Remediation Division, holds a list of Known Contaminated Sites. The "Known Contaminated Sites" list is a municipal listing of sites where contamination of soil and/or ground water is confirmed at levels greater than the applicable cleanup criteria or standards. Remedial activities are underway or required at the sites with an on-site source(s) of contamination and at locations where the source(s) of contamination is unknown. Sites with completed remedial work that require engineering and/or institutional controls have reporting measures in place to ensure the effectiveness of past actions, and some include maintenance and/or monitoring.

The Known Contaminated Sites Listings features three categories of sites:

A. Sites with on-site source(s) of contamination
B. Sites with unknown source(s) of contamination
C. Sites with closed case(s) with restrictions.

All sites in Andover Township are classified as "A. Sites with on-site source(s) of contamination". Sites identified in the listing of Known Contaminated Sites in New Jersey can undergo a variety of remediation approaches, ranging from relatively simple "cut and scrape" removals to highly complex remedial activities.

Levels of remediation action are further classified in the Known Contaminated Sites database. First, a C1 remedial level, is associated with simple sites with one or two contaminants localized to soil and the immediate spill or discharge area. Second, a C2 remedial level is associated with more complicated contaminant discharges, multiple site spills and discharges, more than one contaminant, with both soil and groundwater impacted or threatened. A C3 remedial level is associated with high complexity and threatening sites. These may include multiple contaminants, some at high concentrations, with unknown sources continuing to impact soils, groundwater and possibly surface waters and potable water resources.
Andover Township contains fifteen known contaminated sites (Table 9), mainly on the southeastern side of the Township (Figure 16). Many of these contaminated sites are located at existing or former filling stations where underground storage tanks may have leaked and soil remediation is required. It is important to note again, that the data set currently shown is from 2001, and that some of the sites may have been remediated since publication of the data.

Table 9 – Known Contaminated Sites in Andover Township

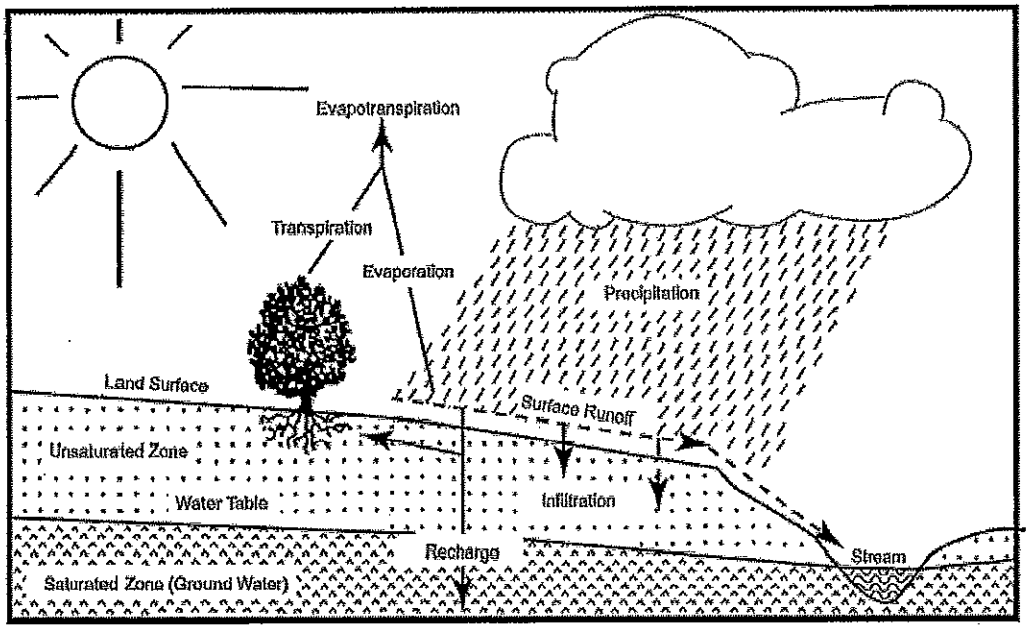
ID	Place	Remediation Level
0	147 ANDOVER MOHAWK ROAD	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
1	158 ANDOVER SPARTA RD. OI L SPILL	C2: Formal Design - Known Source or Release with GW Contamination
2	171 ANDOVER MOHAWK ROAD	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
3	220 ANDOVER SPARTA ROAD	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
4	23 POTTER AVENUE	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
5	259 STICKLES POND ROAD	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
6	ANDOVER CITGO STATION US OIL CORP	C2: Formal Design - Known Source or Release with GW Contamination
7	HEMLOCK AVENUE LANDFILL	C3: Multi-Phased RA - Unknown or Uncontrolled Discharge to Soil or GW
8	SHELL SERVICE STATION #138509	C2: Formal Design - Known Source or Release with GW Contamination
9	135 ELM AVENUE	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
10	264 ANDOVER SPARTA ROAD	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
11	3 LINDA LANE	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
12	42 PERONA ROAD	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
13	465 ROUTE 206	C1: No Formal Design - Source Known or Identified-Potential GW Contamination
14	SUSSEX COUNTY ANDOVER MAINTENANCE GARAGE	C2: Formal Design - Known Source or Release with GW Contamination

Groundwater Recharge

Groundwater recharge is an important determining factor when considering the carrying capacity of a region. According to the New Jersey Geological Survey (NJGS):

> *The potential for natural groundwater recharge begins with precipitation (rain, snow, hail, sleet). Some of the precipitation never seeps into the soil, but instead leaves the system as surface runoff. The water that seeps into the soil is infiltration. Part of the water that does infiltrate is returned to the atmosphere through evapotranspiration. Evapotranspiration refers to water that is returned to the atmosphere from vegetated areas by evaporation from the soil and plant surfaces and soil water that is taken up by plant roots and transpired through plant leaves or needles. Infiltrated water that is not returned to the atmosphere by evapotranspiration moves vertically downward and, upon reaching the saturated zone, becomes ground water. This ground water could be in a geologic material that is either an aquifer or nonaquifer, depending on whether it can yield satisfactory quantities to wells.* (NJGS GSR-32)

Groundwater Recharge in the Hydrologic Cycle



Source: New Jersey Geological Survey Report GSR-32.

In addition to supplying water to wells, groundwater can also provide base flow to streams, wetlands, and other water bodies, directly affecting the ecology and geomorphology of these resources.

Andover Township's groundwater recharge rates are generally 13 to 18 inches per year (Figure 17). A groundwater recharge rate of 14 to 18 inches is generally considered to be one of the more abundant aquifers, however, other portions of the Township have extremely low recharge rates, primarily found in areas where steep slopes are excessive and rock outcroppings are abundant. Given that a large portion of the Township is covered by lakes that provide drinking water and rock outcrops, loss of groundwater recharge could have significant impacts on the Township's many water bodies.

Over half of the Township (63%) has a recharge rate of 13-18 inches per year. These good recharge rates are evident throughout the Township. Lower recharge rates are found in isolated pockets throughout the Township.

Well Head Protection Areas

The Well Head Protection Program (WHPP), was instituted in 1986 as part of the Federal Safe Drinking Water Act Amendments. The amendments mandated that all States develop a WHPP for both public community and public non-community water supply wells. The New Jersey WHPP was approved in 1991. Well Head Protection Areas (WHPA) are a component of this program. These are areas from which a well draws its water within a specified time frame. Once these areas have been delineated, they become priority areas for efforts to prevent contamination of groundwater resources.

Public supply wells draw water from underground water sources commonly known as aquifers. Aquifers allow underground water flow through porous and permeable areas in the bedrock, and this groundwater moves from areas of high pressure to areas of low pressure. The longer a well is pumped the greater the distance the water will flow through the aquifer to the well. The time it takes the water to move to the flowing pump is known as Time of Travel (TOT). The TOT is dependent on a variety of factors such as the rate of pumping, aquifer thickness, hydraulic gradient and porosity.

Aquifers are recharged, or re-supplied with water, primarily through precipitation. The rate at which aquifers are recharged depends on many factors, including soil type, land cover, topography and the type of bedrock in which the aquifer is found.

The Well Head Protection Program identifies well locations along with categorizing the Time of Travel for the water to reach the pump wells. The three "tiers" consist of; 2 years, 5 years and 12 years. The purpose for this delineation is to determine impacts of pollution on a pumped well. Most remediation efforts of a known contaminated area will occur before the 2-year tier level, thus helping to ensure the public safety. However, contamination within the well's 2-year tier will need to be addressed more rapidly to ensure public health.

Andover Township does contain several public well supply areas located primarily on the northeastern portion of the Township, as depicted in Figure 18, Well Head Protection Areas. A comparison shows that some of the known contaminated sites located in the Township are also located within wellhead protection areas. This information helps in planning for appropriate remediation of these sites given their proximity to the wellhead.

Wetlands

Wetland habitats generally occur between well-drained upland areas that rarely receive floodwater and low-lying, permanently flooded waters of lakes or streams. Wetlands characteristically include swamps, bogs, marshes and bottomland areas. Although they usually lie along rivers and lakes, wetlands may occur on slopes where they are associated with groundwater seeps or in areas of a perched water table. Wetlands depicted on Figure 19 are taken from the New Jersey Department of Environmental Protection's Land Use/Land Cover information from 2002.

The NJDEP wetland mapping in Figure 19 indicates that 1,906 acres of wetlands exist in Township. The predominant wetland type is deciduous wooded and shrub, comprising over 73% of the total acreage of wetlands at 1,385 acres. These wooded wetlands are present throughout the Township in a scattered pattern. Herbaceous wetlands are typically emergent-like habitats located along stream corridors where vegetation can be frequently flooded and run down by moving water. In late summer, vegetation is typically stable and hardy, maintaining a vegetative state below scrub/shrub. Both of these wetland types are primarily located along water courses, but are present along the fringes of larger areas of deciduous wooded wetlands spread across the Township.

Agricultural wetlands represent 8% (148 acres) of those in the Township. Agricultural wetlands are wetland areas that have been modified for crop production, generally by the installation of drainage features such as ditches or tiles. If drainage features are removed and the land is allowed to fall into succession, these areas will generally revert to wetlands. Agricultural wetlands are typically located at the edge of existing wetland areas which abut field fringes.

Eight general wetland types are identified in Figure 19 and listed in Table 10 below.

Table 10 – Wetland Types

	Acres	%
Deciduous Wetlands	1,385	73
Herbaceous Wetlands	242	13
Agricultural Wetlands	148	8
Mixed Forest Wetlands	76	4
Disturbed or Modified Wetlands	31	2
Phragmites Wetlands	15	1
Coniferuous Wetlands	8	0
Freshwater Tidal Marsh	0	0
Total	**1,906**	**100**

The importance of wetlands is multi-faceted. They serve as aquifer recharge areas and as areas that trap and filter pollutants through natural bio-chemical processes. The filtering capabilities of wetlands are particularly valuable along waterways, to help protect existing water quality. Wetlands in these areas may serve to buffer harmful nonpoint source pollutants.

Wetlands play a particularly valuable role in the Township, acting as filters for the headwaters to many of the water courses in Andover. Streams in the Township classified as trout-producing or trout maintenance highlight the importance of wetlands to stream health.

State regulations afford some protection to wetlands under the Freshwater Wetlands Protection Act (N.J.S.A. 13:9B). Wetlands are categorized in three primary ways, exceptional resource value, ordinary, and intermediate value.

Exceptional Value wetlands are defined as a wetland that:

1. Discharges into FW1 or FW2 trout production waters or their tributaries;
2. Is a present habitat for threatened or endangered species; or
3. Is a documented habitat for threatened or endangered species, and which remains suitable for breeding, resting, or feeding by these species during the normal period these species would use the habitat.

Wetlands of intermediate resource is any freshwater wetland not defined as exceptional or ordinary.

Wetlands of ordinary value are defined a wetland that does not exhibit any of the characteristics of exceptional value, and which is an isolated wetland smaller than 5,000 square feet.

The regulations do not prevent destruction or disturbance per se, however offer transitional area buffers encompassing wetlands that limit disturbance in or near a wetland. An exceptional value wetland is afforded a 150' transition buffer and an intermediate resource value wetland is given a 50' transitional buffer. There is no transition buffer associated with a wetland of ordinary resource value. Given the limited protection of wetland areas, it is prudent to consider additional environmental resource protection strategies that can build upon these State protections. More and more, the importance of wetlands in flood control and water quality is becoming known.

Floodplains

The Federal Emergency Management Agency (FEMA) has prepared maps of the 100-year floodplain along a number of the streams and rivers in the Township, as taken from the Q3 Flood Digital database and depicted on Figure 20. This mapping is prepared to provide information to homeowners, floodplain managers, engineers and flood insurance providers on the flooding risks associated with the location of dwellings and structures. It should be noted that the digital floodplain data that FEMA provides was created by digitizing the existing Flood Insurance Rate Maps (FIRM) with varying scales. In most cases, the data is distorted to varying degrees and is useful only for generalized floodplain location and magnitude.

Andover Township participates in the National Flood Insurance Program (NFIP), and has adopted standards regarding development in the floodplain. A Flood Hazard Study initiated participation in the Program and development regulations to prohibit or limit development in the floodplain are designed to reduce the risk of flood damage and protect public safety.

FEMA requires all persons with improved property within specially designated flood hazard areas, as certified by the Township Flood Search Official and shown on the Flood Insurance Rate Maps (FIRM), to purchase flood insurance. They recommend that even those not directly in a flood hazard area purchase insurance, as flood damage can occur outside the flood hazard areas as well.

The mapping of floodplains provided by FEMA carries a number of different designations. The 100-year floodplain is delineated for most streams though some do not have base flood elevations (BFE's) determined, as indicated. Streams that do not have BFE's determined have not been subject to detailed hydraulic study to determine potential flood extent, and water levels during the 100-year storm have not been determined.

The FIRM mapping of the 100-year floodplain is an essential resource that identifies the hazard of flood associated with areas in the Andover. There are a number of areas not depicted as floodplain which flood on a regular basis, pointing to the need for development of more complete and accurate flood data. The extent of the 100-year flood plain imposes severe limitations on development and it is sound public policy is to prohibit development throughout these mapped areas.

Riparian Areas

The health of surface waters within the Township is dependent upon the health and natural functioning of the areas that surround them, commonly known as riparian areas. The term riparian is derived from the Latin "ripa", which means *bank* or *shore.*

Riparian areas are a diverse and important part of the ecosystem. Due to their position in the landscape, they are conveyed a great amount of energy and nutrients. At the same time, this position makes them most vulnerable, subject to a combination of effects which can be related directly to anthropogenic activities.

Riparian areas serve a multitude of functions for surface waters, the most critical of which is to provide a transition area from surrounding land uses. A forested riparian area acts as a stream or river stabilizer in many ways, controlling water temperature, stabilizing the stream bank, filtering pollutants from runoff, controlling sedimentation and contributing organic matter to the stream ecosystem. Riparian forests are among the most vigorous forest types, uniquely positioned to take advantage of abundant available water and receive the benefits of nutrient flow. They, in-turn, provide critical nutrients and woody debris which enhance stream health by providing habitat for in-stream organisms. This in turn enhances the overall health of the riparian ecosystem through ripple effects.

Careful delineation of riparian areas and implementation of appropriate management strategies can insure continued maintenance and potential enhancement of existing water quality. This is especially critical in more developed portions of the Township, where water quality will continue to decline if riparian areas are not better protected. Figure 21 depicts riparian areas within the Township, comprised of streams, a 150' foot stream buffer, wetlands and slopes greater than 15%(seen in Figure 22) which are adjacent and drain to stream corridors. A 150' buffer was utilized as it is the minimum buffer permitted by the NJDEP for Category One surface waters. Forested areas indicate where the potential exists to extend riparian protection into non-wetland areas. Protection of portions of these adjacent forested areas will better protect and can enhance water quality and stream health.

Development and subsequent loss of riparian areas can have a number of negative impacts on surface waters. First and foremost, loss of riparian areas eliminates filtration of sediment and nonpoint source pollution, greatly impacting waterways. In addition to sediment, which enters the stream from off-site sources, deterioration and elimination of stream-side and stream bank vegetation lends to scouring, which causes bank deterioration and contributes to further erosion and sedimentation. Streams lacking forested or other vegetative riparian areas also lack habitat provided by woody debris. In-stream woody debris not only provides areas for fish and amphibians to reproduce, it also provides critical nutrients and substrate. Road crossings, which include bridges and culverts, are also destructive to riparian areas and stream channels. Crossings create breaks in an otherwise uninterrupted corridor, making wildlife migration difficult. Bridges are also prime sources of nonpoint pollution, often washed directly into the stream from the bridge deck.

New Jersey's adopted stormwater management regulations provide future guidance and additional protection measures for riparian areas. The "special resource protection" area requirement for Category 1 waters in the State requires a 300' buffer (minimum 150') around such streams. The special resource protection area is to be left in a natural state, with no installation of structural stormwater management facilities. The New Jersey Department of Environmental Protection implements this requirement in order to protect surface water quality from new stormwater discharges, which often carry nonpoint source pollution and eroded sediment into waterways. The regulations implement a vegetative buffer for Category 1 waters to provide filtration of run-off, reducing nonpoint source pollutants and sediment reaching streams.

Development Suitability Matrix

The previous sections outlined various natural features and constraints throughout the Township related to soil characteristics and hydrology. Increased development pressures throughout the State, and the Township, has resulted in development activities that may not be suited to their current locations. In an effort to curb future development that may jeopardize not only natural resources and the overall health of the ecosystem, but also negatively impact development after completion, a more critical analysis of the siting of developments should be undertaken. As a preliminary overview a "Development Suitability Matrix" can be used to identify general areas where development is more or less suitable. Table 11 identifies this type of method using the combined resources discussed in previous section.

Table 11 – Development Suitability Matrix

Attributes	Most Suitable	Moderately Suited	Least Suitable
100-year floodzone	Not Present	Not Present	Present
Wetlands	Not Present	Not Present	Present
Soil Contamination	Not Present	Not Present	Present
Hydric Soils	Not Present	Groups 2&3	Group 1
Steep Slopes	0-8%	8-15%	15% or Greater
Depth to Bedrock	60" or more	20"to 40"	10" to 20"
Depth to Seasonal High Water Table	6' or more	1.5' to 4'	1.5' or less

While this table offers an overview of the type of conditions that can affect potential development, a site by site investigation should always be conducted in order to determine the best options per site.

Steep Slopes

Another striking characteristic of the Township's landscape is its predominant steeply sloping topography. Andover, being situated in the Valley and Ridge region, exemplifies unique geologic formations. Ridgelines dot the landscape adding even greater scenic qualities and unique habitat opportunities.

Steep slopes, depicted on Figure 22, represent transitional areas in the landscape from higher terrain to lower terrain and ultimately into floodplains and stream channels. The latter are often created by the erosional effects of water scouring of the landscape. The most extensive areas of steep slope are found along the central area of the Township, running in a parallel manner from the north east to the south west. These areas represent the largest contiguous areas of slopes greater than 25%. However, a great deal of land in the Township is classified as having slopes over 15%. This is attributed to the unique geologic conditions of the Ridge and Valley region, with Kittatinny Mountain highlighting this geologic province.

Steep slopes have a number of implications for community development and the environment. Slopes in excess of 25% present serious limitations for development, often requiring extensive and costly engineering and construction. Development on slopes in excess of 15% can degrade the environment, if not properly managed. Since many areas of slopes occur in and around the banks of streams and rivers, where clearing creates the potential for accelerated erosion and stream sedimentation, protection of these steep slope areas is critical. The clearing of trees and vegetation that stabilizes the slope not only causes erosion and sedimentation problems, it can also contribute to increased water temperatures in streams and rivers.

Ridgelines

Figure 23, which depicts elevation contours of the Township, was derived from a 10 meter digital elevation model. Ridgelines are valuable topographic features often prominent in the visual landscape. Simply defined, a ridgeline is *a horizontal line or demarcation representing the intersection of two slopes having generally opposing aspects, usually representing the highest common elevation of both.* The prominence of ridgelines varies depending on the surrounding terrain, and a ridgeline may not be visible from the surrounding landscape if there are only moderate elevation changes. Its visual impact is therefore diminished, as in much of the Township.

Figure 23 depicts the ridgelines in the Township, delineated based on the above definition. Utilizing the NJDEP's 10 meter digital elevation model and contour information ridgelines were delineated manually. There are a number of major ridgelines throughout the Township. The most prominent are found along the central portion of the Township. However, the entire Township has significant ridgelines adding to the overall character of the landscape.

Development on ridgelines can have major negative impacts on visual character as forested ridgelines are cleared to make way for homes with "views". From a homeowner's perspective they represent desirable locations for home sites, taking advantage of views from the home site to the surrounding landscape. However, from a community perspective, undeveloped ridgelines are desirable places to protect because of the views they provide. Selective cutting of trees and careful placement of the building envelope can minimize disturbance to the visual landscape. Ridgelines should be recognized as valuable community assets; development on ridgelines transforms these community assets to the benefit of few and generally to the detriment of the environment.

New Jersey Landscape Project

In 1993, the New Jersey Department of Environmental Protection's Endangered and Nongame Species Program (ENSP) initiated a move to a landscape level approach for endangered species protection. With suburbanization and development occurring in all areas of the State, an increasing amount of habitat that could potentially support threatened and endangered species was being lost daily.

In order to address habitat loss, ENSP needed to grasp the extent and suitability of remaining resources in the State. To accomplish this, they partnered with the Center for Remote Sensing and Spatial Analysis (CRSSA) at Cook College, Rutgers University. Utilizing LandSat Thematic Mapper satellite imagery, CRSSA mapped land cover for the entire State of New Jersey, broken down into 20 different habitat/land cover types. After generalized cover types were classified, detailed methodologies were developed to address the habitat suitability issues for each focus category, including beach/dunes, emergent landscapes, forested wetlands, forested areas and grasslands. Version 2 of the Landscape Project data, released in February of 2004 and presented in Figures 24 and 25, replaced the land cover information compiled by Rutgers with the 1995 land use/land cover data prepared by the New Jersey Department of Environmental Protection. Now that the 2002 land use/land cover data for New Jersey is complete, it will replace the 1995 information.

