NATURAL RESOURCES INVENTORY

"Old Peppy"

TOWNSHIP OF CRANFORD
UNION COUNTY, NEW JERSEY
DECEMBER 2003

Natural Resources Inventory

Prepared by the Environmental Commission
Township of Cranford
Union County, New Jersey

December 2003

ENVIRONMENTAL COMMISSSION OF THE TOWNSHIP OF CRANFORD

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ACKNOWLEDGEMENTS

The Natural Resource Inventory (NRI) of the Township of Cranford was made possible through the approval and support of the Township Committee and a matching grant from the New Jersey Department of Environmental Protection, Office of Environmental Services. This edition of the NRI is an update of the original, which was published in December 1993.

Many of the Commissioners devoted significant amounts of their time in producing this document. Much of the research for the update of the NRI came from Commissioners Don Ehrenbeck, Kathy Lewis and Joe Musillo. Other Commissioners who aided in reviewing the text were Steve Jandoli, Matt Polsky, Gary Rowen and Jonathan Sassi.

Special thanks goes to Tom Parlapiano, a former Commissioner who authored the Wildlife chapter; Bob Fridlington of the Cranford Historical Society who updated the History of Cranford chapter; Betty Ann Kelly for writing the Native Vegetation section of the Vegetation chapter; Jeff Sias, former Township Engineer, and the Engineering Department for their help in the preparation of the maps; and Wayne Rozman, Chris Ozemko and Sandi Jacobs of the Department of Public Works for their help with the Trees section of the Vegetation chapter. I would also like to thank Nicole Weiss of The Louis Berger Group who prepared the maps for this NRI. Finally, I am very grateful for the support I received from my wife, Carolyn, during the many months that I spent organizing and editing this update.

My sincere thanks goes to each of these individuals. They can be proud of this document.

Nelson Dittmar
Chair
Cranford Environmental Commission
December 2003

I. INTRODUCTION

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Over the past forty years, Americans have become increasingly aware of our natural environment and its processes, and how we are interrelated. No longer is nature thought of as a commodity to be bought, sold, or exploited. There is a greater sensitivity to the fact that our actions, no matter how small, can have a profound effect upon the natural world around us.

THE CRANFORD ENVIRONMENTAL COMMISSION

In 1968, the New Jersey Legislature enacted laws that permitted municipalities to create quasi-autonomous environmental commissions to engage in a number of environmental activities, including advocacy. The enabling legislation (*N.J.S.A. 40:56A-2*) states that the environmental commission "shall keep an index of all open areas, publicly or privately owned, including open marshland, swamps and other wetlands, in order to obtain information on the proper use of such areas, and may from time to time recommend to the planning board…and governing body…plans and programs for inclusion in a municipal master plan and the development and use of such areas." The Legislature created environmental commissions for, among other purposes, conducting research into the use and possible use of the open-land areas of a municipality. These commissions may advertise, prepare, print, and distribute books, maps, charts, plans, and pamphlets, if it is deemed necessary for their purposes. As noted above, they shall keep an index of all open areas.

Because the Township of Cranford is almost completely developed, it is important to be aware of and consider the Township's remaining natural resources when evaluating both private and public actions. A <u>Natural Resource Inventory</u> (<u>NRI</u>) is a compilation of a municipality's environmental features and natural resource characteristics in both graphic and narrative formats. The <u>NRI</u> is a factual, unbiased document that seeks to provide baseline data for evaluating and measuring environmental issues within the Township, with the ultimate goal being the preservation of significant environmental resources.

As a result of an increasing concern for our environment, the Cranford Environmental Commission prepared an <u>NRI</u> in 1993 to aid in the identification of environmentally sensitive areas and to enable the Commission to work toward the protection of these areas. In 2003, we decided that with the significant improvement in the available technology, we could update the <u>NRI</u> with better and more maps. We have also updated and expanded the information in the text of the document. In addition, pursuant to the Municipal Land Use Law (N.J.S.A. 40:55D-27), whenever an environmental commission prepares an NRI and submits it to the local planning board and zoning board of adjustment, these boards shall forward to the environmental commission informational copies of every development application submitted to either board. Although this referral is for informational purposes only, it enables the environmental commission to comment on applications as they are before each board, resulting in a more proactive role for the Commission in the development of the Township.