After reclassifying data based on standards developed for each category, the habitat data was intersected, or combined, with the Natural Heritage Program's Biological Conservation Database (BCD). This database is a Geographic Information System (GIS) coverage that provides information on the sighting of threatened and endangered species, based on the field work of ENSP scientists and sightings reported by members of the public. It is the most comprehensive data available in digital form on the location of threatened and endangered species.

The Landscape Program data provides users with scientifically sound, peer-reviewed information on the location of critical habitat based on the conservation status of the species that are present. Habitats are ranked on a scale of 1 to 5, based on the following criteria:

Table 12 - NJ Landscape Program Ranking System

Rank	Indication
1	Suitable habitat, no species of special concern, or threatened or endangered species sighted
2	Habitat patch with species of special concern present
3	Habitat patch with State threatened species present
4	Habitat patch with State endangered species present
5	Habitat patch with Federal threatened or endangered species present

According to New Jersey Endangered and Nongame Species Program status definitions, "Endangered" applies to a species whose prospects for survival within the state are in immediate danger. "Threatened" applies to species that may become Endangered if conditions surrounding it begin to or continue to deteriorate. "Special Concern" applies to species that warrant special

attention because of some evidence of decline, inherent vulnerability to environmental deterioration, or habitat modification that would result in their becoming Threatened.

Andover Township is rich in habitat suitable to support populations of threatened and endangered species, as depicted on Figures 24 and 25. This includes primarily forest and forested wetland areas that canvas the Township. Discrepancies in acreage totals for forested and other Landscapes habitat type differ from previously reported 2002 Land Use/Land Cover data. The reason for this is due to a difference data. The landscapes data reports only on habitat that is suitable for particular species while the Land Use/Land Cover data reports entire coverage area. Table 13 summarizes the area of each habitat type by rank.

Table 13 - NJ Landscape Project Habitat Summary

Habitat Type	Rank	Acres	% of Total Acres of Habitat Type
Forest	2 – Species of Special Concern sighted	86	1
	3 – State Threatened Species sighted	52	1
	4 – State Endangered Species sighted	7,648	98
	Total	**7,786**	
Forested Wetland	1 – Suitable habitat	49	4
	2 – Species of Special Concern sighted	280	23
	3 – State Threatened Species sighted	615	50
	4 – State Endangered Species sighted	243	20
	5 – Federally Threatened or Endangered Species sighted	48	4
	Total	**1,235**	
Grassland	1 – Suitable habitat	483	32
	2 – Species of Special Concern sighted	510	34
	3 – State Threatened Species sighted	515	34
	Total	**1,508**	
Emergent	1 – Suitable habitat	56	11
	2 – Species of Special Concern sighted	404	78
	3 – State Threatened Species sighted	11	2
	4 – State Endangered Species sighted	13	3
	5 – Federally Threatened or Endangered Species sighted	25	5
	Total	**508**	

The critical forest habitat of the Township is the most dominant habitat and supports state endangered species (see table 14 for complete listing of threatened and endangered species). This habitat covers most of the Township, consisting of 7,786 acres, or 59% of the Township's

entire land coverage. These critical forested habitat areas support species such as the Barred Owl, Red-Shouldered Hawk, Red Headed Woodpecker, Longtail Salamander and Bog Turtles.

Forested wetlands represent the next most prevalent habitat type. The location of forested wetlands are distributed widely throughout the Township and cover 1,235 acres, or almost 9% of the total land cover in the Township. Forested wetlands generally overlap into forested classification areas and often produce unique habitat for herptile species. Critical species located in forested wetlands are often similar to those in neighboring or overlapping critical forested habitat and include the Bog Turtle.

The remaining land cover consists of grassland and emergent habitat. Grassland habitat in the Township supports populations of State threatened species such as the Long Eared Owl, Bobolink, Grasshopper Sparrow and Savannah Sparrow. Grassland habitat accounts for 1,508 acres in the Township (11%) and is located in the northern and southern portions of the Township. Emergent habitat, includes 508 acres scattered throughout the Township in isolated pockets, is critical to the reproductive cycles of many amphibian species, reliant on both emergent wetlands and spring (vernal) pools for this process. Bog Turtles are sighted in the emergent habitat of the Township. The NJDEP, in cooperation with The Center for Remote Sensing and Spatial Analysis (CRSSA) at Cook College, developed a project to identify and monitor vernal habitats, which will eventually be incorporated in the Landscape Project data. New regulations adopted in 2001 afford protection to emergent and vernal habitats where previously none existed. This lack of protection was largely due to the size of pools and isolated emergent areas, as many are less than 1 acre and could be drained and filled with a general wetland permit. CRSSA and NJDEP are developing maps of both potential and certified vernal and emergent habitats.

Table 14: List of Endangered and Threatened Species in Andover Township

Common Name	Scientific Name	Threatened	Endangered
Red Shoulder Hawk	*Buteo lineatus*		X
Barred Owl	*Strix varia*	X	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	X	
Bobcat	*Lynx rufus*		X
Longtail Salamander	*Eurycea L. longicauda*	X	
Long-eared Owl	*Asio otus*	X	
Blue spotted Salamander	*Ambystoma laterale*		X
Silver-bordered Fritillary	*Boloria selene myrina*	X	
American Bittern	*Botaurus lentiginosus*		X
Bog Turtle	*Clemmys muhlenbergii*		X
Bobolink	*Dolichonyx oryzivous*	X	
Grasshopper Sparrow	*Ammodramus savannarum*	X	
Savannah Sparrow	*Passerculus sandwichensis*	X	

The Landscape Project data is intended to aid municipalities, County and State governments, conservation agencies and citizens in determining the extent of critical habitat within their

respective jurisdictions and communities. After identifying critical habitat, a variety of means can be employed to protect it, including the following:

- Prioritizing open space acquisitions based on the presence of habitat for threatened and endangered species
- Adopting regulations aimed at protecting critical habitat
- Adopting management policies for open space that are consistent with protection of critical habitat
- Permitting flexibility in development techniques that can accommodate the protection of critical habitat
- Promoting land stewardship practices that are consistent with the protection of critical habitat

As suburban sprawl has reached across New Jersey, valuable habitat has been lost that supports rare and diverse species in the state. Many threatened and endangered species require large contiguous, unfragmented areas to thrive and reproduce. Preserving large contiguous areas of critical habitat not only ensures the health and survival of threatened and endangered species but also contributes to the preservation of open space and future diversity of the region. The loss of a diverse ecosystem can lead to monocultures of invasive species and the detriment of the ecosystem. Efforts to protect critical habitat areas should be thoughtfully considered to ensure preservation of rare and diverse species.

Invasive Species

The importance of preserving and conserving native or indigenous plant and animal species in New Jersey has been increasing in recent years. As development has fragmented and altered previously natural plant and animal communities, opportunities for introduction of invasive species has resulted in the decline and elimination of important biological sites throughout the state. Often, invasive species have no pest or other attributable agents that can keep one dominant population from overtaking a region. This results in a monoculture, whereby one plant species dominates and pushes out native species. A monoculture can have devastating impacts on a region. The lack of plant diversity inevitably leads to the lack of a diverse animal population, with few species able to thrive on the newly introduced invasive species. Additionally, the new species can invite other invasive species able to thrive on the new ecosystem. As more and more native plant and animals are being lost the world over, new initiatives to foster a diverse ecosystem have taken root.

As witnessed in the previous section on the New Jersey Landscapes database and the following section on Natural Heritage sites, the State has taken great efforts to inform and educate residents on the importance of preserving natural species and reducing invasive species for the necessary biological diversity needed to support threatened and endangered species. Efforts to encourage the planting and maintenance of native species should be encouraged while the introduction, removal and altering of habitat areas that will encourage the spread or introduction of invasive species should be discouraged whenever possible. Appendix 3 lists invasive and native plant species for New Jersey as identified by the Native Plant Society of New Jersey. Prevalent invasive species found in Andover Township include Garlic Mustard, Purple Loosestrife, Crown

Vetch, and Japanese Stiltgrass. The use of invasive species should be strongly discouraged and the replanting and introduction of native species should be encouraged wherever possible.

Migratory Flyways[15]

Bird migration is an important biological necessity faced by many bird species. The need to migrate often revolves around a species need for a stable food source, finding appropriate nesting sites escaping climates not suitable for winter habitat. The routes followed by migratory birds are numerous, and while some of them are simple and easily traced, others are extremely complicated. Differences in distance traveled, in time of starting, in speed of flight, in geographical position, in the latitude of the breeding and wintering grounds and in other factors all contribute to great diversity. No two species follow exactly the same path from beginning to end; geographical groups of species with an almost continental distribution may travel different routes.

Migration routes may be defined as the lanes of individual travel from any particular breeding ground to the winter quarters of the birds that use them. Flyways, on the other hand, may well be conceived as those broader areas in which related migration routes are associated or blended in a definite geographic region. They are wide arterial highways to which the routes are tributary.

There are four (4) major North American flyways that have been named the Atlantic, the Mississippi, the Central and the Pacific Flyways. Except along the coasts, the flyway boundaries are not always sharply defined and both in the northern breeding, and the southern wintering, grounds there are more or less overlapping.

Bird migration is generally thought of as a north-and-south movement, with the lanes of heavier concentration following the coasts, mountain ranges and principal river valleys. In general, it may be said that the great routes of migration do conform very closely to major topographical features when these happen to lie in the general direction of the travel to be performed. It happens to work out nicely in North America where the coasts, mountain chains and come of the larger rivers do not depart from a north-and-south alignment.

Atlantic Flyway

The Atlantic Flyway may be described as extending from the offshore waters of the Atlantic Coast west to the Allegheny Mountains where, curving northwestward across northern West Virginia and northeastern Ohio, it continues in that direction across the prairie provinces of Canada and the Northwest Territories to the Arctic Coast of Alaska. The flyway embraces several primary migration routes and many more that are important as tributaries, some of the latter being branches from primary routes of other flyways. The Atlantic Flyway route from the northwest is of great importance to migratory waterfowl and other birds some of which are flocks of Canvasbacks, Redheads and Lesser Scaups that winter on the waters and marshes south of Delaware Bay. The coastal route of the Atlantic Flyway, which in general follows the shore line, has its northern origin in the eastern Arctic islands and the coast of Greenland. This is a

[15] Information from http://www.birdnature.com/

regular avenue of travel, and along it are many famous points for the observation of migrating land and water birds.

Andover Township, located in the Atlantic Flyway, provides a variety of habitat types suitable to migratory bird species. Grassland and forest habitat, along with unique wetland and water features, offers a diverse mix of habitat suitable for migratory birds. In addition, as seen in the Landscapes Project discussion in the previous section, a variety of threatened and endangered bird species are located in the Township. Habitat sites that host migratory and local bird population should be monitored and protected. The loss of habitat areas used by migratory birds not only affects local and regional populations but also reduces the bird populations on a larger scale, impacting global species.

Monarch Butterfly Flyway[16]

As with bird populations, Monarch butterflies also migrate in a north to south pattern, wintering in Mexico and spending summers throughout the United States. Monarch Butterfly migration patterns have been difficult to track and recent efforts to discover more about a Monarch's migration habits include tagging and tracking the butterfly. Recent data has been able to map volunteer sightings of Monarchs to more precisely show habitat and migration patterns. While Monarchs are common throughout the United States, the prairies and northeast are especially abundant with sightings, due to the abundance of milkweed and other nectar producing plants abundant in these areas. Andover Township provides habitat that can be considered suitable to migrating populations. This includes grasslands, forested areas and a variety of plant species for the butterfly to feed on. Volunteer efforts to help support and attract summering and migrating Monarchs can help to bolster their population. These can include providing "butterfly gardens" rich in nectar producing plants and safe resting sites.

Natural Heritage Sites[17]

The Natural Heritage Priority Sites Coverage was created through the Natural Heritage Database as a means to identify and help protect and conserve New Jersey's biological diversity. The database provides detailed, up-to-date information on rare species and natural communities to planners, developers, and conservation agencies for use in resource management, environmental impact assessment, and both public and private land protection efforts. The purpose of creating the database was to help identify the best habitats for rare plant and animal species and natural communities through analysis of information in the NJ Natural Heritage Database. Natural Heritage Priority Sites contain some of the best and most viable occurrences of endangered and threatened species and natural communities, but they do not cover all known habitat for endangered and threatened species in New Jersey.

Figure 26 identifies the locations of Natural Heritage Sites in Andover Township. The Township contains every rank afforded in the Natural Heritage Site listings. These areas should be carefully monitored for long term viability of rare species and effects of habitat change. Each site is ranked according to its significance for biological diversity. The ranks can be used to

[16] Information from http://www.learner.org/jnorth/tm/monarch/Resources.html
[17] NJ Department of Environmental Protection, New Jersey Office of Natural Lands Management (ONLM)

distinguish between sites that are of global significance for conservation of biological diversity vs. those that are of state significance. The scale ranges from B1 to B5 with sites ranked B1-B3 generally being of global significance and sites ranked B4-B5 being of state significance. In addition to the biological diversity rank, each site is categorized as a macrosite or a standard site. Standard sites are smaller in size (usually less than 3200 acres in size), while macrosites tend to be larger (usually greater than 3200 acres in size). It is not unusual to find several standard sites entirely contained within the boundaries of a macrosite. The following definitions break down each rank:

B1: Outstanding significance, generally the "last of the least" in the world, such as the only known occurrence of any element (species or natural community), the best or an excellent occurrence of an element ranked critically imperiled globally, or a concentration (4+) of good or excellent occurrences of elements that are imperiled or critically imperiled globally. The site should be viable and defensible for the element or ecological processes contained. Sites are classified as Macrosites (usually greater than 3200 acres in size) or Standard Sites (usually less than 3200 acres in size).

B2: Very high significance, such as the most outstanding occurrence of any natural community. Also includes areas containing other occurrences of elements that are critically imperiled globally, a good or excellent occurrence of an element that is imperiled globally, an excellent occurrence of an element that is rare globally, or a concentration (4+) of good occurrences of globally rare elements or viable occurrences of globally imperiled elements. Sites are classified as Macrosites (usually greater than 3200 acres in size) or Standard Sites (usually less than 3200 acres in size).

B3: High significance, such as any other viable occurrence of an element that is globally imperiled, a good occurrence of a globally rare element, an excellent occurrence of any natural community, or a concentration (4+) of good or excellent occurrences of elements that are critically imperiled in the State. Sites are classified as Macrosites (usually greater than 3200 acres in size) or Standard Sites (usually less than 3200 acres in size).

B4: Moderate significance, such as a viable occurrence of a globally rare element, a good occurrence of any natural community, a good or excellent occurrence or only viable state occurrence of an element that is critically imperiled in the State, an excellent occurrence of an element that is imperiled in the State, or a concentration (4+) of good occurrences of elements that are imperiled in the State or excellent occurrences of elements that are rare in the State. Sites are classified as Macrosites (usually greater than 3200 acres in size) or Standard Sites (usually less than 3200 acres in size).

B5: Of general biodiversity interest. Sites are classified as Macrosites (usually greater than 3200 acres in size) or Standard Sites (usually less than 3200 acres in size).

Conclusion

The Township of Andover possesses an array of natural features and critical environmental resources that combine to form a landscape unique to Andover. Andover's soils are typical of the Highlands and Ridge and Valley regions. The majority of soils have a moderate depth to bedrock with a high water table, posing significant limitations to development for residential purposes. Many of the soils contain high percentages of stony material and rock outcroppings, posing further limitations to development. On-site septic suitability, as identified by the NJDEP in 1999, indicates that the soils may not be suitable for septic systems in a wide portion of the Township. This is largely due to shallow depth to bedrock and seasonal high water that the soils in that area exhibit.

The surface waters in the Township include a system of headwater tributaries and streams draining to the various lakes in the Township. While many of the Streams in the Township are not currently designated C-1, portions of the Paulins Kill are classified as C-1. Many of the streams also support trout production and trout maintenance, providing further indication of their importance to ecosystem health.

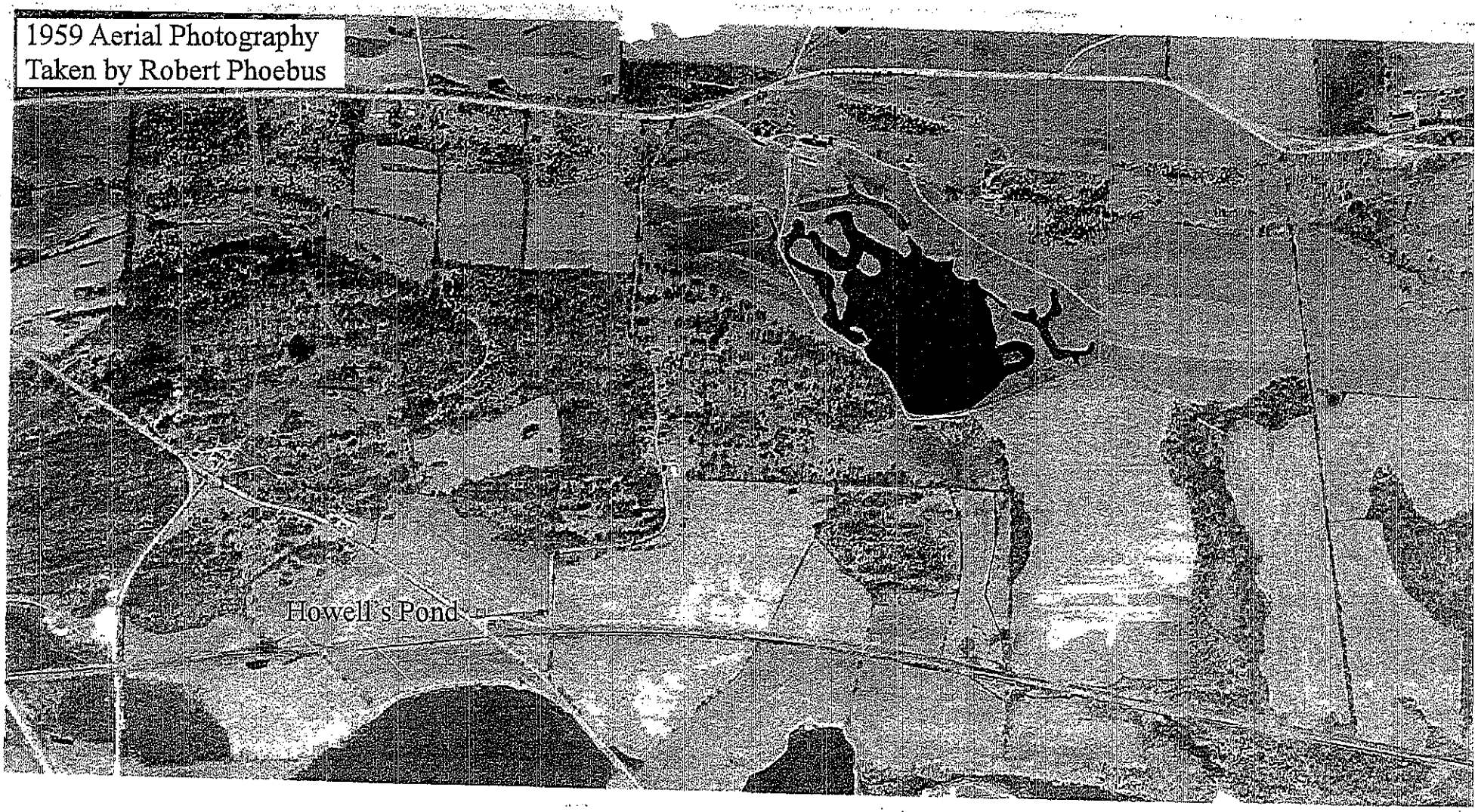
The wetlands present in Andover are generally forested and are located along most of the stream corridors, overlapped in some areas by FEMA-designated floodways, making this an important riparian habitat area. Riparian areas, an important part of the ecosystem, serve a multitude of functions, including controlling water temperature, stabilizing the stream bank, filtering pollutants from runoff, controlling sedimentation and contributing organic matter to the stream ecosystem. They are uniquely suited to passive recreation activities and can serve as corridors for wildlife migration.

The Township is primarily covered by contiguous forested areas of state endangered species habitat. This type of large contiguous habitat is becoming increasingly rare in New Jersey and should be carefully protected as a valued resource. State endangered species, such as the Red Shouldered Hawk, Barred Owl, wood turtle and the Federally Endangered Bog Turtle require large contiguous areas to forage and breed.

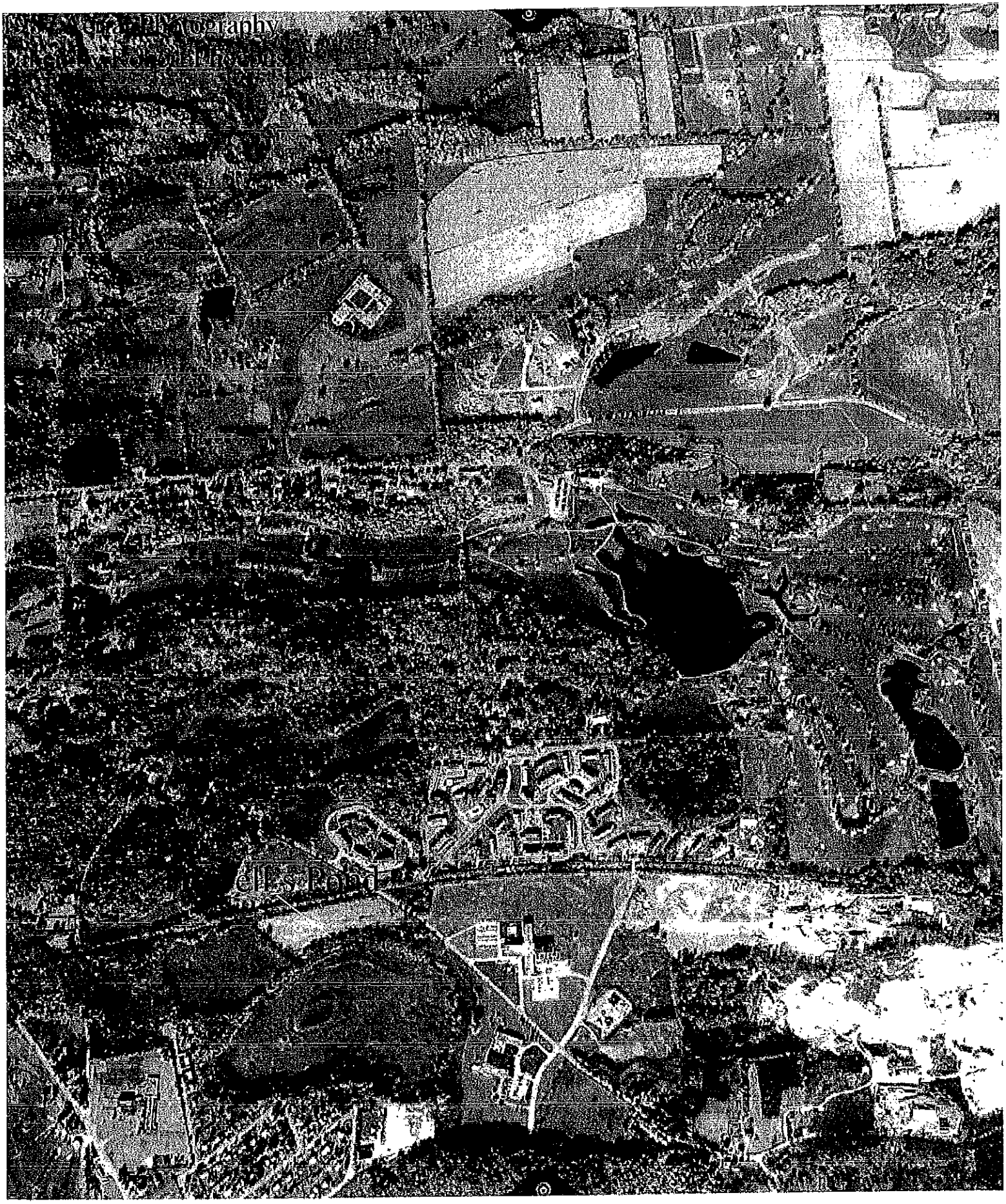
Andover Township contains a diverse set of natural resources that has contributed to the Township's historical development and plays a role in the future health of the regional ecosystem. The surface waters, geology, soils, wetlands and forest combine to create an environment unique to the Township. Loss of or impact to any of these resources can have a direct effect on the biodiversity of the area. Future planning efforts should reflect the need to preserve the natural resource base, which enhances the quality of life of residents in the Township and the future health of the regional ecosystem.

Appendices

Appendix 1: Historic Aerial Photography of Howell's Pond Area
Photos by Robert Phoebus


1959 Aerial Photography
Taken by Robert Phoebus
Howell's Pond

1966 Aerial Photography
Taken by Robert Phoebus


ell's Point

Appendix 2: Geologic Units – Technical Descriptions[18]

OCa Allentown Dolomite (Lower Ordovician and Upper Cambrian) (Wherry, 1909) – Very thin to very thick bedded dolomite containing minor orthoquartzite and shale. Upper part is medium-light- to medium-dark-gray, fine- to medium-grained, locally coarse-grained, medium- to very thick bedded dolomite. Floating quartz sand grains and two sequences of medium-light- to very light gray, thin-bedded quartzite and discontinuous, dark-gray chert lenses occur directly below upper contact. Rhythmically bedded lower dolomite beds alternate between light and dark gray weathering, medium and very light gray, fine and medium grained, and thin and medium bedded, which are interbedded with shaly dolomite. Ripple marks, crossbeds, edgewise conglomerate, mud cracks, oolites, and algal stromatolites occur throughout unit, but more typically in lower part. Shaly dolomite increases downward toward lower conformable contact with the Leithsville Formation. Oldest beds contain trilobite fauna of early Late Cambrian age; younger beds contain latest Cambrian fauna (Howell, 1945; Howell and others, 1950). Thickness about 580 m (1,900 ft).

Ya Amphibolite - Gray- to grayish-black, medium-grained amphibolite composed of hornblende and andesine. Some phases contain biotite and (or) clinopyroxene. Ubiquitous and associated with almost all other Middle Proterozoic units. Some amphibolite is clearly metavolcanic in origin, some is metasedimentary, and some appears to be metagabbro.

Ylb Biotite-quartz-oligoclase gneiss – White- to light-gray-weathering, light- to medium-gray or greenish-gray, fine- to coarse-grained, massive to moderately well layered, foliated gneiss composed of oligoclase or andesine, quartz, biotite, and, locally, garnet. Commonly interlayered with amphibolite.

Omb Bushkill Member (Middle Ordovician) (Drake and Epstein, 1967) - Interbedded medium- to darkgray, thinly laminated to thick-bedded shale and slate and less abundant medium-gray to brownish-gray, laminated to thin-bedded siltstone. To the southwest, fine-grained, thin dolomite lenses occur near base. Complete turbidite sequences (Bouma, 1962) occur locally, but basal cutout sequences (Tbcde, Tcde or Tde) dominate. Conformable lower contact is placed at top of highest shaly limestone; elsewhere, lower contact is commonly strain slipped. Correlates with graptolite *Climacograptus bicornis* to *Corynoides americanus* zones of Riva (1969, 1974) (Parris and Cruikshank, 1992). Thickness ranges from 1,250 m (4,100 ft) in Delaware River Valley to 457 m (1,500 ft) at New York State line.

Yf Franklin Marble – White- to light-gray-weathering, white, grayish-white, or, less commonly pinkish orange, coarse- to locally fine-crystalline calcite marble with accessory amounts of graphite, phlogopite, chondrodite, clinopyroxene, and serpentine. Contains pods and layers of clinopyroxene-garnet skarn, hornblende skarn, and clinopyroxene-rich rock. Thin layers of metaquartzite occur locally. Intruded by the Mount Eve Granite in the Pochuck Mountain area. Franklin Marble is host to the Franklin and Sterling Hill zinc ore bodies; exploited for talc and

[18] "Bedrock Geology and Topographic Base Maps of New Jersey", New Jersey Geological Survey CD Series CD 00-1, New Jersey Geological Survey, 2001.

asbestiform minerals near Easton, Pennsylvania. Subdivided into an upper marble, "Wildcat marble," and a lower marble, "Franklin marble," by New Jersey Zinc Co. geologists.

Ch Hardyston Quartzite (Lower Cambrian) (Wolff and Brooks, 1898) - Medium- to light-gray, fine- to coarse-grained, medium- to thick-bedded quartzite, arkosic sandstone and dolomitic sandstone. Basal pebble to cobble conglomerate typically contains clasts of local basement affinities. Contains fragments of the trilobite *Olenellus thompsoni* of Early Cambrian age. Thickness approximately 0.5 to 62 m (1.6-200ft).

Ybh Hornblende granite - Pinkish-gray- to medium-buff-weathering, pinkish-white or light-pinkish-gray, medium- to coarse-grained, gneissoid to indistinctly foliated granite and sparse granite gneiss composed principally of microcline microperthite, quartz, oligoclase, and hornblende. Some phases are quartz syenite or quartz monzonite. Includes small bodies of pegmatite and amphibolite not shown on map. UPb age approximately 1,090 Ma.

Yh Hypersthene-quartz-plagioclase gneiss – Gray- to tan-weathering, greenish-gray to greenishbrown, medium-grained, moderately well layered and foliated, greasy-lustered gneiss of charnockitic affinity composed of andesine or oligoclase, quartz, clinopyroxene, hornblende, hypersthene, and sparse amounts of biotite. Commonly interlayered with amphibolite and mafic-rich quartz-plagioclase gneiss.

Oj Jacksonburg Limestone (Middle Ordovician) (Kümmel, 1908; Miller, 1937) - Upper part is medium- to dark-gray, laminated to thin-bedded shaly limestone and less abundant medium-gray arenaceous limestone containing quartz-sand lenses. Upper part thin to absent to northeast. Lower part is interbedded medium- to dark-gray, fine- to medium-grained, very thin to medium-bedded fossiliferous limestone and minor medium- to thick-bedded dolomite-cobble conglomerate having a limestone matrix. Unconformable on Beekmantown Group and conformable on the discontinuous sequence at Wantage in the Paulins Kill area. Contains conodonts of North American midcontinent province from Phragmodusundatus to Aphelognathus shatzeri zones of Sweet and Bergstrom (1986). Thickness ranges from 41 to244m (135-800 ft).

Cl Leithsville Formation (Middle to Lower Cambrian) (Wherry, 1909) - Thin- to thick-bedded dolomite containing subordinate siliciclastic rocks. Upper part is medium- to medium-dark-gray, fine- to mediumgrained, pitted, friable, mottled and massive dolomite. Middle part is medium-gray, stylolitic, fine-grained, thin- to medium-bedded dolomite that is interbedded with shaly dolomite and, less commonly, varicolored quartz sandstone, siltstone, and shale. Lower part is medium-gray, medium-grained, medium-bedded dolomite containing quartz-sand grains in stringers and lenses near the contact with the Hardyston Quartzite. Archaeocyathids of Early Cambrian age suggest an intraformational disconformity separating rocks of Middle and Early Cambrian age (Palmer and Rozanov, 1976). Thickness approximately 305 m (1,000 ft).

Obl Lower part - Very thin to thick-bedded, interbedded dolomite and minor limestone. Upper beds are light-olive-gray to dark-gray, fine- to medium-grained, thin- to thick-bedded dolomite. Middle part is olivegray-, light-brown-, or dark-yellowish-orange- weathering, dark-gray, aphanitic to fine-grained, laminated to medium-bedded dolomite and light-gray to light-bluish-

gray-weathering, medium-dark- to dark-gray, fine-grained, thin- to medium-bedded limestone, that is characterized by mottling with reticulate dolomite and light-olive-gray to grayish-orange, dolomitic shale laminae surrounding limestone lenses. Limestone grades laterally and down section into medium- gray, fine-grained dolomite. Lower beds consist of medium-light- to dark-gray, aphanitic to coarse-grained, laminated to medium-bedded, locally slightly fetid dolomite having thin black chert beds, quartz-sand laminae, and oolites. Lenses of light-gray, very coarse to coarse-grained dolomite and floating quartz sand grains and quartz-sand stringers at base of sequence. Lower contact placed at top of distinctive medium-gray quartzite. Contains conodonts of *Cordylodus proavus* to *Rossodus manitouensis* zones of North American Midcontinent province as used by Sweet and Bergstrom (1986). Unit **Obl** forms Stonehenge Formation of Drake and Lyttle (1985) and Drake and others (1985), upper and middle beds are included in Epler Formation, and lower beds are in Rickenbach Dolomite of Markewicz and Dalton (1977). Unit is about 183 m (600 ft) thick.

Om Martinsburg Formation, undivided (Upper and Middle Ordovician) (Bayley and others, 1914) - Interbedded light-olive-gray, greenish-gray-, or dark-yellowish-brown-weathering, medium-dark- to darkgray, laminated to medium-bedded graywacke and siltstone and olive-gray- to dark-yellowish-brownweathering, medium-dark- to dark-gray slate. Turbidite cycles are common. Mapped only east of Lafayette and west of Lake Grinnell where thickness is at least 305 m (1000 ft).

Ym Microcline gneiss - Light-gray- to pinkish-white-weathering, tan to pinkish-white, fine- to mediumgrained, well-layered gneiss composed principally of quartz, microcline, and lesser amounts of oligoclase. Common accessory minerals include biotite, garnet, magnetite, and, locally, sillimanite.

Yp Pyroxene gneiss – White- to tan-weathering, greenish-gray, fine- to medium-grained, well-layered gneiss containing oligoclase, clinopyroxene, variable amounts of quartz, and trace amounts of opaque minerals and titanite. Some phases contain scapolite and calcite. Commonly interlayered with pyroxene amphibolite or marble.

Ylo Quartz-oligoclase gneiss – White-weathering, light-greenish-gray, medium- to coarse-grained, moderately layered to indistinctly foliated gneiss and lesser amounts of granofels composed of quartz, oligoclase or andesine, and, locally, biotite, hornblende and (or) clinopyroxene. Contains thin amphibolite layers.

Obu Upper part - Locally preserved upper beds are light- to medium-gray- to yellowish-gray-weathering, medium-light- to medium-gray, aphanitic to medium-grained, thin- to thick-bedded, locally laminated, slightly fetid dolomite. Medium-dark to dark-gray, fine-grained, medium-bedded, sparsely fossiliferous limestone lenses occur locally. Lower beds are medium-dark- to dark-gray, medium- to coarse-grained, mottled surface weathering, medium- to thick-bedded, strongly fetid dolomite that contains pods and lenses of dark-gray to black chert. Cauliflower-textured black chert beds of variable thickness occur locally. Gradational lower contact is placed at top of laminated to thin-bedded dolomite of the lower part (**Obl**) of the Beekmantown Group. Contains conodonts high in the *Rossodus manitouensis* zone to low zone D of the North American midcontinent province as used by Sweet and Bergstrom (1986). Upper beds are

included in Epler Formation; lower beds are included in Rickenbach Dolomite of Drake and Lyttle (1985) and Drake and others (1985); entire upper part (**Obu**) is Ontelaunee Formation of Markewicz and Dalton (1977). Thickness ranges from 0 to 244 m (0-800 ft).

Appendix 3: Invasive and Native Plant Species
List from the Native Plant Society of New Jersey

Invasive Species Common in New Jersey

Herbaceous Dicots:

Achillea millefolium, Yarrow
Alliaria petiolata, Garlic Mustard
Artemisia vulgaris, Mugwort
Cichorium intybus, Chickory
Coronilla varia, Crown Vetch
Daucus carota, Wild Carrot
Glechoma hederacea, Gill-Over-The -Ground
Hesperis matronalis, Dane's Rocket
Lythrum salicaria, Purple Loosestrife
Malva moschata, Musk Mallow
Meliotus alba, White Sweet Clover
Plantago lanceolata, English Plantain
Polygonium cuspidatam, Japanese Knotweed
Rumex crispus, Curly Dock
Trifolium pratense, Red Clover
T. repens, White Clover

Monocots:

Allium vineale, Field Garlic
Arundinaria, Bambusa, Any Hardy Bamboo
Dendrocalamus, Bamboo
Cynodon dactylon, Bermuda Grass
Dactylis glomerata, Orchard Grass
Digitaria sanguinalis, Crab Grass
Echinochloa crusgalli, Barnyard Grass
Hemercallus fulva, Day Lily
Microstegium vimineum, Japanese Stilt Grass
Phragmites australis, Common Reed

Vines and Woody Plants

Acer platanoides, Norway Maple
Alianthus altissima, Tree of Heaven
Berberis thunbergii, Japanese Barberry
Celastrus orbiculatus, Asian Bittersweet
Elaeaghus angustifolia, Russian Olive
E. umbellata, Autumn Olive

Hedera helix, English Ivy
Lonicera japonic, Japanese Honeysuckle
Rhamnus cartharticus, Buckthorn
R. frangula, Alder Buckthorn
Rosa multiflora, Multiflora Rose

Category 2, Invasive But Not As Widespread (Yet)

Herbaceous Dicots:

Ajuga reptans, Common Bugleweed
Centaurea maculosa, Spotted Knapweed
Chelidonium majus, Celandine
Chrysanthemum leucanthemum, Ox-Eye Daisy
Dianthus armeria, Depford Pink
Galinsoga ciliata, Galinsoga
Lamium purpureum, Purple Dead Nettle
Linaria vulgaris, Butter-and-Eggs
Lysimachia nummularia, Moneywort
Matricaria matricariodes, Pineapple Weed
Mentha spicata, Spearment
Polygonum persicaria, Lady's-Thumb
Portulaca oleracea, Purslane
Ranunculus acris, Common Buttercup
R. bulbosus, Bulbous Buttercup
R. ficaria, Lesser Celandine
R. repens, Creeping Buttercup
Rumex acetosella, Sheep's Sorrel
Rumex obtusifolius, Broad Dock
Verbascum thapsus, Common Mullein
V. blattaria, Moth Mullein

Monocots:

Commelina communis, Day Flower

Vines and Woody Plants:

Albizia julibrissin, Mimosa
Prunus avium, Crab Cherry
Wisteria frutescens, Wisteria
W. floribunda, Wisteri

Native Species Common in New Jersey

Actaea alba, White baneberry
Anemone quinquefolia, Wood anemone
Anemonella thalictroides, Rue anemone
Aquilegia Canadensis, Columbine
Arctostaphylos uvaursi, Bearberry
Arisaema triphyllum, Jack-in-the-pulpit
Asarum canadense, Wild ginger
Asclepias tuberosa, Butterfly weed
Asplenium platyneuron, Ebony Spleenwort

Campanula rotundifolia, Harebell
Castalia odorata, Water-lily
Chimaphila maculata, Spotted Wintergreen
Cimicifuga racemosa, Black snake root
Claytonia virginica, Spring Beauty
Corydalis aurea, Golden corydalis
Corydalis sempervirens, Pale corydalis
Cypripendium acaule, Pink ladyslipper

Dennstedtia punctilobula, Hay-scented Fern
Dentaria laciniata, Cut-leaf toothwort
Dicentra cucullaria, Dutchman's Breeches
Drosera filiformis, Thread-leaved Sundew
Drosera longifolia, Long-leaved sundew
Drosera rotundifolia, Round-leaved Sundew

Epigaea repens, Trailing arbutus

Gaultheria procumbens, Wintergreen
Geranium maculatum, Cranesbill

Hepatica triloba, Liverwort
Houstonia coerulea, Bluet
Hypoxis hirsute, Yellow star grass

Iris species

Leiophyllum buxifolium, Sand-myrtle
Lobelia cardinalis, Cardinal flower

Maianthemum canadense, Canada May Flower
Mertensia virginica, Virginia bluebell
Mitchella repens, Partridgeberry
Mitella diphylla, Bishop's cap

Opuntia humifusa, Prickly pear
Osmunda regalis, Royal fern

Polygonatum biflorum, Smooth Solomon's seal
Polystichum acrostichoides, Christmas Fern

Sanguinaria Canadensis, Bloodroot
Sarracenia purpurea, Pitcherplant
Sedum ternatum, Stonecrop
Sisyrinchium angustifolium, Blue-eyed Grass
Smilacina racemosa, Solomon's plume

Thalictrum dioicum, Early meadow rue
Thalictrum polygamum, Tall meadow Rue
Thelypteris hexagonoptera, Winged Beech fern
Tiarella cordifolia, Foamflower
Trillium erectum, Wake-robin

Uvularia perfoliata, Bellwort

Viola blanda, Sweet white violet
V. Canadensis, Canada violet
V. conspersa, Dog violet
V. cucullata, Blue marsh violet
V. eriocarpa, Smooth yellow violet
V. lanceolata, Lance-leaved violet
V. pallens, Wild white violet
V. palmate, Palm-leaved violet
V. papillionacea, Common blue violet
V. pedata, Bird's foot violet
V. primulifolia, Primose-leaved violet
V. pubescens, Downy yellow violet
V. rostrata, Long-spurred violet
V. rotundifolia, Round-leaved yellow Violet
V. sagittata, Arrow-leaved violet
V. sororia, Wooly violet
V. Striata, Pale violet

Appendix 4: Glossary

Anderson Classification System (Land Use/Land Cover): The Anderson classification system is a hierarchical system to describe land cover. The system is based on four digits which represent one to four levels of classification. These levels include; level I is general, level II is more descriptive, level III is detailed, and level IV is the most detailed. For example level one would include a broad category of wetlands while level two would describe wetlands by their character, wooded or grassland.

Bedrock: The solid rock formations found beneath the soils and superficial rock.

Category 1 streams: Waters designated in the tables in N.J.A.C. 7:9B-1.15(c) through (h), for purposes of implementing the anti-degradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality characteristics because of their clarity, color, scenic setting, other characteristics of aesthetic value, exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).

Category 2 streams: Waters not designated as Outstanding National Resource Waters or Category One at N.J.A.C. 7:9B-1.15 for purposes of implementing the anti-degradation policies set forth at N.J.A.C. 7:9B-1.5(d).

Coniferous Forests: Forests comprising of a majority of coniferous (cone bearing) tree stands.

Deciduous Forests: Forests comprising of a majority of deciduous (cyclic foliage loss) tree stands.

Farmland Capability: Refers to lands containing soils that are productive for agricultural purposes.

Floodplains: Lowland areas adjacent to rivers, lakes or oceans. Floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by a 10-year flood and the 100-year floodplain by the 100-year flood.

Geographical Information Systems (GIS): A system for management, analysis, and display of geographic knowledge, which is represented using a series of information sets such as maps and globes, geographic data sets, processing and work flow models, data models, and metadata.

Hardiness Zones: A map prepared by the United States Department of Agriculture. The map shows 10 different zones, each of which represents an area of winter hardiness for the plants of agriculture and our natural landscape.

Highly erodible Lands: The United States Department of Agriculture, Natural Resources Conservation Service rates soils based on their potential for erosion by two factors; wind and water.

Natural Resource Inventory (NRI): A document that uses maps and text to describe the municipality's most important natural resources.