The NRI serves as a database for the Environmental Commission, Planning Board, and Zoning Board of Adjustment, and the Township's professional staff and planning consultant, when evaluating and making recommendations on development proposals. If utilized properly, the resulting process will help the Township protect appropriate resources. The document also serves as a point of reference when the Township updates its Master Plan, as it is required to do every six years. In addition, the NRI can be utilized by concerned citizens and civic groups whenever they plan community-service projects.

This updated NRI will be distributed to various review boards, and to Township offices such as the Library and schools. It is the hope of the Commission that the resulting referral process will raise the environmental consciousness of the members of the Planning Board and the Zoning Board of Adjustment, and the environmental awareness of any members of the public who attend the meetings of these Boards.

This NRI contains a chapter on each of the following topics: a municipal profile; open space; the history of the Township; geology; soils; hydrology (groundwater and surface water); meteorology; vegetation; and wildlife. In addition, maps of open space, historical sites, geology, soils, surface water, wetlands, and floodplains are included in the document. The maps were prepared from Geographic Information Systems (GIS) data available from the New Jersey Department of Environmental Protection, the United States Geologic Survey, the United States Fish and Wildlife Service, the United States Environmental Protection Agency, the Natural Resource Conservation Service, and the United States Census Bureau. Throughout the text, words shown in italics are terms that are either defined in the text or in the Glossary in Section XI.

II. MUNICIPAL PROFILE

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The Township of Cranford is an older suburban community located in central Union County, New Jersey. Situated approximately halfway between the cities of Elizabeth and Plainfield, the 4.79 square-mile Township lies on a gently sloping plain east of the Watchung Mountains (see Figure 1). The Township is bordered on the north by Kenilworth and Springfield, on the east by Roselle and Roselle Park, on the south by Clark, Winfield Park and Linden, and on the west by Garwood and Westfield.

Divided roughly in half by NJ Transit's Raritan Valley Line (the former Central Railroad of New Jersey mainline), each side of town has a unique character. The older north side contains the majority of the Township's large Victorian homes, many of which are located along the Rahway River. The south side, much of which was farmland prior to the 1940s, contains a newer mix of housing, primarily Cape Cods and split-levels, as well as the Cranford Business Park, built on the former municipal landfill.

Cranford's central location is convenient for travel. The Township is situated approximately ten miles southwest of Newark Liberty International Airport and approximately twenty miles from Manhattan. The local street network is depicted in Map 1 in Appendix A. Exits 136 and 137 of the Garden State Parkway are located in Cranford, providing the Township with easy access to New York, the New Jersey Shore area and other parts of the region via connections with highways such as the New Jersey Turnpike and Interstate Routes 78, 80 and 287. With regard to rail, NJ Transit's Raritan Valley Line has a station in Cranford, providing access to Newark Penn Station, from which connections may be made to New York Penn Station and New Jersey's PATH system, as well as with NJ Transit's other lines and Amtrak's Northeast Corridor.

According to the U.S. Census, Cranford's population steadily increased in the first half of the twentieth century, reaching a peak of 27,391 persons in 1970. As is the case with many mature towns in the northeast United States, the Township has been losing population since then, reporting a 2000 population of 22,578 persons (Table 1).

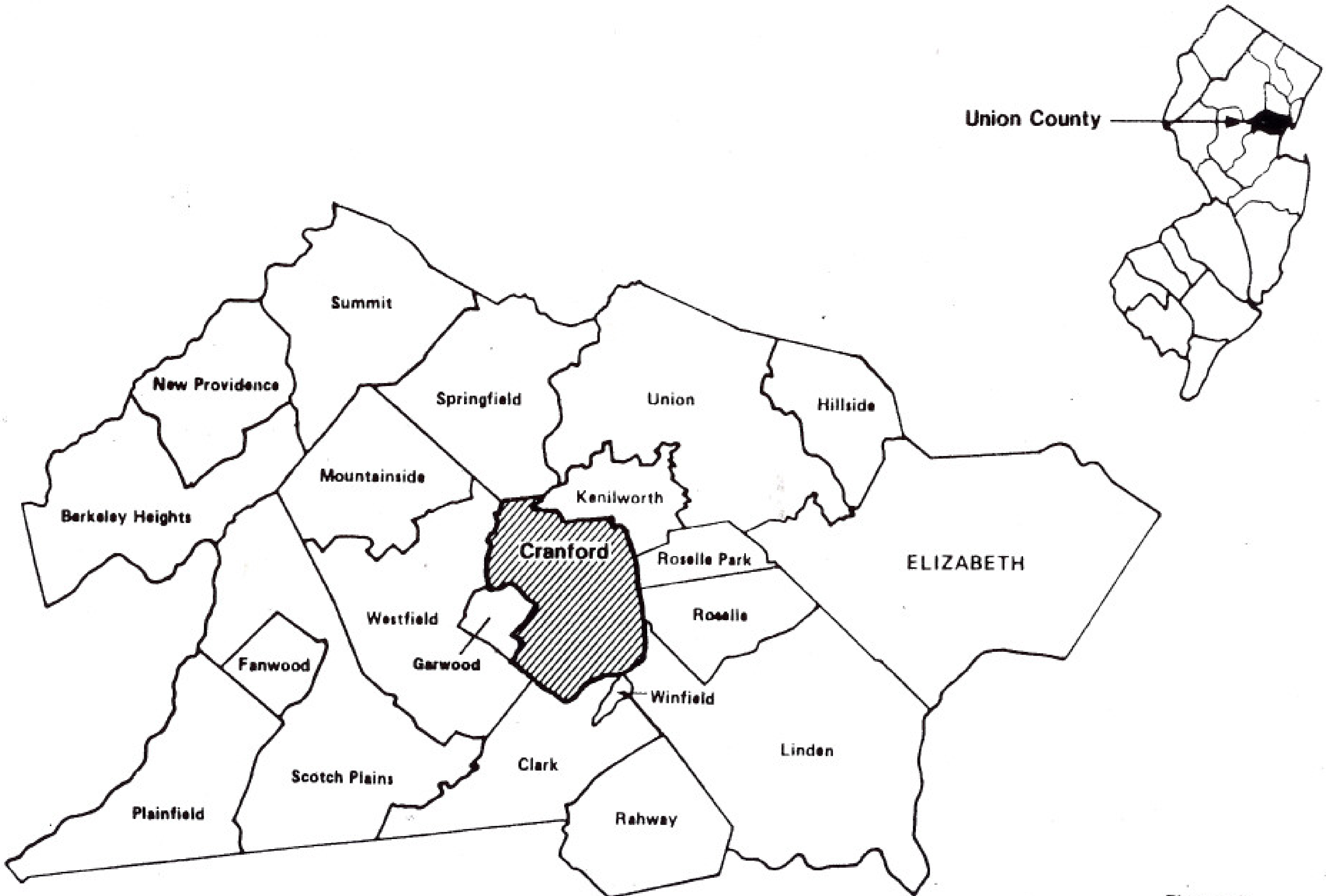

Figure 1
REGIONAL LOCATION

TABLE 1

POPULATION TRENDS: 1950 – 2000

Year	Population	Change from Preceding Decade Actual	Percent
1950	18,602	-	-
1960	26,424	7,822	42.0
1970	27,391	967	3.7
1980	24,573	(2,818)	(10.9)
1990	22,624	(1,949)	(7.9)
2000	22,578	(46)	(0.2)

Source: U.S. Department of Commerce, Bureau of the Census, 2003.

Of Cranford's 22,578 residents in 2000, 21,089 were white (93.4 percent), 610 were Black or African American (2.7 percent), 550 were Asian (2.4 percent) and the remaining 329 (1.5 percent) were of other racial backgrounds. Latinos or Hispanics of any race comprised 3.6 percent (812) of the population (Table 2).

With regard to age in 2000, 5,511 Township residents (24.4 percent) were estimated to be 19 years of age or younger, 10,900 residents (48.3 percent) were estimated to be between the ages of 20 and 54 years, and 2,121 residents (9.4 percent) were estimated to be between 55 and 64 years of age. The remaining 4,046 Township residents (17.9 percent) were estimated to be 65 years and older (Table 3). The median age of Cranford residents in 2000 was 40.4 years.

According to the 2000 Census, the Township's housing stock consisted of 8,560 units. Of these, 8,397 (98.1 percent) were occupied and 163 (1.9 percent) were vacant (Table 4). Of the occupied units, 6,962 (81.3 percent) were owner-occupied and 1,435 (16.8 percent) were renter-occupied. By an overwhelming margin, Cranford's most common form of housing in 2000 was the single-family, detached structure (76.2 percent), followed by the two-family structure (9.5 percent). The median year of housing construction in the Township was 1949. As depicted in Table 5, almost 67 percent of Cranford's homes (5,621) are heated by natural gas, with almost 28 percent (2,345) by fuel oil.