Riparian Zones: Areas or zones of vegetation directly separating land from water and immediately adjacent land that is frequently inundated, or, in other words, the floodways of streams.

Soil Survey Geographic SSURGO: The SSURGO soils layers were developed by the Natural Resources Conservation Service (NRCS), of the US Department of Agriculture, as part of the National Cooperative Soil Survey. The surveys determine soil characteristics and capabilities and are designed to help understand soils and their use.

Subwatersheds: Smaller drainage basins found within larger watersheds.

Surface Waters: Water at or above the land's surface which is neither groundwater nor contained within the unsaturated zone, including, but not limited to, the ocean and its tributaries, all springs, streams, rivers, lakes, ponds, wetlands, and artificial waterbodies.

Watersheds: A Watershed is the area of land that drains into a body of water such as a river, lake, stream or bay. It is separated from other systems by high points in the area such as hills or slopes. It includes not only the waterway itself but also the entire land area that drains to it

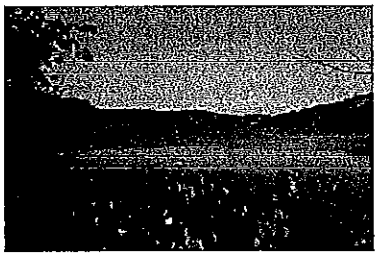
Wetlands: Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation.

Appendix 5: Photographic Inventory

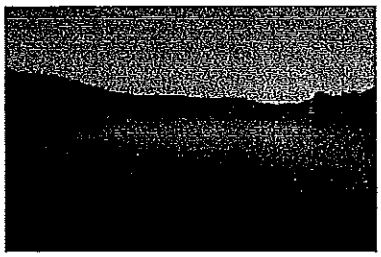
Aeroflex Airport 001.jpg

Aeroflex Airport 001.jpg

Aeroflex Airport 002.jpg



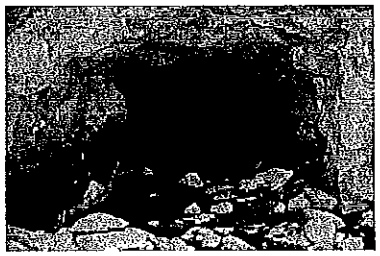
Aeroflex -Waywayanda 003.jpg



Aeroflex -Waywayanda 004.jpg

Carpenter Frog-004.jpg

Carpenter Frog-005.jpg



Cave Entry-006.jpg

Cave Interior-007.jpg

Cave Interior-008.jpg

Cave Mouth-009.jpg

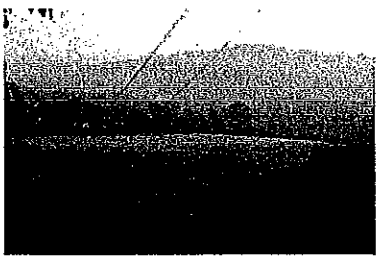
Cornfield Warbasse Junction-010.jpg

Cornfield Warbasse Junction-011.jpg

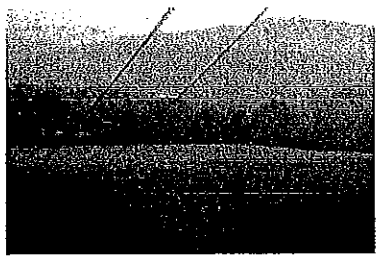
Cornfield Warbasse Junction-012.jpg

Farm - Pierce Road-013.jpg

Farm Fields -Lawrence Road-014.jpg



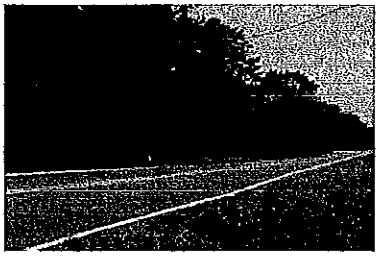
Farm Fields -Lawrence Road-015.jpg



Farm Fields -Lawrence Road-016.jpg

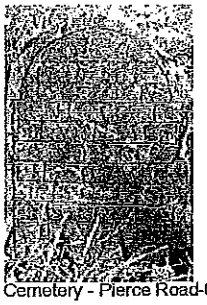
Farm Fields -Lawrence Road-017.jpg

Forest - Warbasse Junction-018.jpg

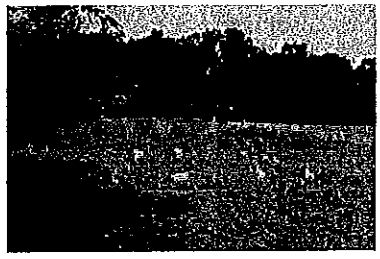


Forest - Warbasse Junction-019.jpg

German Cemetery - Pierce Road-020.jpg



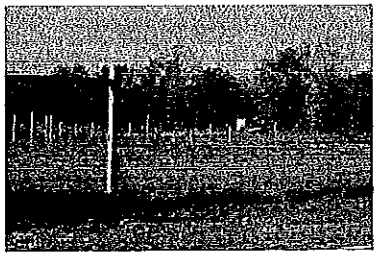
German Cemetery - Pierce Road-021.jpg

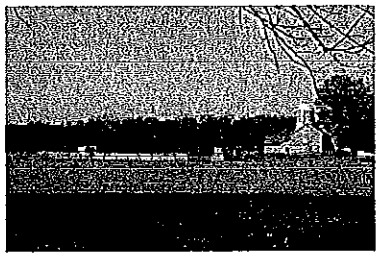


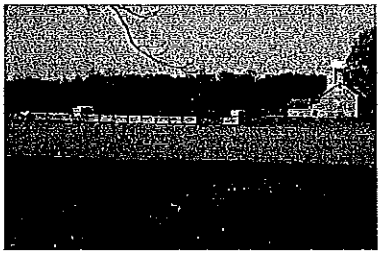
German Cemetery - Pierce Road-022.jpg


German Cemetery - Pierce Road-023.jpg


Good Hand Farm-024.jpg

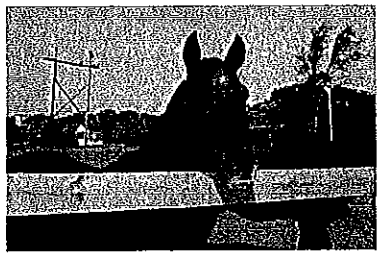

Good Hand Farm-025.jpg


Good Hand Farm-026.jpg


Good Hand Farm-027.jpg


Good Hand Farm-028.jpg


Hidden Valley Lake-029.jpg


Horses - Lawrence Road-030.jpg


Howell's Pond-031.jpg

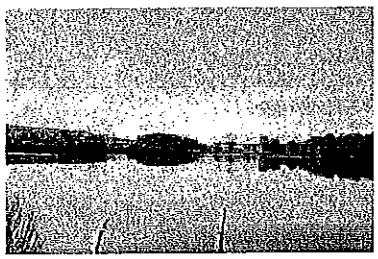

Howell's Pond-032.jpg

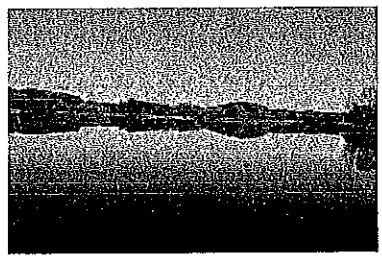

Howell's Pond-033.jpg

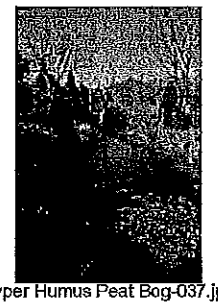

Howell's Pond-034.jpg

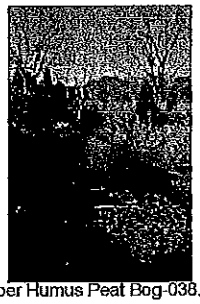

Howell's Pond-035.jpg


Hyper Humus Causeway #1-036.jpg


Hyper Humus Causeway #2-037.jpg


Hyper Humus Causeway #2-038.jpg


Hyper Humus Peat Bog-037.jpg


Hyper Humus Peat Bog-038.jpg


Hyper Humus Peat Bog-039.jpg


Iron Mine-Bat Caves-040.jpg

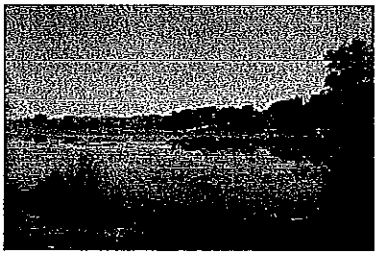

Iron Mine-Bat Caves-041.jpg


Iron Mine-Bat Caves-042.jpg

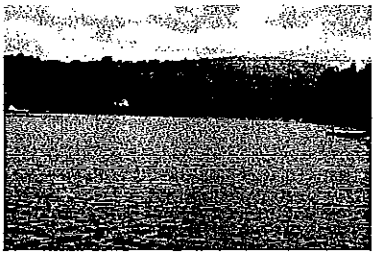

Iron Mine-Bat Caves-043.jpg


Iron Ore-Rutherford Ave.-044.jpg

Kittatinny Park-045.jpg



Lake Iliff-046.jpg



Lake Lenape-047.jpg

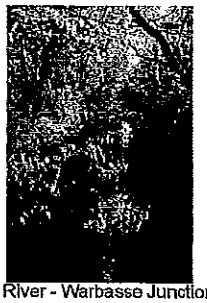
Lake Lenape-048.jpg

Lawrence Lake-049.jpg

Martinsburg Shale-050.jpg

Paulinskill Flood Plain -Limestone Storage ...

Paulinskill Flood Plain -Limestone Storage ...



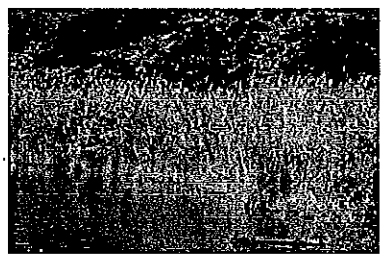
Paulinskill River - Warbasse Junction-053.jpg

Paulinskill River - Warbasse Junction-054.jpg

Pequest River and Floodplain-055.jpg

Pequest River and Floodplain-056.jpg

Pequest Wetlands-057.jpg



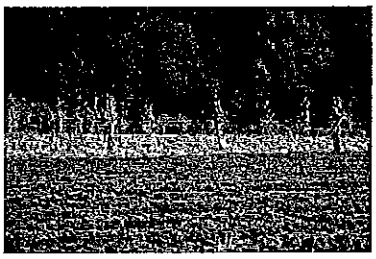
Phragmites - diagnostic, turtle-058.jpg

Riders at Hyper Humus-059.jpg

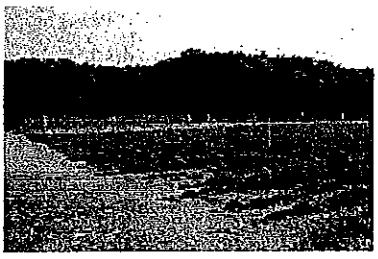
Rock Outcrop - Tyson-060.jpg

Rock Outcrop-Kittatinny Park-061.jpg

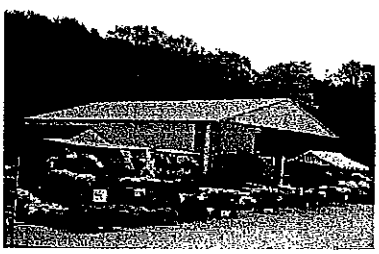
Rock OutcropSteep Slope-Rutherford Ave.-...



SC Strawberry Farm-063.jpg



SC Strawberry Farm-064.jpg



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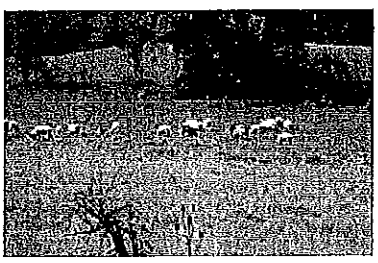
SC Strawberry Farm-066.jpg

SC Strawberry Farm-067.jpg

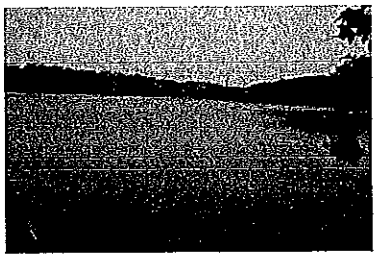


Sheep Farm - Greendell-068.jpg


Steep Slope-Iron Mine-069.jpg

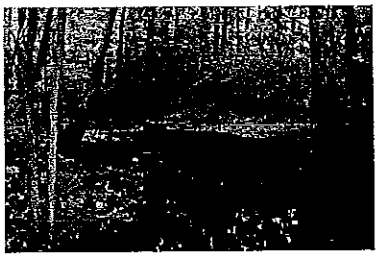

Steep Slopes - Erosion-070.jpg


Steep Slopes - Roseville-072.jpg


Stickles Pond-072.jpg


Stickles Pond-073.jpg

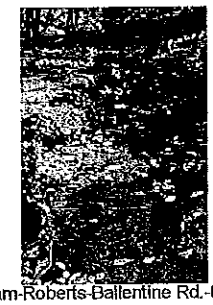

Stream - Tyson-074.jpg


Stream and Flood Plain - Elm St.-075.jpg


Stream Flood Plain-Roberts-078.jpg


Stream Flood Plain-Roberts-079.jpg

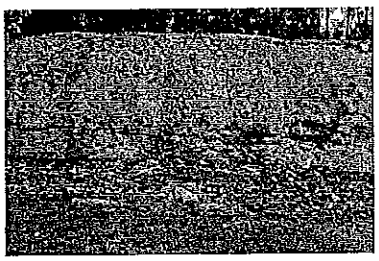

Stream, Kilroy Rd.-076.jpg

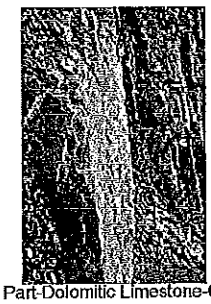

Stream-Roberts-Ballentine Rd.-077.jpg


Stryker's Pond-080.jpg


Swans at Hyper Humus-081.jpg


Tyson Family Memorial-082.jpg


Upper Part-Dolomitic Limestone-083.JPG


Upper Part-Dolomitic Limestone-084.JPG


Valentine's Pond-085.jpg


Valley View Farm-086.jpg


Valley View Farm-087.jpg


Valley View Farm-088.jpg


Vernal Pool - Hillside Park-089.jpg

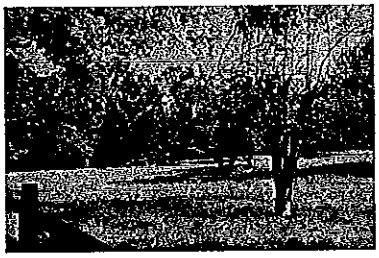

Vernal Pool - Roberts-090.jpg


Vernal Pool - Roberts-091.jpg


Vernal Pool - Roberts-092.jpg

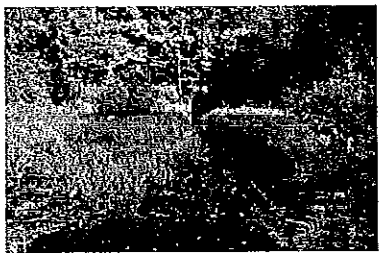
Vernal Pool - Rutherford Ave.-93.jpg

Vernal Pool 2 - Hillside Park-094.jpg



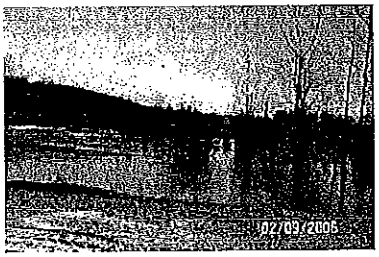
Westby Orchard-094.jpg

Wetlands- Deer Pond Road-095.jpg



Wetlands-Stream Hidden Valley Lake-096.jpg

Woods near Howell's Pond-097.jpg



Z-ANH Lagoon Flooding 2006 098.jpg

Z-Limestone Valley Flooding 2006 099.jpg

Z-Limestone Valley Flooding 2006 100.jpg

References

Buell, Murray F. and Beryl Robichaud. 1973. Vegetation of New Jersey. Rutgers University Press. New Bruswick, NJ.

New Jersey Department of Environmental Protection. 1999. Surface Water Quality Standards, N.J.A.C. 7:9B. State of New Jersey. Trenton, NJ.

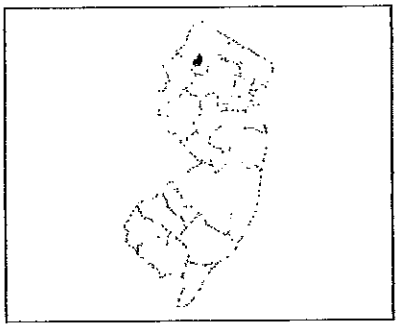
New Jersey Geological Survey. 2000. Bedrock Geology and Topographic Base Maps of New Jersey, New Jersey Geological Survey CD Series CD 00-1. State of New Jersey. Trenton, NJ.

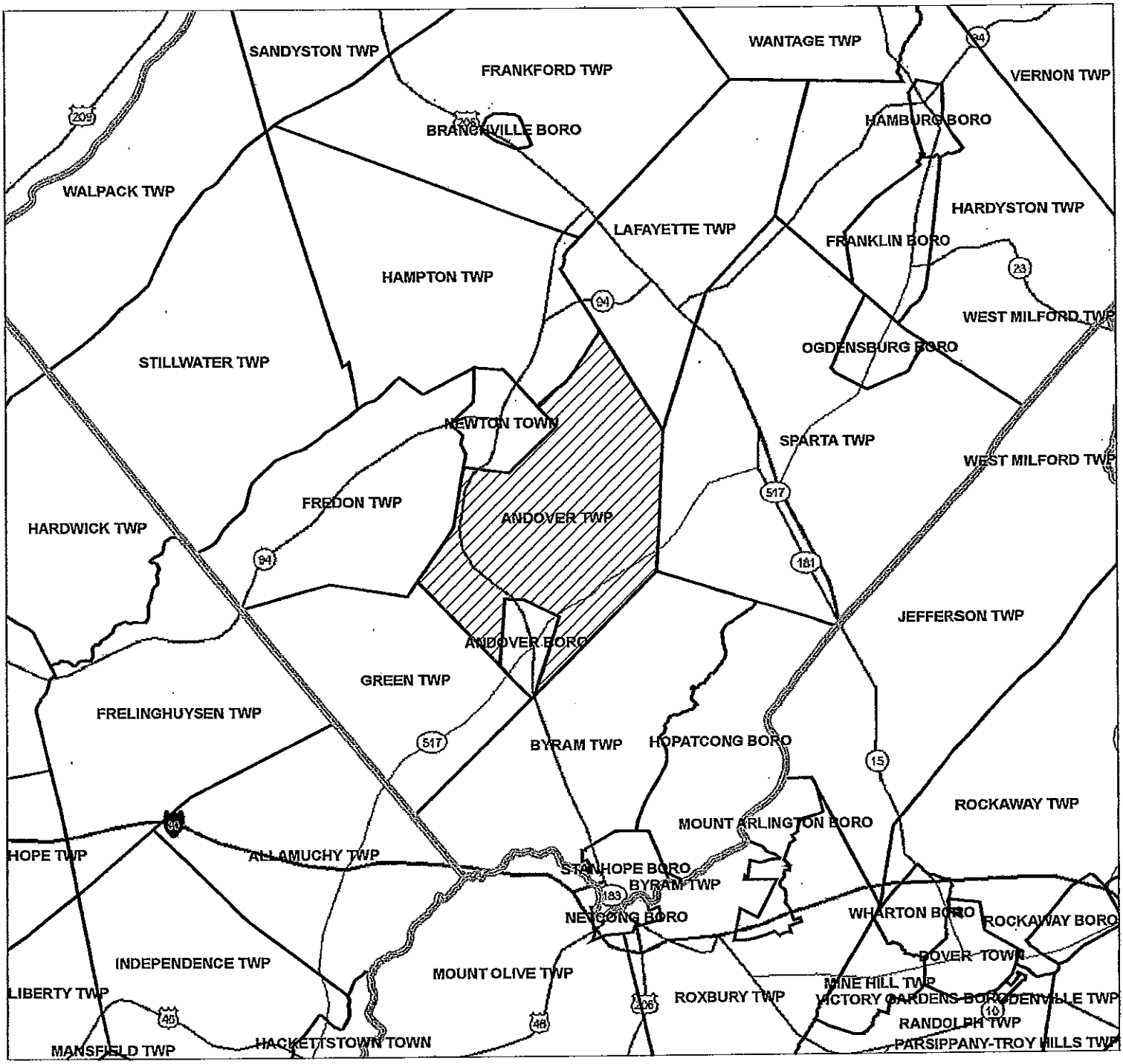
Regional Location

Andover Township
Sussex County, NJ

February 2007

Figure 1





Data Sources:
NJDEP
ESRI Road Atlas

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

BANISCH
ASSOCIATES, INC
Planning and Design

2002 Land Use/Land Cover

Figure 2

Andover Township
Sussex County, NJ

February 2007

Legend

- Forest
- Urban
- Agriculture
- Barren Land
- Wetlands
- Water

Data Sources:
NJDEP
2002 LU/LC WMA 1

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

BANISCH
ASSOCIATES, INC
Planning and Design

2002 Detailed Land Use/Land Cover

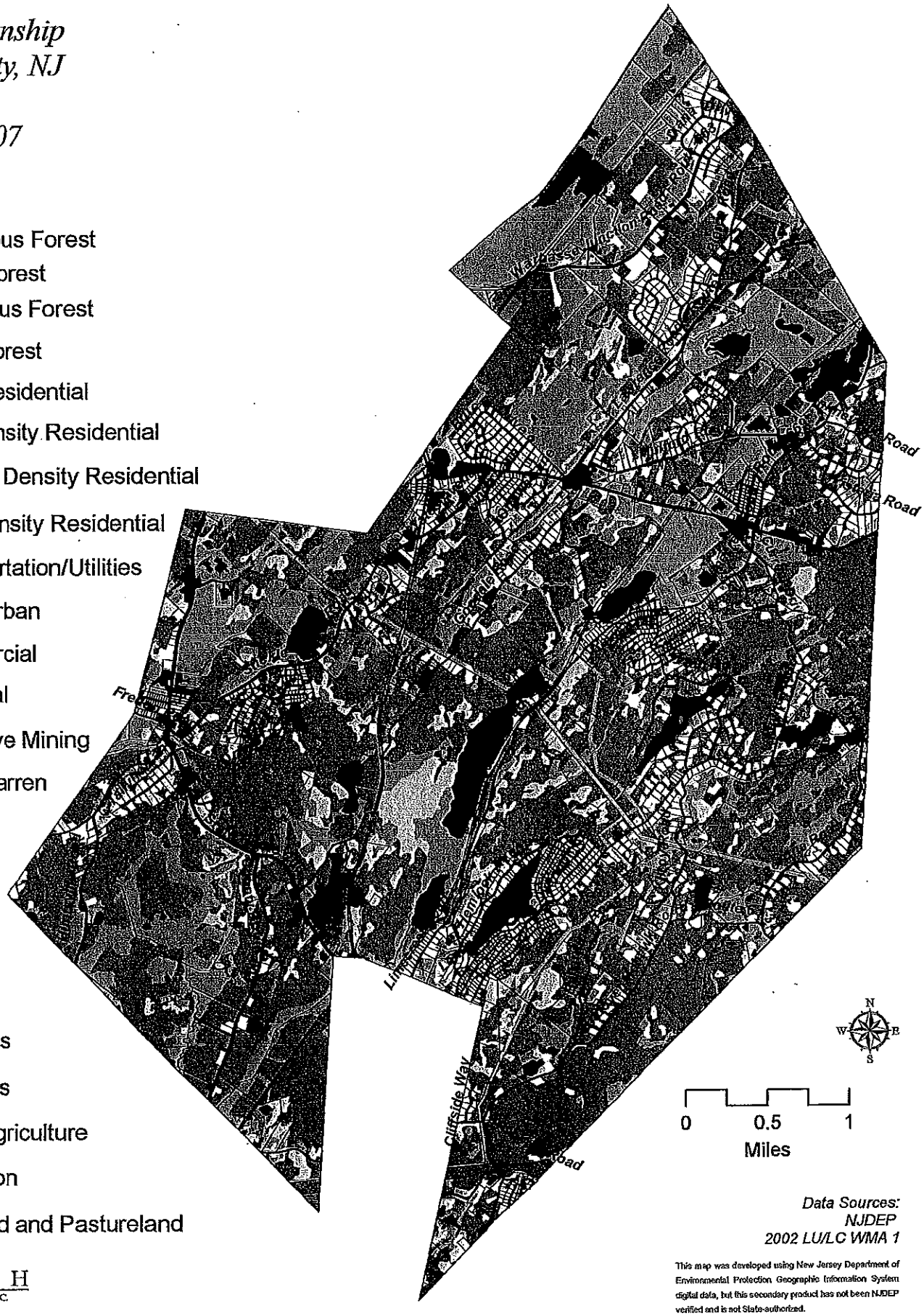
Figure 3

Andover Township
Sussex County, NJ

February 2007

Legend

- Coniferous Forest
- Mixed Forest
- Deciduous Forest
- Other Forest
- Rural Residential
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Transportation/Utilities
- Other Urban
- Commercial
- Industrial
- Extractive Mining
- Other Barren
- Water
- Wetlands
- Orchards
- Other Agriculture
- Plantation
- Cropland and Pastureland



Data Sources:
NJDEP
2002 LU/LC WMA 1

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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ASSOCIATES, INC
Planning and Design

1972 to 1995 Land Use/Land Cover Comparison

Figure 4

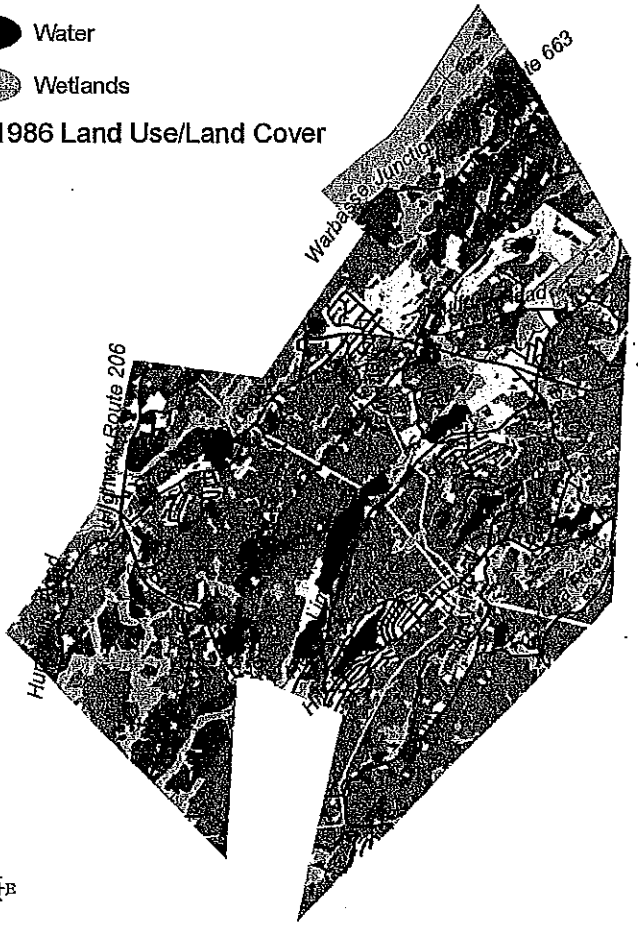
Andover Township
Sussex County, NJ

February 2007

Legend

- Agriculture
- Barren Land
- Forest
- Urban
- Water
- Wetlands

1986 Land Use/Land Cover



1995 Land Use/Land Cover

1972 Land Use/Land Cover

N
W E
S

0 0.5 1 2

Miles

Data Sources:
NJDEP
1995 LU/LC WMA 1 Version 1.3
1972 LU/LC

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Open Space and Recreation Areas

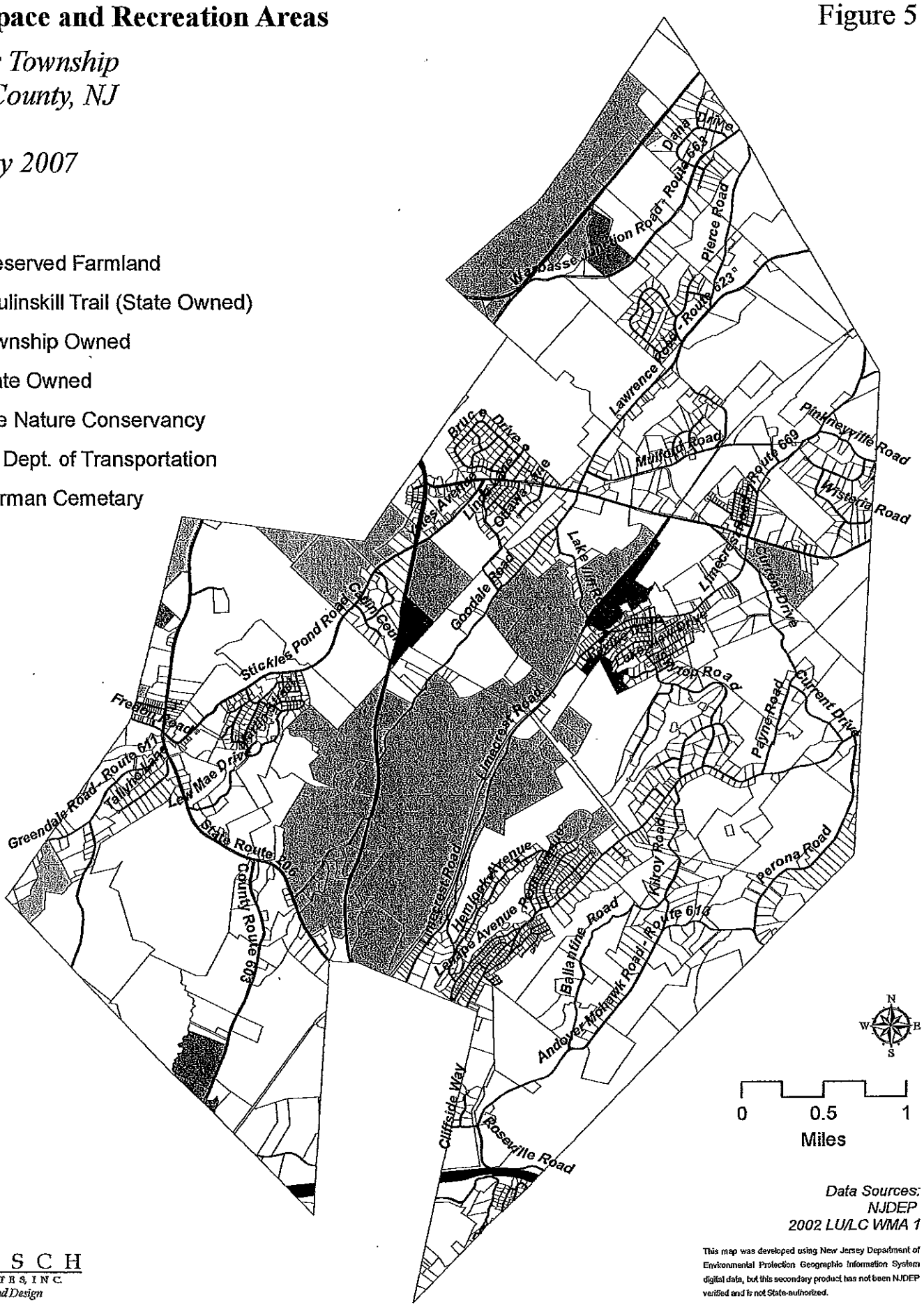
Figure 5

Andover Township
Sussex County, NJ

February 2007

Legend

- Preserved Farmland
- Paulinskill Trail (State Owned)
- Township Owned
- State Owned
- The Nature Conservancy
- NJ Dept. of Transportation
- German Cemetary



Data Sources:
NJDEP
2002 LU/LC WMA 1

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Forested Areas

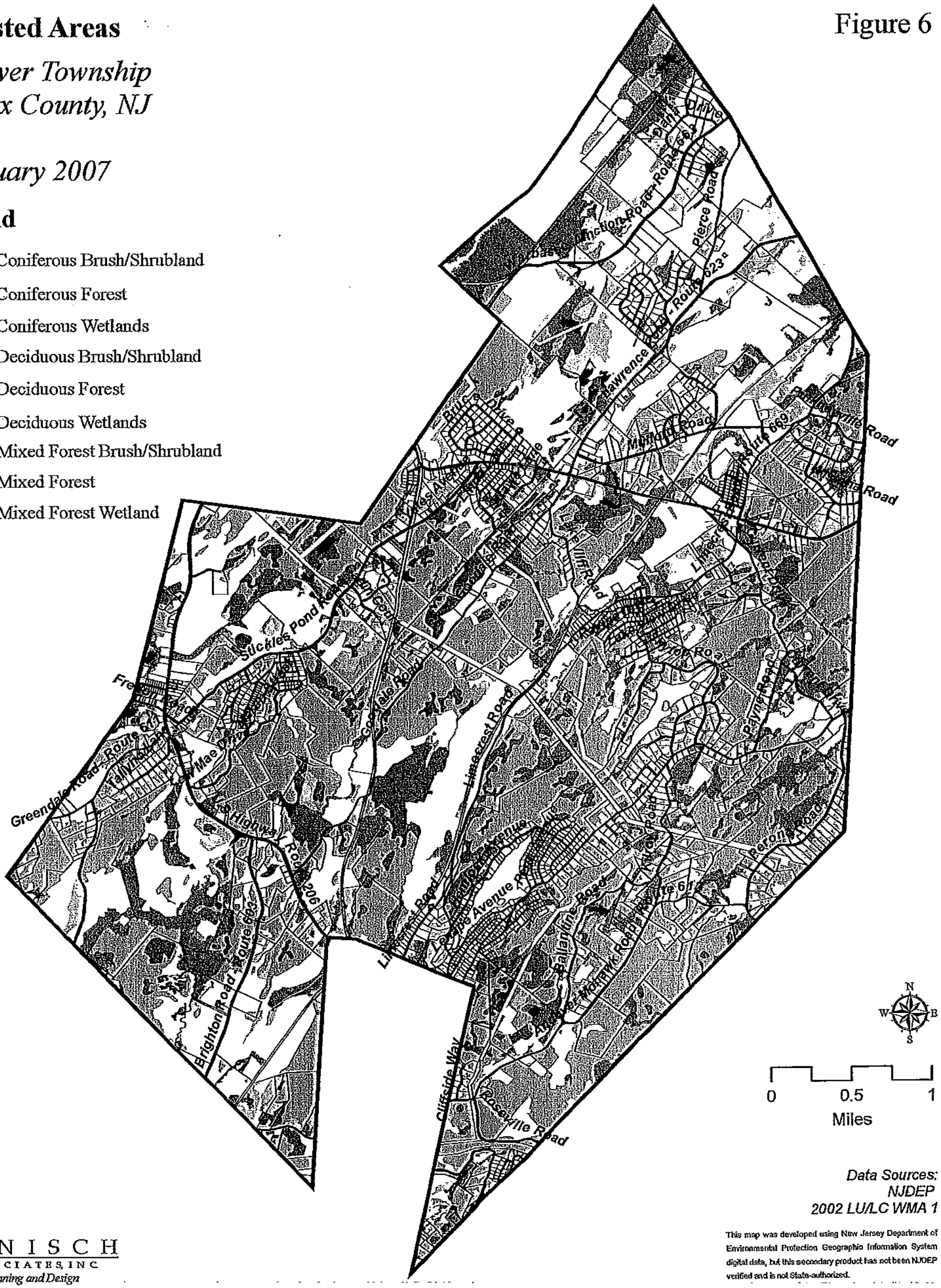
Andover Township
Sussex County, NJ

February 2007

Figure 6

Legend

- Coniferous Brush/Shrubland
- Coniferous Forest
- Coniferous Wetlands
- Deciduous Brush/Shrubland
- Deciduous Forest
- Deciduous Wetlands
- Mixed Forest Brush/Shrubland
- Mixed Forest
- Mixed Forest Wetland



Data Sources:
NJDEP
2002 LU/LC WMA 1

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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ASSOCIATES, INC
Planning and Design

Bedrock Geology

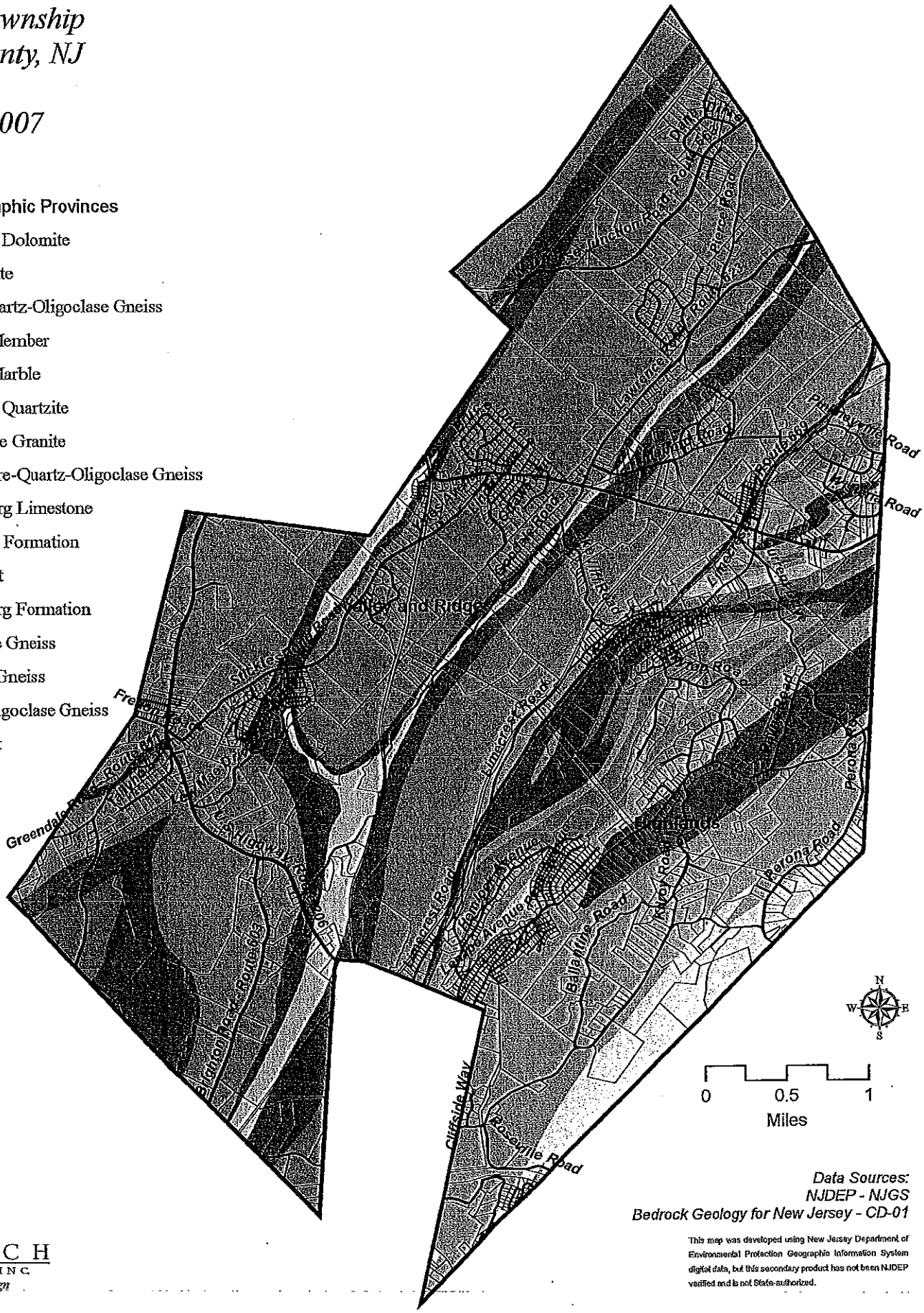
Figure 7

Andover Township
Sussex County, NJ

February 2007

Legend

- Physiographic Provinces
- Allentown Dolomite
- Amphibolite
- Biotite-Quartz-Oligoclase Gneiss
- Bushkill Member
- Franklin Marble
- Hardyston Quartzite
- Hornblende Granite
- Hypersthere-Quartz-Oligoclase Gneiss
- Jacksonburg Limestone
- Leithsville Formation
- Lower Part
- Martinsburg Formation
- Microcline Gneiss
- Pyroxene Gneiss
- Quartz-Oligoclase Gneiss
- Upper Part



Data Sources:
NJDEP - NJGS
Bedrock Geology for New Jersey - CD-01

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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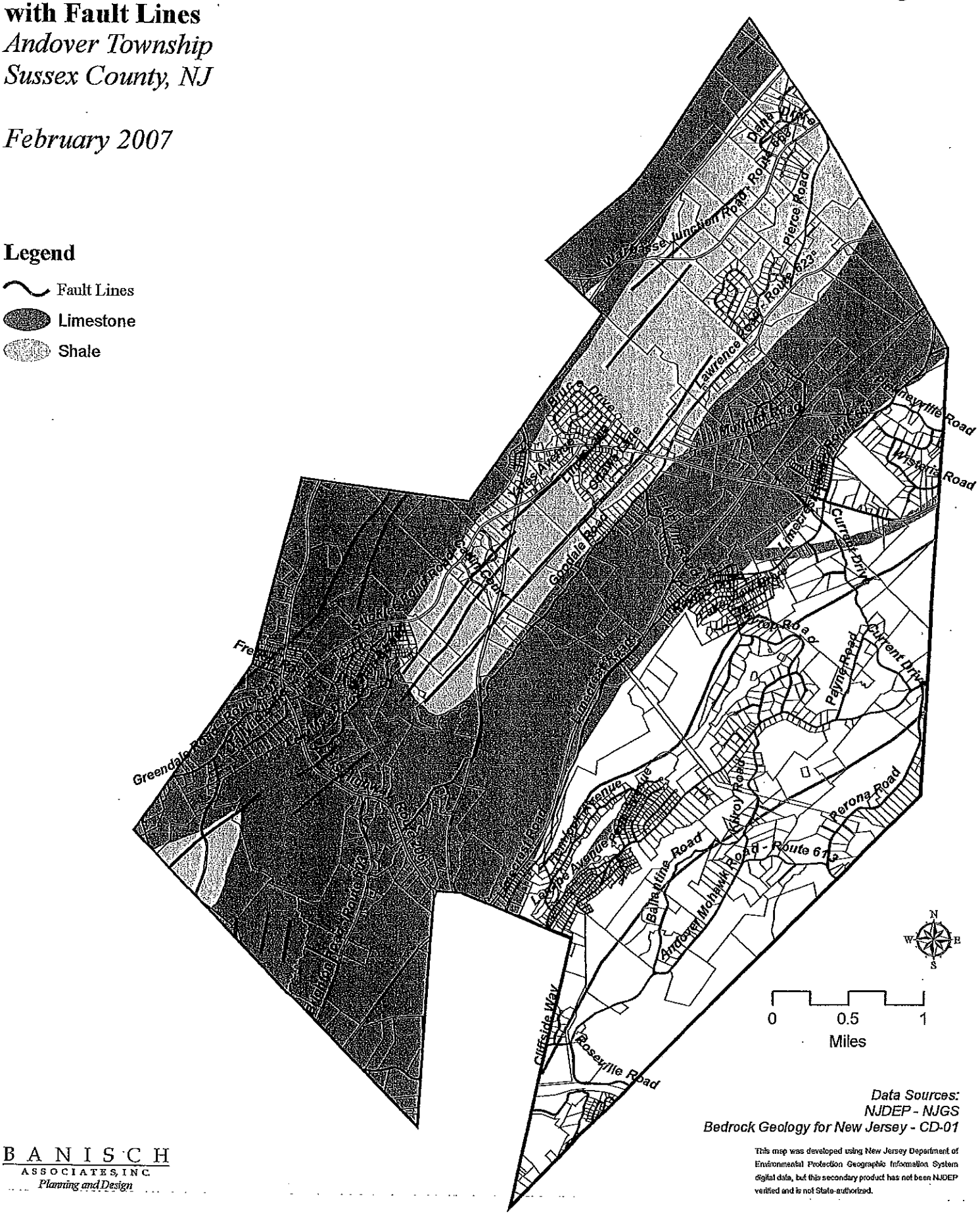
Limestone and Shale with Fault Lines