TABLE 2

2000 POPULATION BY RACE

	Actual Population	Percentage of Total Population
White alone	21,089	93.4%
Black or African American alone	610	2.7
American Indian or Alaska Native alone	0	0
Asian alone	550	2.4
Native Hawaiian or Other Pacific Islander alone	5	0.02
Some other race alone	127	0.6
Two or more races	197	0.9
Total	22,578	100.0
Hispanic or Latino of any race	812	3.6

Source: U.S. Department Commerce, Bureau of the Census, 2003.

TABLE 3

2000 POPULATION BY AGE

	Actual Population	Percentage of Total Population
Under 5 years	1,478	6.5%
5 to 19 years	4,033	17.9
20 to 34 years	3,701	16.4
35 to 44 years	3,869	17.1
45 to 54 years	3,330	14.8
55 to 64 years	2,121	9.4
65 years and over	4,046	17.9
Median Age	40.4 years	

Source: U.S. Department of Commerce, Bureau of the Census, 2003.

TABLE 4

SELECTED HOUSING CHARACTERISTICS: 2000

Description	Actual	Percent
Housing Units		
Total	8,560	100.0%
Owner-Occupied	6,962	81.3
Renter-Occupied	1,435	16.8
Vacant	163	1.9
Units in Structure		
1, Detached	6,523	76.2
1, Attached	232	2.7
2	816	9.5
3 or 4	192	2.2
5 to 9	120	1.4
10 to 19	108	1.3
20 or more	563	6.6
Mobile Home or Trailer	6	0.1
Year Structure Built		
Built 1999 to March 2000	27	0.3
Built 1995 to 1998	56	0.7
Built 1990 to 1994	144	1.7
Built 1980 to 1989	236	2.8
Built 1970 to 1979	347	4.1
Built 1960 to 1969	738	8.6
Built 1950 to 1959	2,646	30.9
Built 1940 to 1949	1,566	18.3
Built 1939 or earlier	2,800	32.6
Housing Units		
1 Room	26	0.3
2 Rooms	123	1.4
3 Rooms	505	5.9
4 Rooms	702	8.2
5 Rooms	921	10.8
6 Rooms	1,683	19.7
7 or More Rooms	4,600	53.7

Source: U.S. Department of Commerce, Bureau of the Census, 2003.

TABLE 5

RESIDENTIAL HEATING FUELS

	Actual	Percentage of Total Units
Total Occupied Units	8,397	100.0%
Utility gas	5,621	66.9
Bottled, tank or LP gas	87	1.0
Electricity	326	3.9
Fuel oil, kerosene, etc.	2,345	27.9
Coal or coke	7	0.1
Wood	5	0.1
Solar energy	0	0.0
Other fuel	0	0.0
No fuel used	6	0.1

Source: U.S. Department Commerce, Bureau of the Census, 2003.

III. OPEN SPACE

III. OPEN SPACE

The enabling legislation which created environmental commissions (N.J.S.A. 40:56A-1, et. seq.) states that a commission, among other responsibilities, "... shall keep an index of all open areas, publicly or privately owned, including open marshlands, swamps and other wetlands, in order to obtain information on the proper use of such areas..." Open space is defined by the Municipal Land Use Law as being:

> any parcel or area of land or water essentially unimproved and set aside, dedicated, designated or reserved for public or private use or enjoyment ... provided that such areas may be improved with only those buildings, structures, streets and off-street parking and other improvements that are designed to be incidental to the natural openness of the land.

As a community, Cranford is nearly completely developed. As a consequence, open space is an important issue for the Township. Open space, which is depicted in Map 2 in Appendix A, comes in many forms in Cranford, including public parks, such as Union County's Nomahegan Park or the Township's Memorial Park, and municipally owned lands, such as the Conservation Center on Birchwood Avenue and a wooded area at the end of Cranford Avenue. The Township also owns several small properties throughout Cranford that provide open space. Together, these lands serve important functions in maintaining Cranford as a desirable place to live and work and are closely allied to the quality of life that Township residents enjoy. The perception that open space is just "undeveloped land" is deceiving, and while open space, itself, is a simple concept, the factors that affect it, and that it affects, are quite complex. Open space is an intricate system that serves a variety of essential functions, often concurrently, which sustain New Jersey's environment and its economic vitality. Open space can protect the quality and quantity of surface and groundwater resources, guide development and growth, preserve natural and historic resources, shape community character, and provide land for recreation. The beneficial impact of open space — from increasing the value of adjacent properties and generating revenue from recreational activities to reducing the cost for public services — has been well documented and can be significant. Open space in Cranford provides all of these services and amenities for its residents who are fortunate to have ready access to municipal parks and over 300 acres of Union County parkland. Almost all of the County parkland is centered along the Rahway River: Rahway River Parkway, Nomahegan, McConnell, Lenape, and Sperry Parks all serve as a greenway along the Rahway River corridor. These County parks provide both active recreation opportunities, such as ballfields and soccer fields, and passive recreation activities, such as walking and birding. It is difficult to imagine life in Cranford without these parks and open spaces, because they are used daily by its residents.