Andover Township
Sussex County, NJ

February 2007

Figure 8



Data Sources:
NJDEP - NJGS
Bedrock Geology for New Jersey - CD-01

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N.J.A.C. 7:9A
Soil Suitability Classes

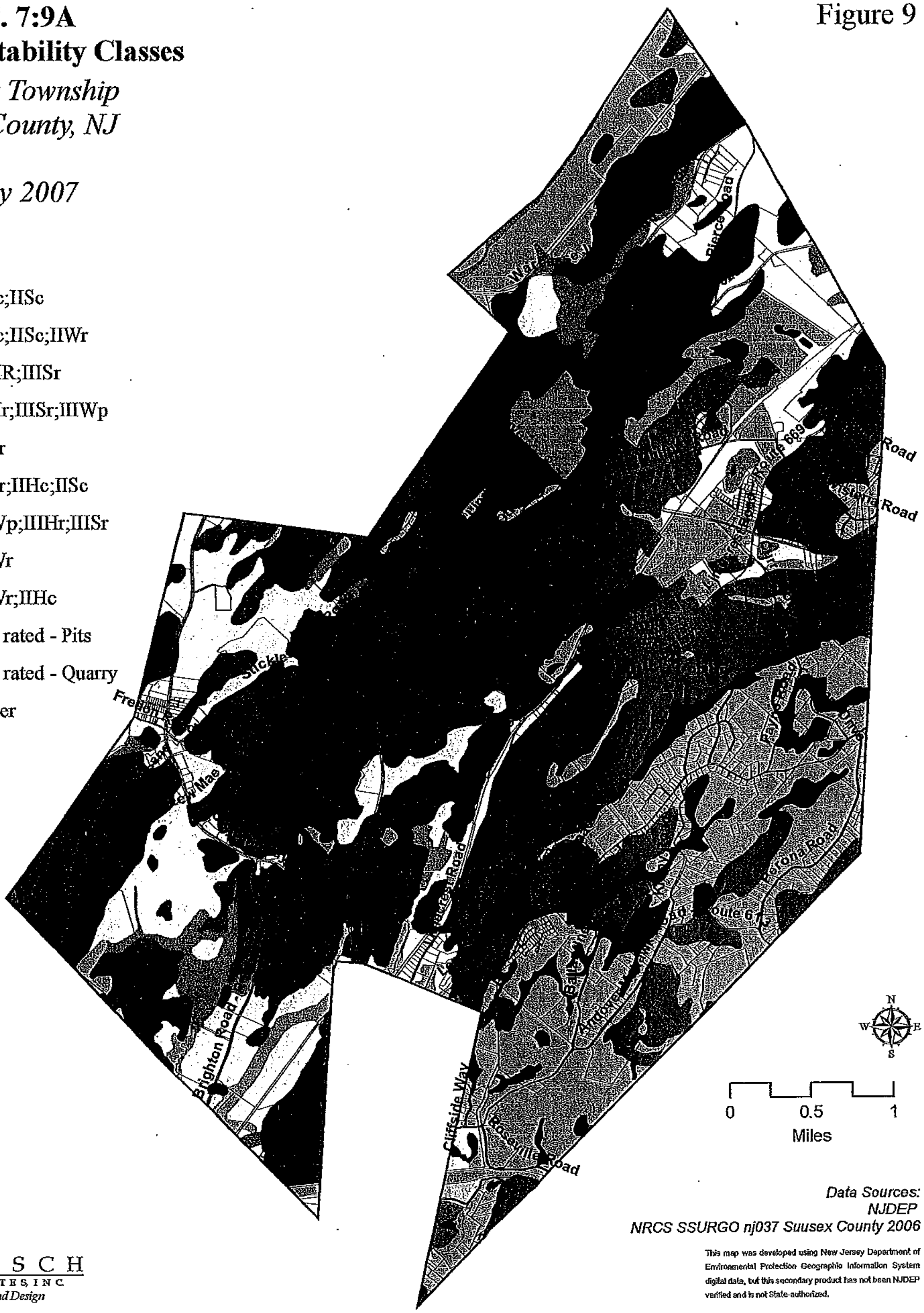
Andover Township
Sussex County, NJ

February 2007

Figure 9

Legend

- IIHc;IISc
- IIHc;IISc;IIWr
- IIIHR;IIISr
- IIIHr;IIISr;IIIWp
- IIISr
- IIISr;IIHc;IISc
- IIIWp;IIIHr;IIISr
- IIIWr
- IIIWr;IIHc
- Not rated - Pits
- Not rated - Quarry
- Water



Data Sources:
NJDEP
NRCS SSURGO nj037 Suusex County 2006

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Generalized Septic Suitability Classes

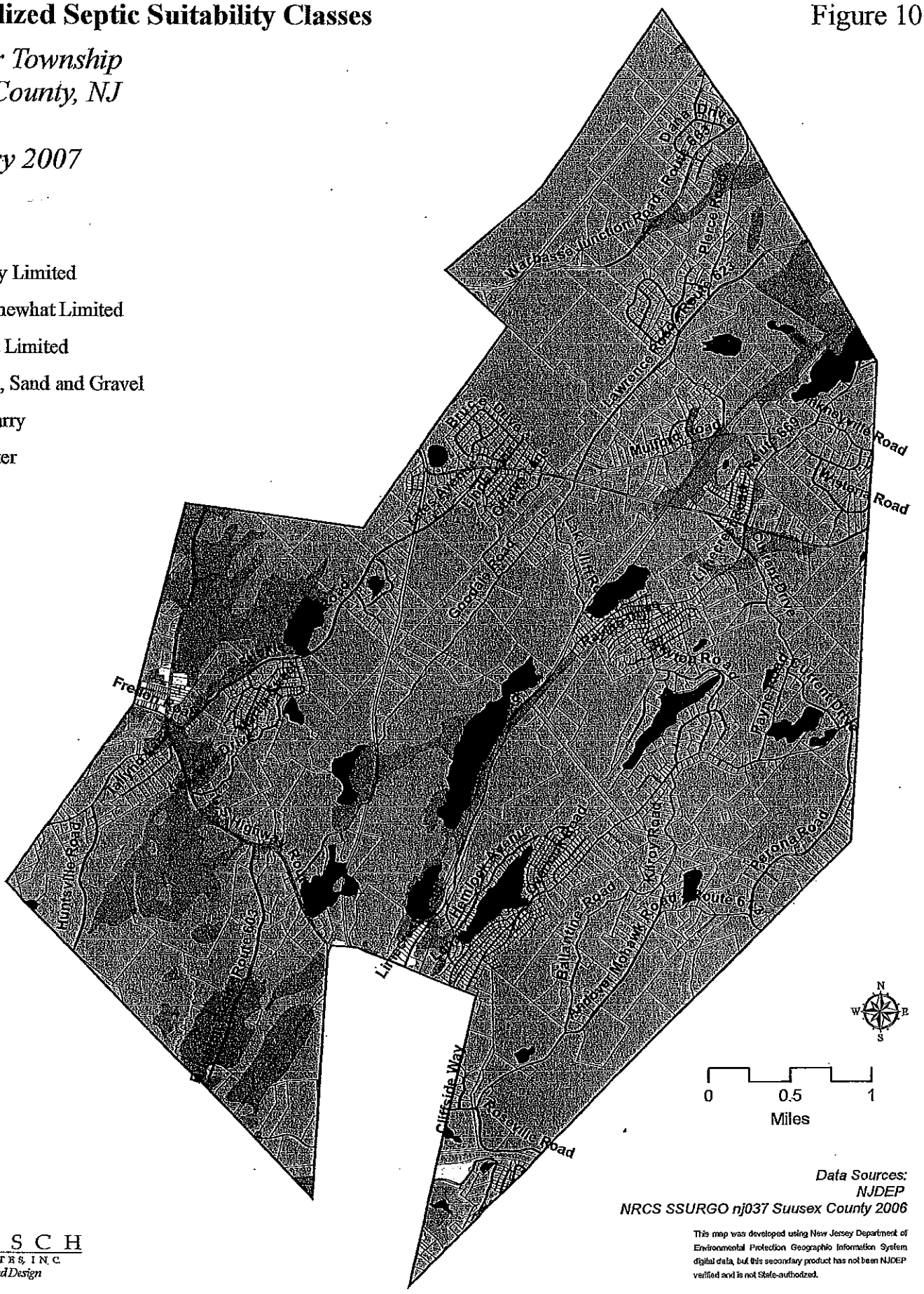
Figure 10

Andover Township
Sussex County, NJ

February 2007

Legend

- Very Limited
- Somewhat Limited
- Not Limited
- Pits, Sand and Gravel
- Quarry
- Water



Data Sources:
NJDEP
NRCS SSURGO nj037 Suusex County 2006

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Depth to Bedrock

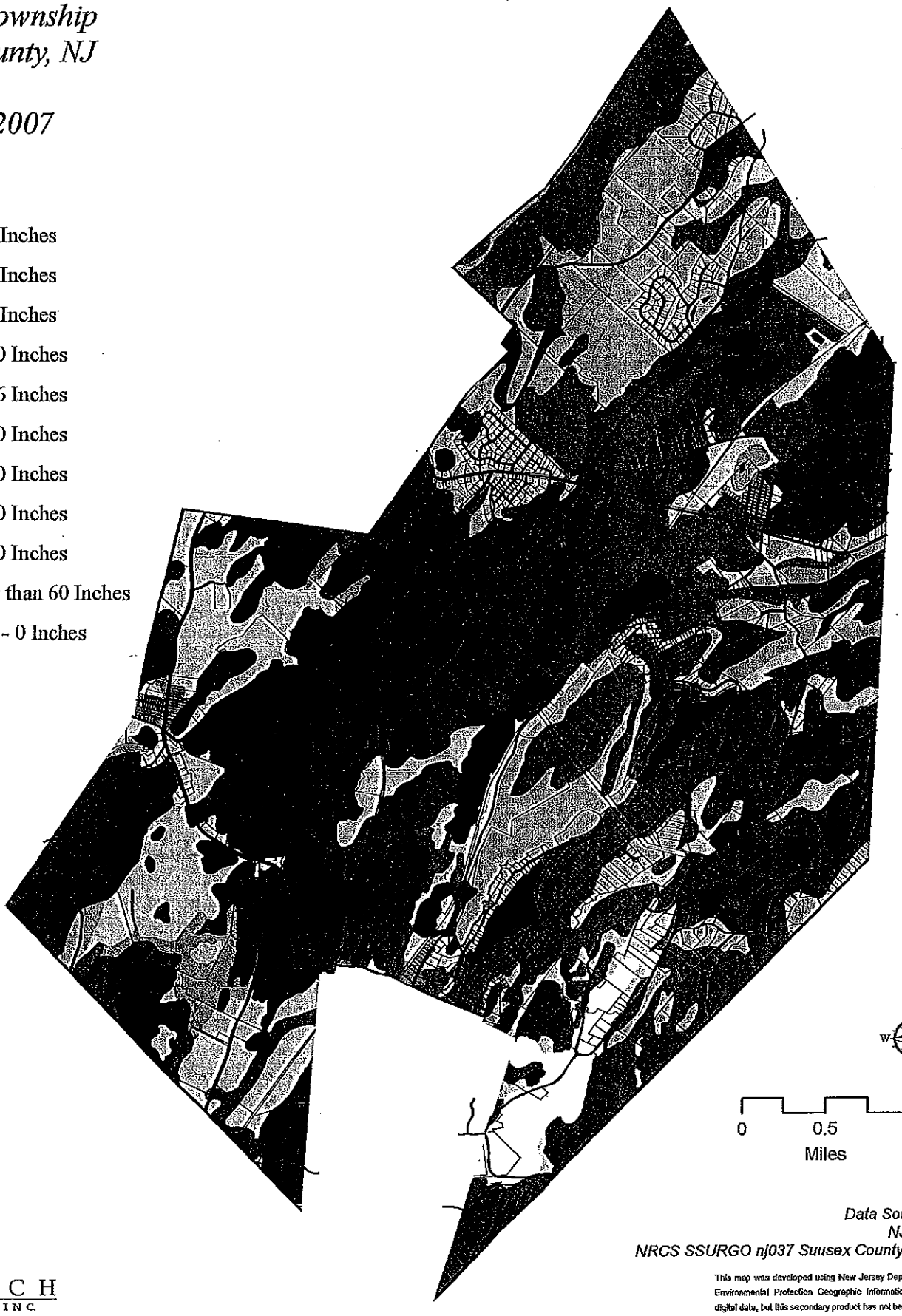
Figure 11

Andover Township
Sussex County, NJ

February 2007

Legend

- 0 to 20 Inches
- 0 to 40 Inches
- 6 to 60 Inches
- 10 to 40 Inches
- 18 to 36 Inches
- 18 to 40 Inches
- 18 to 60 Inches
- 20 to 40 Inches
- 20 to 60 Inches
- Greater than 60 Inches
- Quarry - 0 Inches
- Water



Data Sources:
NJDEP
NRCS SSURGO nj037 Suusex County 2006

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Depth to Seasonal High Water Table

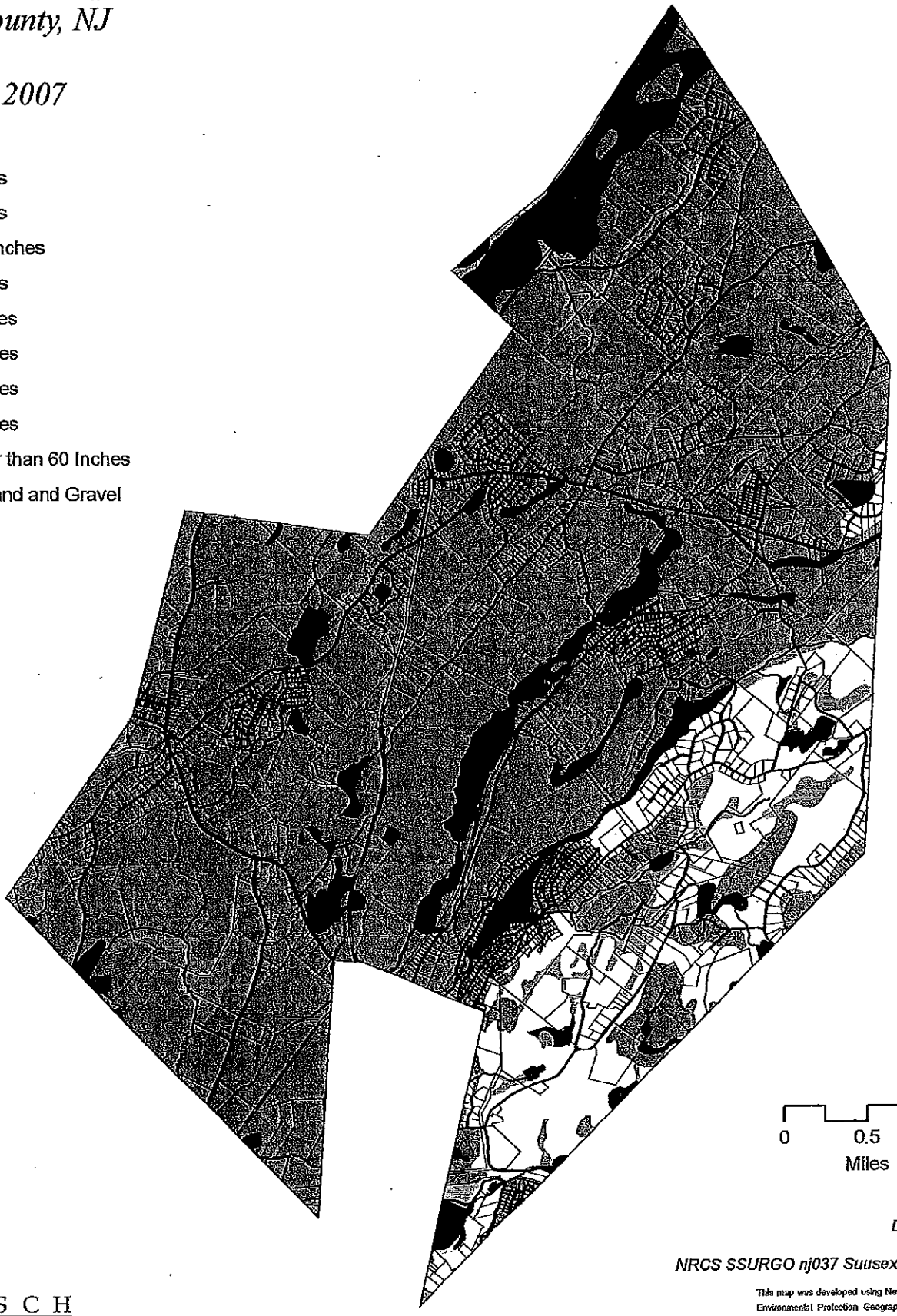
Figure 12

Andover Township
Sussex County, NJ

February 2007

Legend

- Streams
- 0 inches
- 0 to 1 Inches
- 6 Inches
- 11 Inches
- 15 Inches
- 23 Inches
- 33 Inches
- Greater than 60 Inches
- Pits, Sand and Gravel
- Water



Data Sources:
NJDEP
NRCS SSURGO nj037 Suusex County 2006

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Water Erodibility

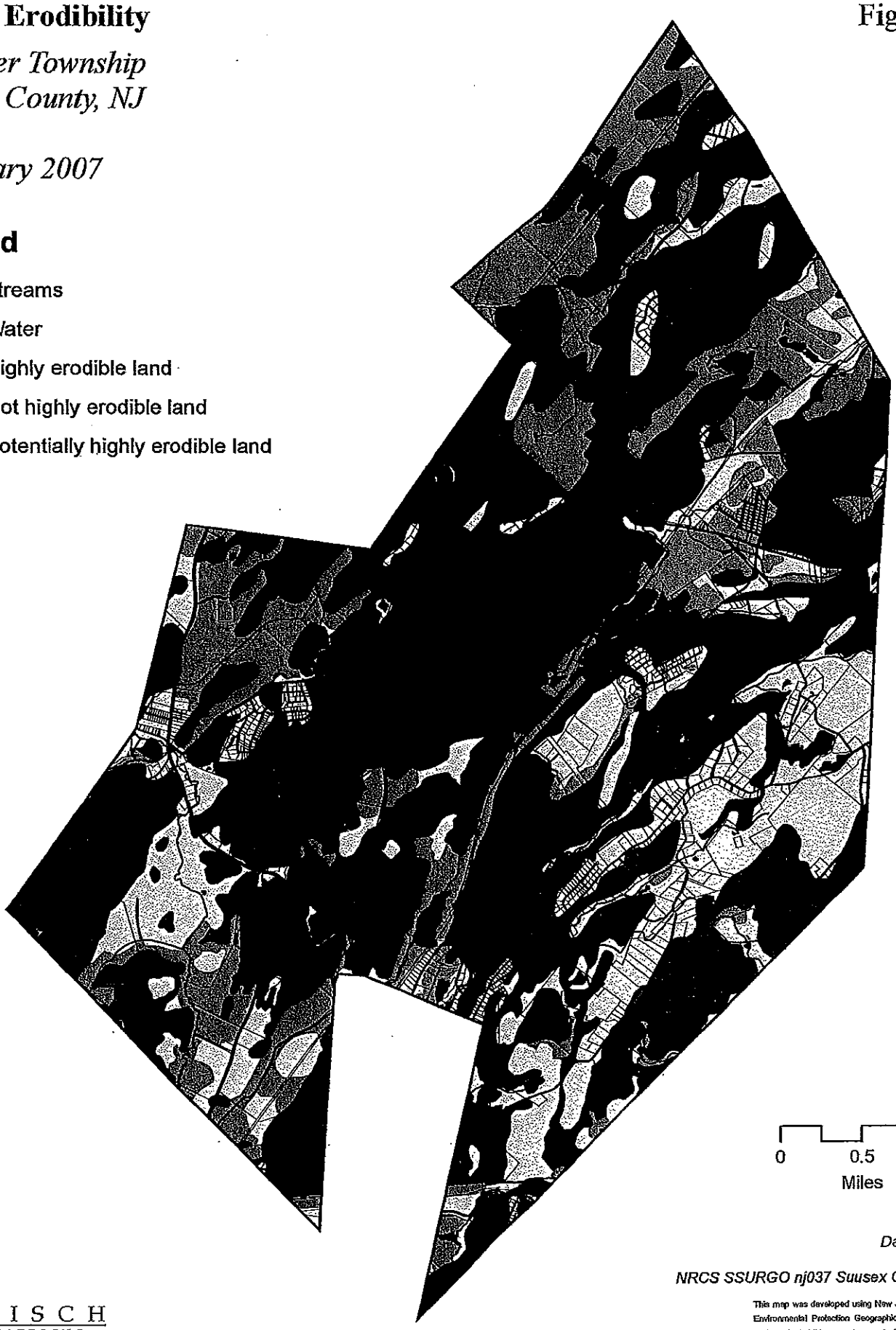
Figure 13

Andover Township
Sussex County, NJ

February 2007

Legend

- Streams
- Water
- Highly erodible land
- Not highly erodible land
- Potentially highly erodible land



N
W E
S

0 0.5 1
Miles

Data Sources:
NJDEP
NRCS SSURGO nj037 Suusex County 2006

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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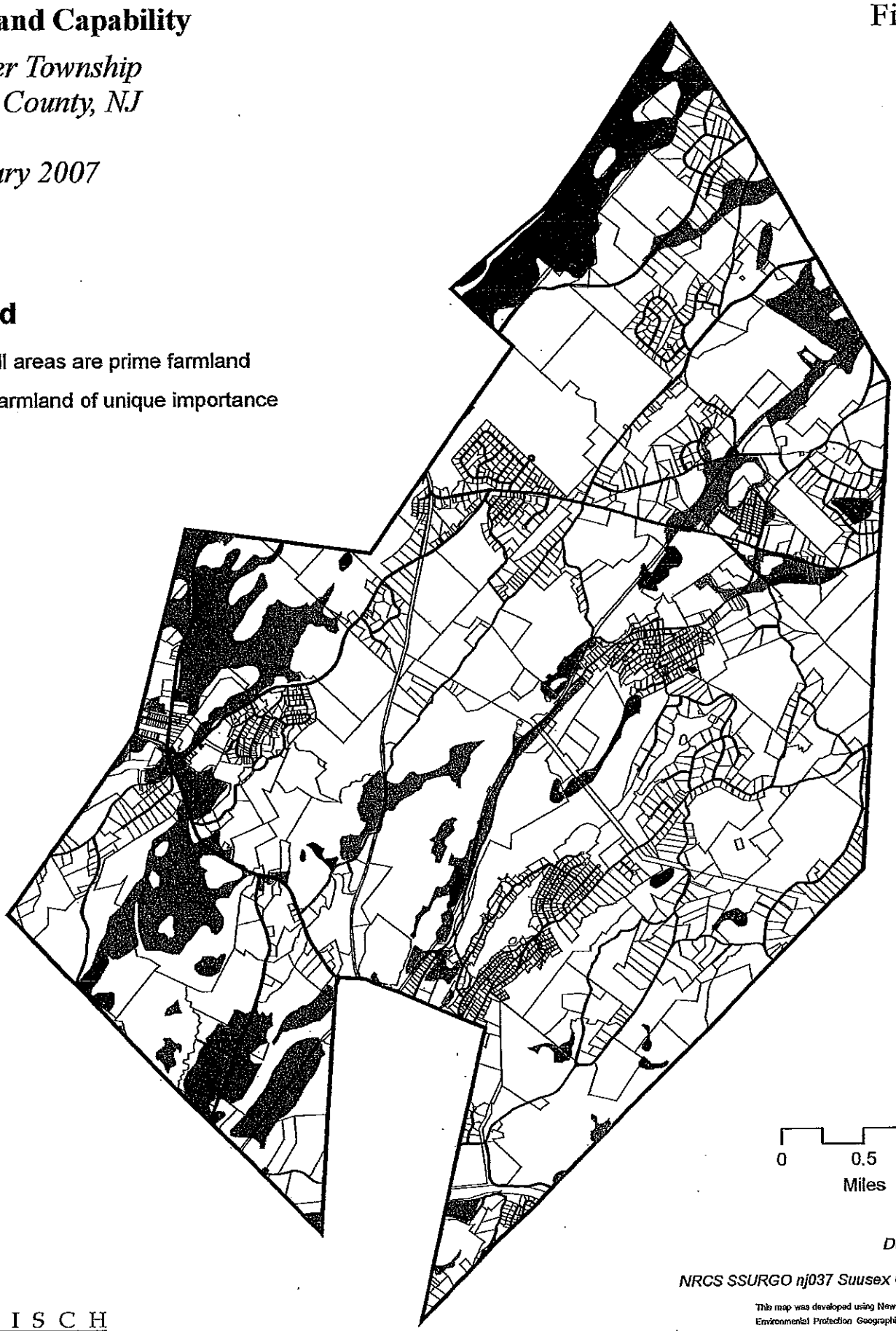
Farmland Capability

Figure 14

Andover Township
Sussex County, NJ

February 2007



Data Sources:
NJDEP
NRCS SSURGO nj037 Suusex County 2006

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Subwatersheds and Surface Waters

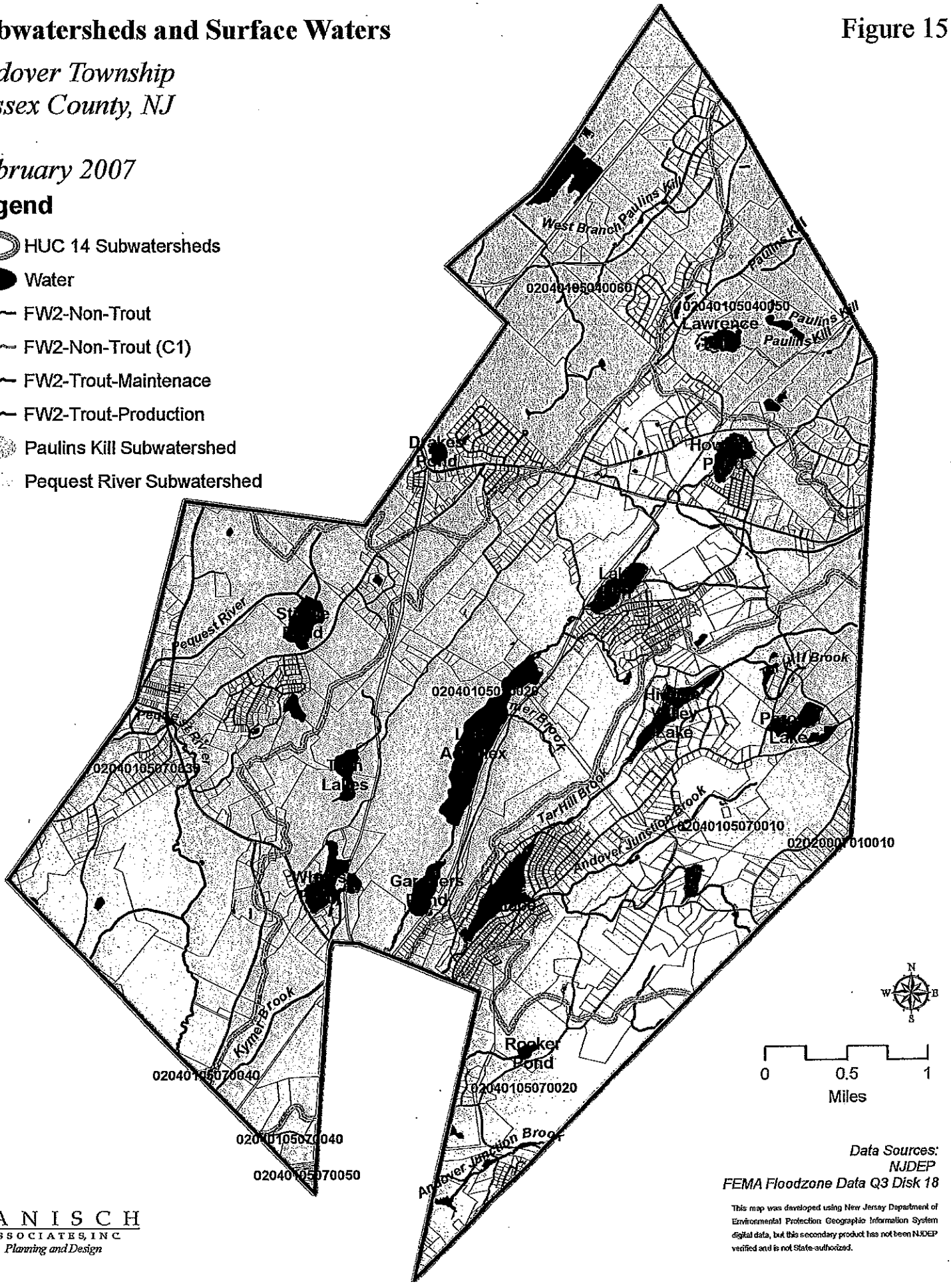
Figure 15

Andover Township
Sussex County, NJ

February 2007

Legend

- HUC 14 Subwatersheds
- Water
- FW2-Non-Trout
- FW2-Non-Trout (C1)
- FW2-Trout-Maintenace
- FW2-Trout-Production
- Paulins Kill Subwatershed
- Pequest River Subwatershed



Data Sources:
NJDEP
FEMA Floodzone Data Q3 Disk 18

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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Known Contaminated Sites

Figure 16

Andover Township
Sussex County, NJ

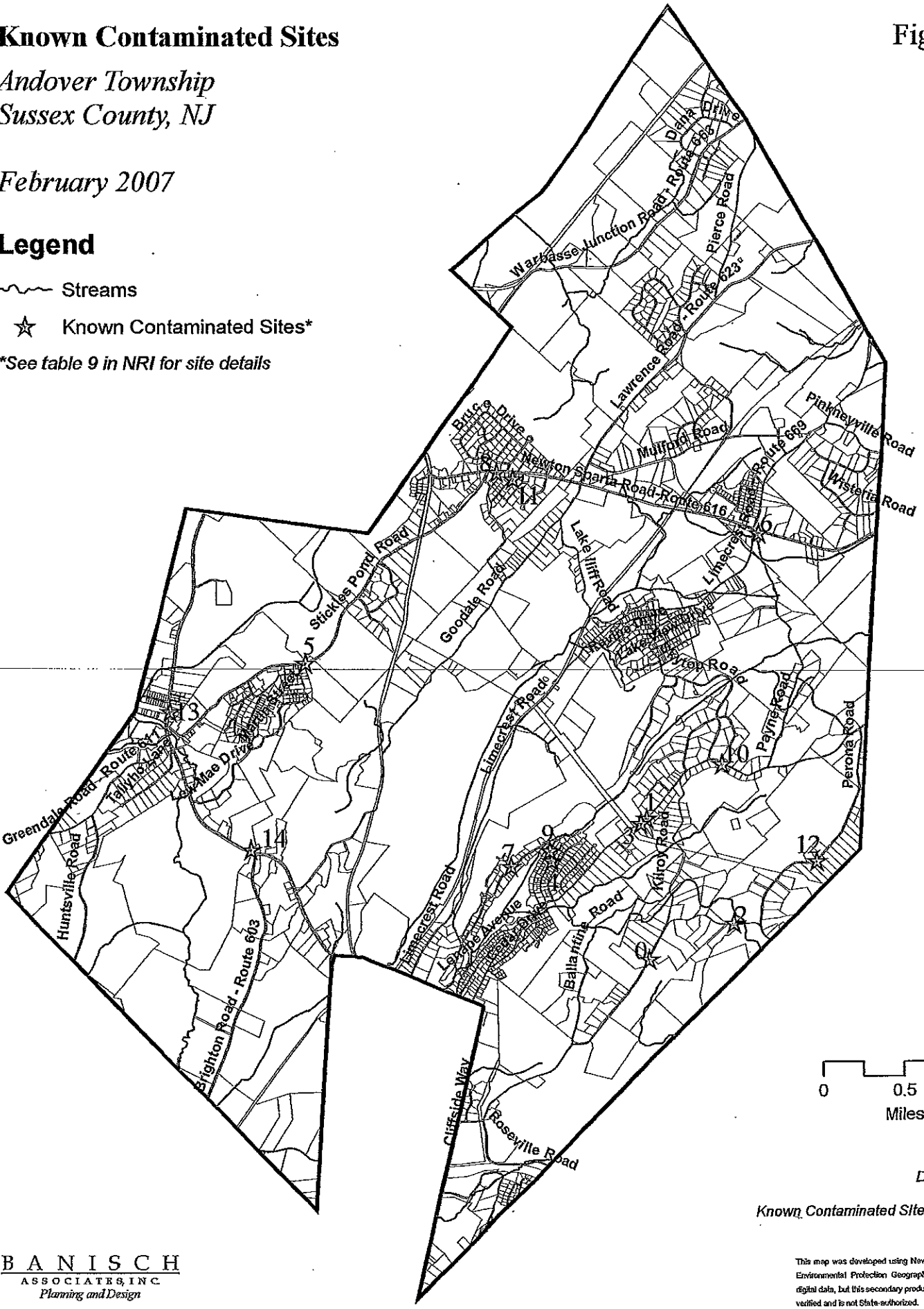
February 2007

Legend

Streams

Known Contaminated Sites*

**See table 9 in NRI for site details*



Data Sources:
NJDEP
Known Contaminated Site Listing-2005

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Groundwater Recharge

Figure 17

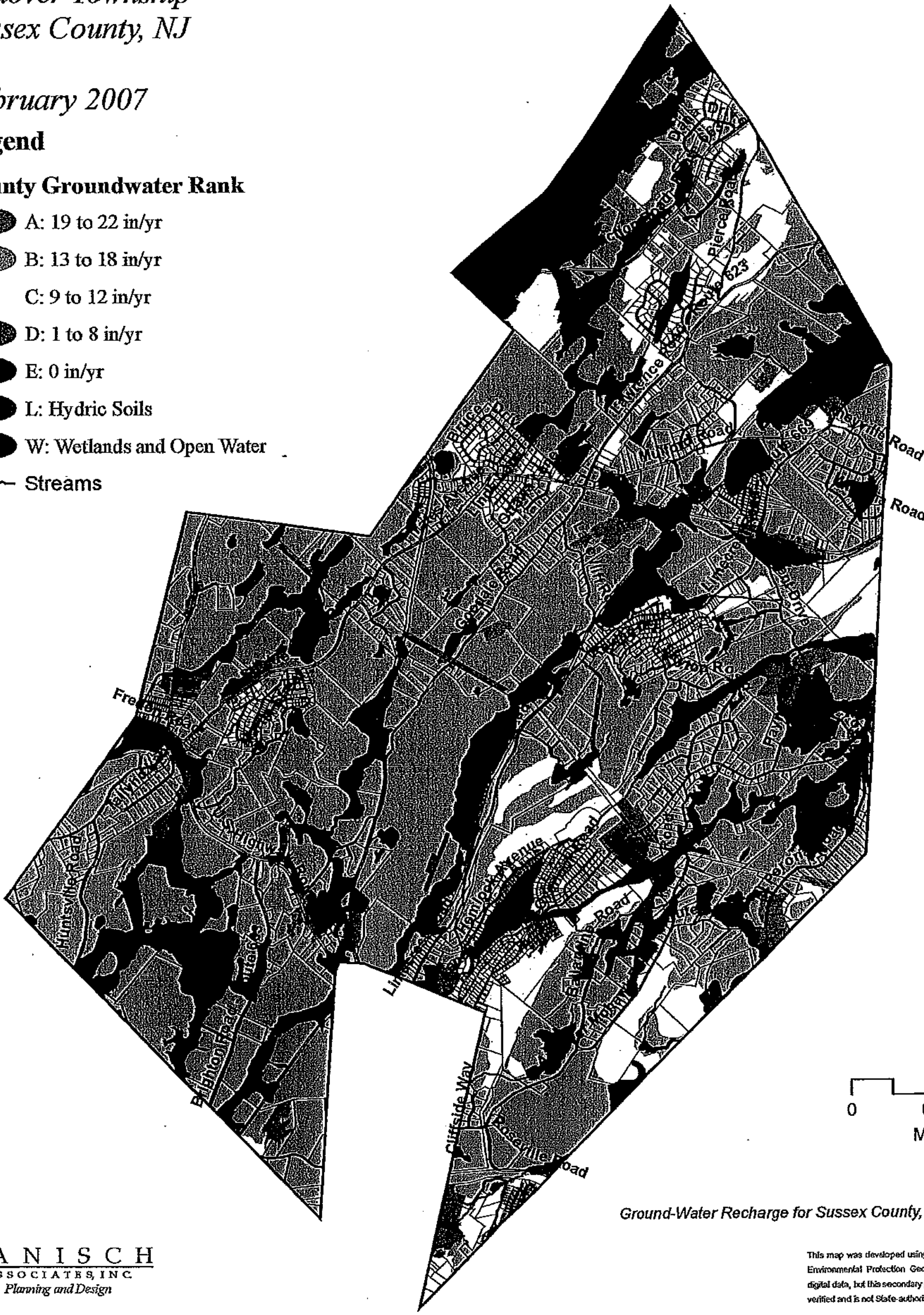
Andover Township
Sussex County, NJ

February 2007

Legend

County Groundwater Rank

- A: 19 to 22 in/yr
- B: 13 to 18 in/yr
- C: 9 to 12 in/yr
- D: 1 to 8 in/yr
- E: 0 in/yr
- L: Hydric Soils
- W: Wetlands and Open Water
- Streams



0 0.5 1
Miles

Data Sources:
NJDEP
Ground-Water Recharge for Sussex County, NJ - 9-15-2005

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Wellhead Protection Areas

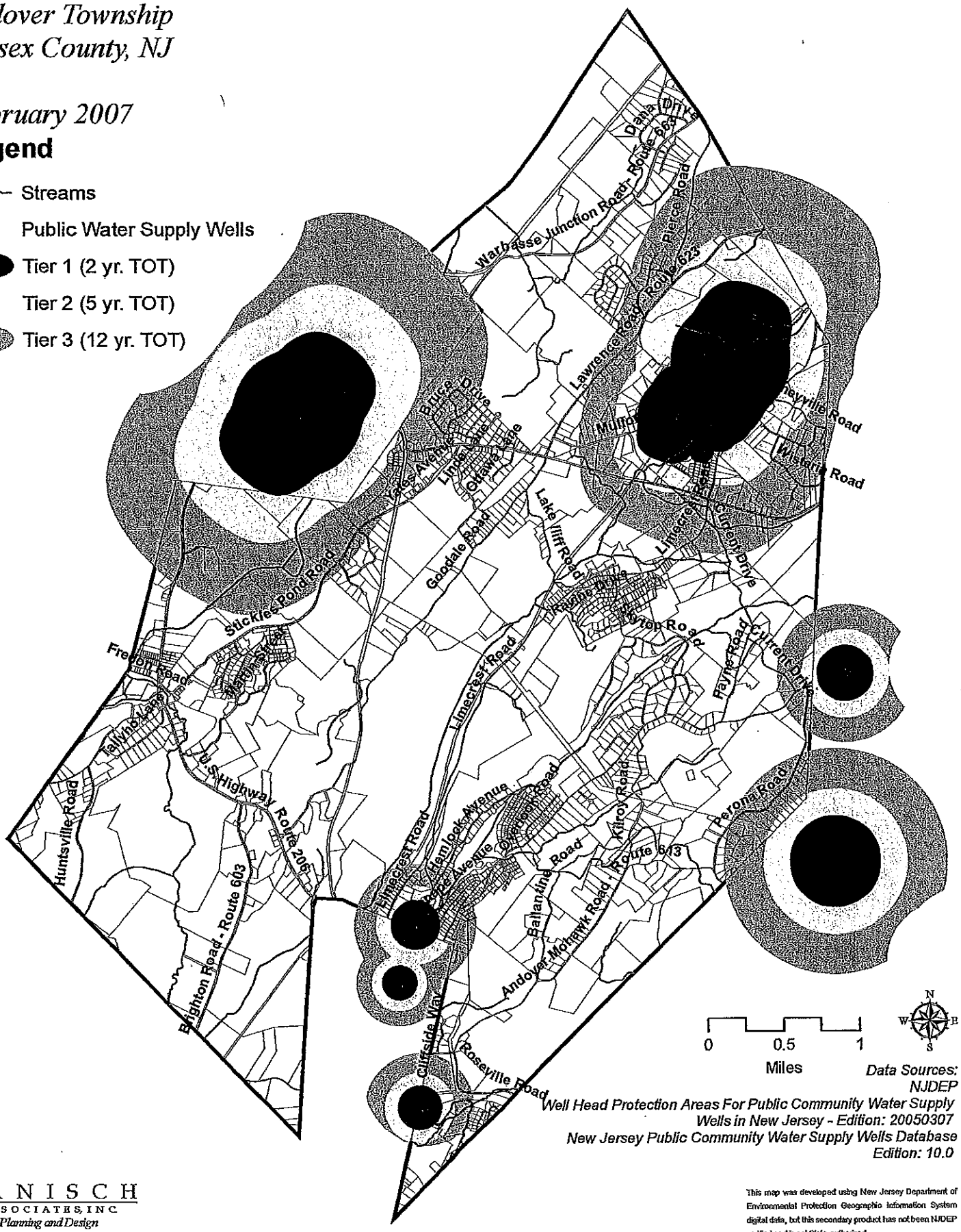
Figure 18

Andover Township
Sussex County, NJ

February 2007

Legend

- Streams
- Public Water Supply Wells
- Tier 1 (2 yr. TOT)
- Tier 2 (5 yr. TOT)
- Tier 3 (12 yr. TOT)



Data Sources:
NJDEP
Well Head Protection Areas For Public Community Water Supply Wells in New Jersey - Edition: 20050307
New Jersey Public Community Water Supply Wells Database Edition: 10.0

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Wetlands

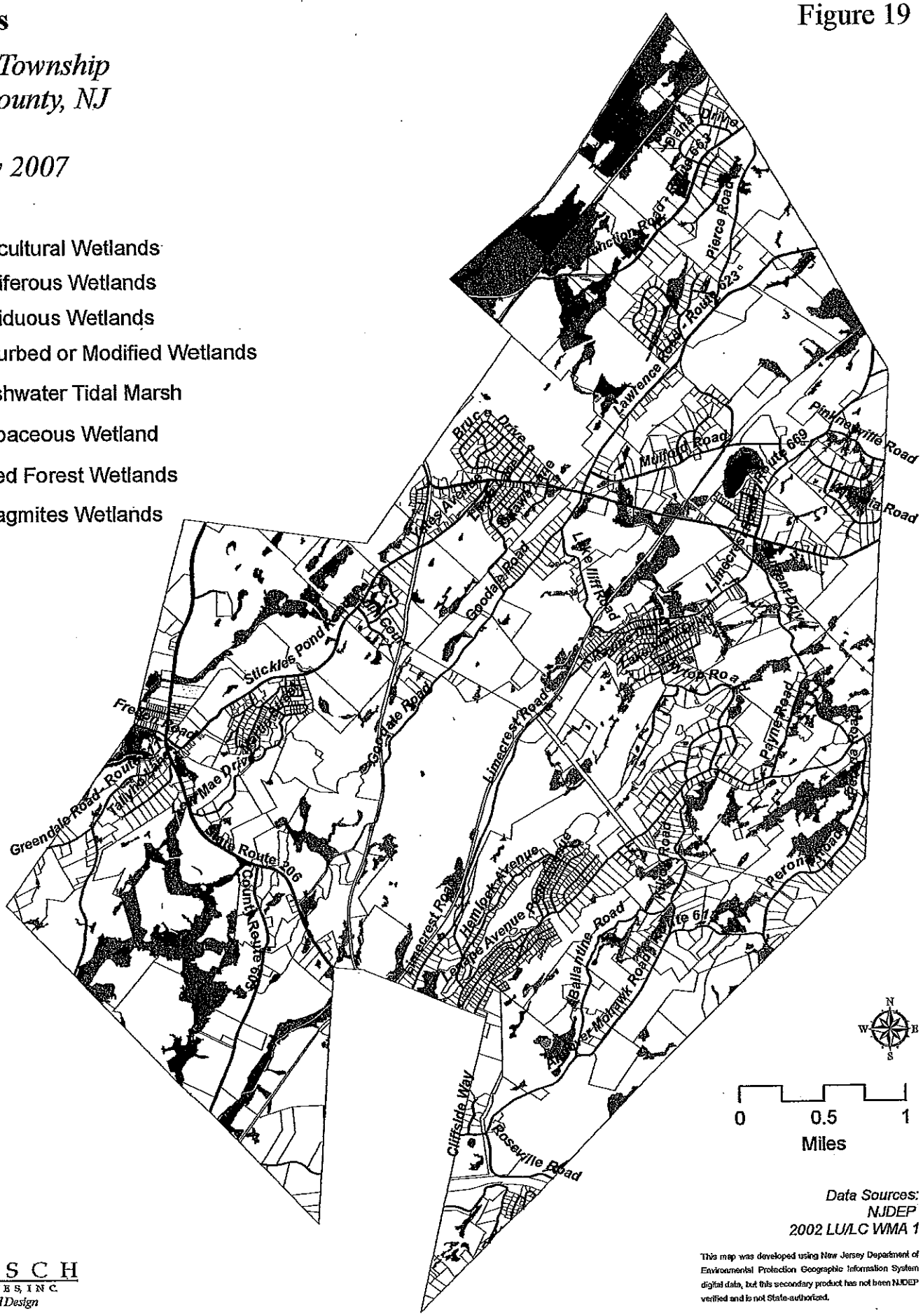
Figure 19

Andover Township
Sussex County, NJ

February 2007

Legend

- Agricultural Wetlands
- Coniferous Wetlands
- Deciduous Wetlands
- Disturbed or Modified Wetlands
- Freshwater Tidal Marsh
- Herbaceous Wetland
- Mixed Forest Wetlands
- Phragmites Wetlands



Data Sources:
NJDEP
2002 LU/LC WMA 1

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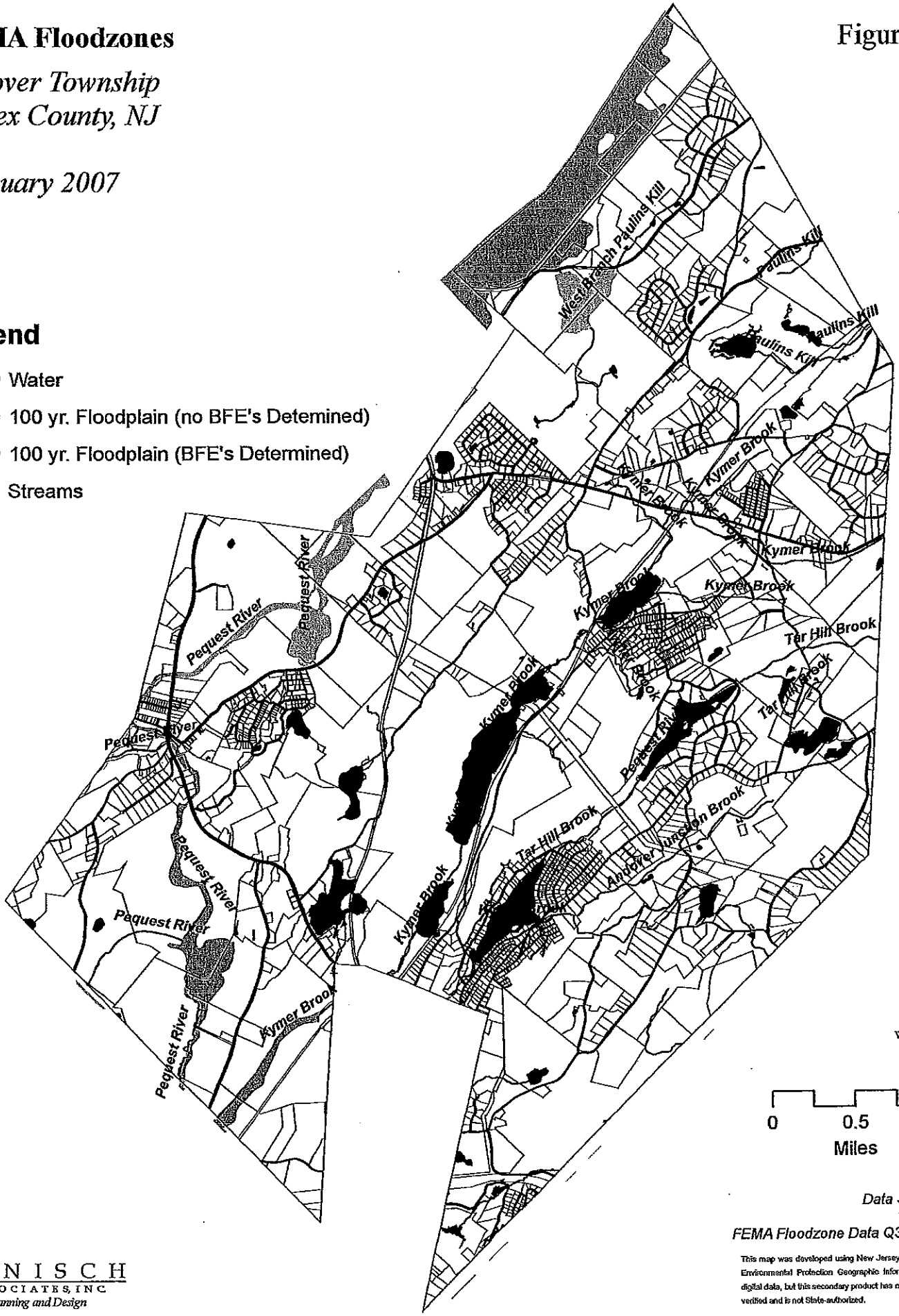
FEMA Floodzones

Andover Township
Sussex County, NJ

February 2007

Figure 20



Data Sources:
NJDEP
FEMA Floodzone Data Q3 Disk 18

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Riparian and Forested Areas

Figure 21

Andover Township
Sussex County, NJ

February 2007

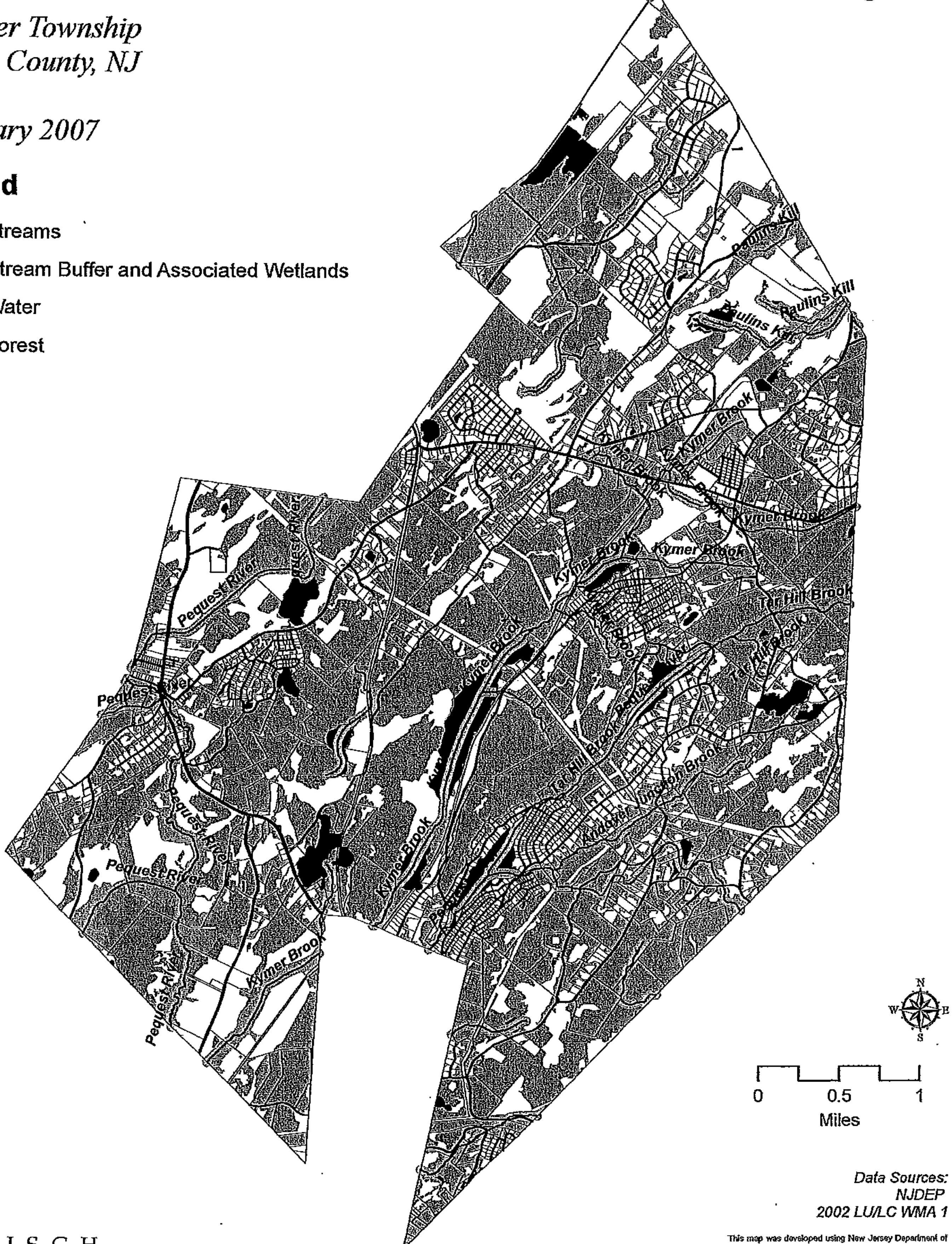
Legend

Streams

Stream Buffer and Associated Wetlands

Water

Forest



Data Sources:
NJDEP
2002 LU/LC WMA 1

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Steep Slopes

Andover Township
Sussex County, NJ

February 2007

Figure 22

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Legend

- Slopes less than 12%
- Slopes 12% to 15%
- Slopes 15% to 20%
- Slopes 20 to 25%
- Slopes greater than 25%

N W E S

0 0.5 1
Miles

Data Sources:
NJDEP - 10 Meter DEM for WMA 1

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Topography and Ridgelines

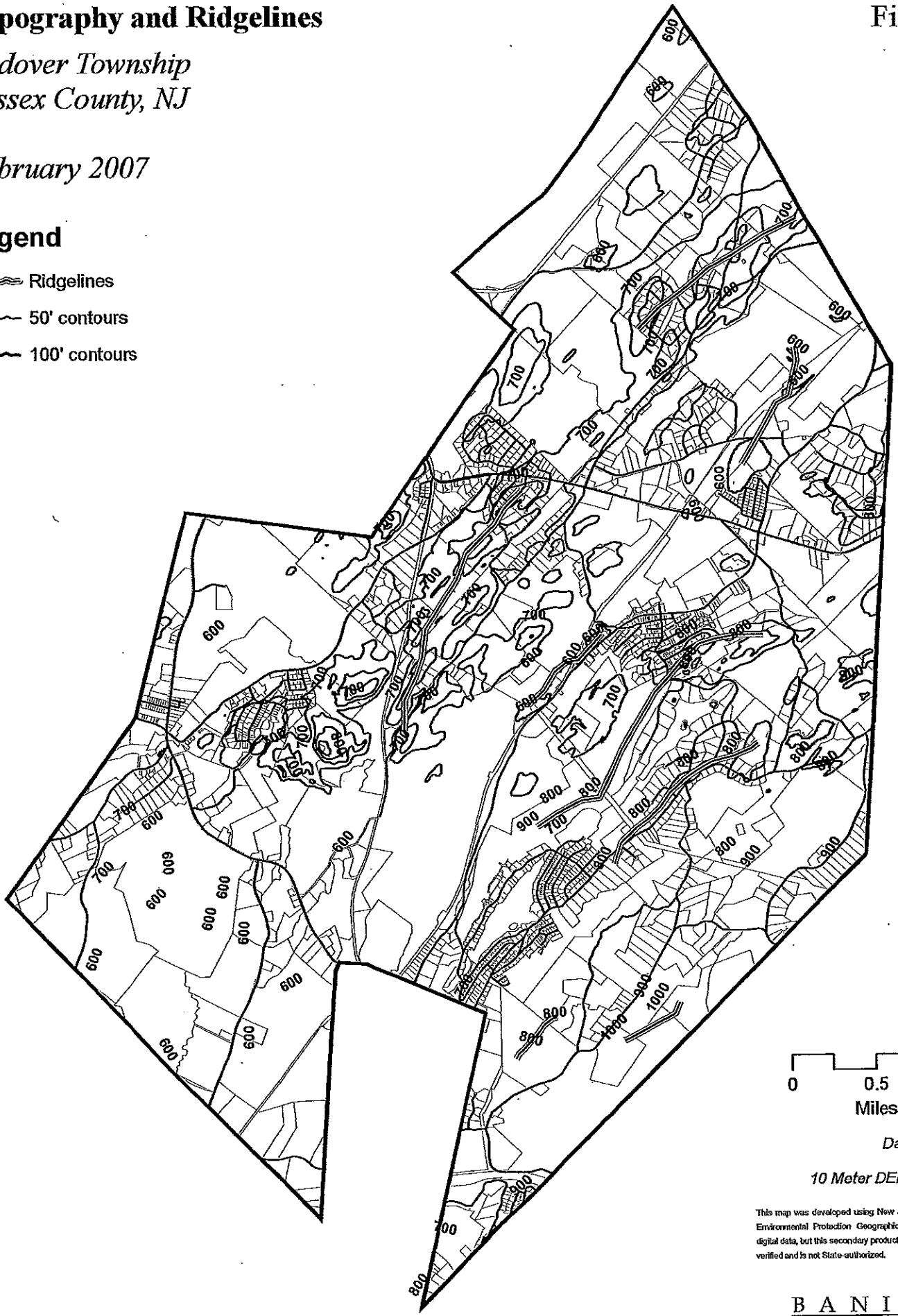
Figure 23

Andover Township
Sussex County, NJ

February 2007

Legend

- Ridgelines
- 50' contours
- 100' contours



Data Sources:
NJDEP
10 Meter DEMs - WMA 1

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Critical Habitat - Forest and Grassland Areas

Figure 24

Andover Township
Sussex County, NJ

February 2007

Rank	Indication
1	Suitable habitat with no field survey conducted
2	Habitat patch with State special concern species present
3	Habitat patch with State threatened species present
4	Habitat patch with State endangered species present
5	Habitat patch with Federal threatened or endangered species present

Legend

- Forest (Rank 2)
- Forest (Rank 3)
- Forest (Rank 4)
- Grassland (Rank 1)
- Grassland (Rank 2)
- Grassland (Rank 3)
- Water

N
W E
S

0 0.5 1
Miles

Data Sources:
NJDEP ENSP Landscapes Data Version 2

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

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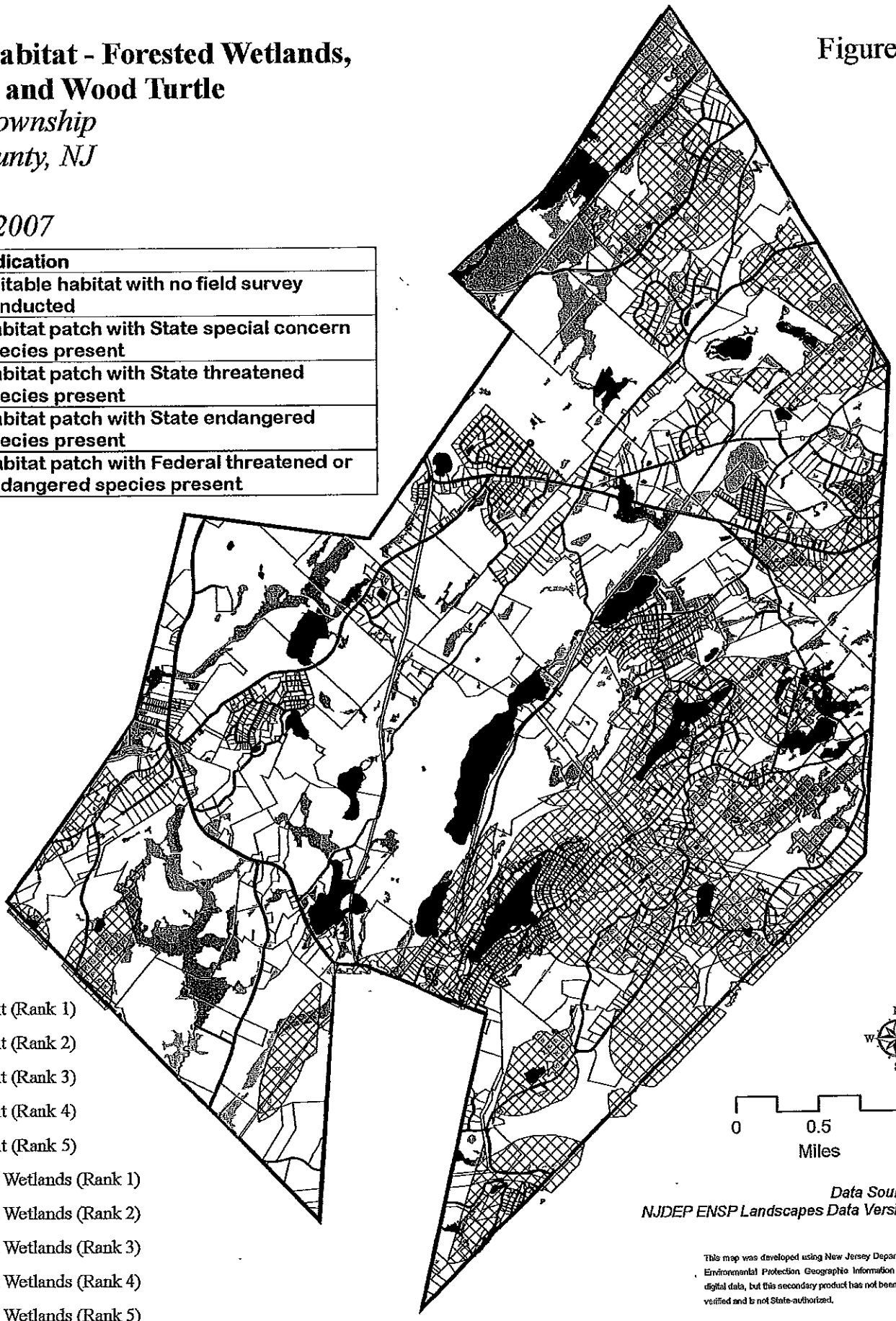
Critical Habitat - Forested Wetlands, Emergent and Wood Turtle

Andover Township
Sussex County, NJ

Figure 25

February 2007

Rank	Indication
1	Suitable habitat with no field survey conducted
2	Habitat patch with State special concern species present
3	Habitat patch with State threatened species present
4	Habitat patch with State endangered species present
5	Habitat patch with Federal threatened or endangered species present



Legend

- Emergent (Rank 1)
- Emergent (Rank 2)
- Emergent (Rank 3)
- Emergent (Rank 4)
- Emergent (Rank 5)
- Forested Wetlands (Rank 1)
- Forested Wetlands (Rank 2)
- Forested Wetlands (Rank 3)
- Forested Wetlands (Rank 4)
- Forested Wetlands (Rank 5)
- Wood Turtle

N
W E
S

0 0.5 1
Miles

Data Sources:
NJDEP ENSP Landscapes Data Version 2

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Natural Heritage Sites

Andover Township
Sussex County, NJ

Figure 26

February 2007

Legend

- B1 Standard Site
- B2 Standard Site
- B3 Macrosite
- B3 Standard Site
- B4 Standard Site
- B5 Standard Site

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
NJDEP
Natural Heritage Priority Site, 2001

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