Information provided by the Township's Engineering Office was used to determine the location of open space. Aerial photographs of the Township also were reviewed and a field reconnaissance was conducted to verify this data.

IV. HISTORY OF CRANFORD

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Situated in the geographic center of New Jersey's Union County, the Township of Cranford is bisected by the meandering Rahway River. The original Native American inhabitants called the area *Wawahakewany* or "place where eggs are found". Indeed, Cranford owes its existence to the river, for it was that feature which drew the first settlers here in the early 18th century. European settlers built mills along the river to grind grain and saw timber. The farm community became known as "Crane's Mills" due to the location of the two Crane family mills opposite one another near the junction of today's Springfield and North Union Avenues. A low-water-crossing place on the river also was known as "Crane's Ford" and it is from this spot that the modern Township takes its name. The last remaining mill on the Rahway River is at 347 Lincoln Avenue East in Cranford. The Williams-Droescher Mill is the longest continuously occupied industrial building in the state of New Jersey.

Cranford, or Crane's Mills as it was known then, served as headquarters for several Continental Army generals during the fierce winter of 1779-80. Crane's Mills was the center of an arc of 2,000 front line troops stretching from Newark to Perth Amboy. Many of these troops quartered in Crane's Mills. Their purpose was to provide an "early warning" front line of defense for Washington's army at Morristown.

For many years after the Revolution, the Crane's Mills area remained a farming community. Hardwood forest predominated west of the river, while east of the river there was farmland in an area known as "Williams Farms". The community was also known for sheep raising and apple growing, producing a potent applejack known as "Jersey Lightning". Part of the village of Westfield since 1794, in the early 19th century the area became known as "Craneville".

While the railroad first stopped here in 1838, it was not until 1861, when a railroad bridge across Newark Bay opened, that the railroad began to have a significant effect on "Craneville." This led to an influx of New Yorkers and Brooklynites seeking summer homes after the Civil War, changing the area forever and leading to the development of its suburban character. Real estate speculators bought up many of the farms and divided them into housing lots. This increase and the change in the composition of the local population brought another name change in 1869. "Craneville" was thought to be too rural by the sophisticated newcomers. Various names were suggested and finally "Cranford" won out over "Riverdale" by a narrow margin. Soon after, the descendants of the Crane family, Josiah Sr. and Josiah Jr., led a movement to separate from Westfield. They successfully petitioned the State Legislature, and in 1871, the Township of Cranford was officially established. Not long after the Township was incorporated, its founders offered the legislature money and land to move the state capital from the banks of the Delaware River in Trenton to the banks of the Rahway River in Cranford. Their bid was rejected.

For some time, Cranford was known as "The Venice of New Jersey" due to the route of the Rahway River through town. The appellation is credited to Roselle lawyer William Sulzer, who later became Governor of New York. In 1886, a small "River Carnival"— the first in an annual tradition—was held, and each year it became bigger and better. Thousands of people came to see the evening carnivals, which featured lighted and decorated canoes and floats. These festivals eventually were discontinued because eager crowds trampled lawns and gardens.

Today, the 22,578 inhabitants of the Township's 4.79 square miles are living in a community that looks to its past to see its future. A program of downtown renewal, including the state's first Special Improvement District, draws upon the Victorian past for its architectural features.

The following is a list of historic buildings and sites in the Township. Reference numbers are keyed to the Historic Sites Map 3 in Appendix A.

1. Williams-Droescher Mill.

   Located at 347 Lincoln Avenue East, the Williams-Droescher Mill represents a 1910-1919 renovation of an earlier mill (c. 1740). The last remaining mill on the Rahway River, the mill is the longest continuously occupied industrial building in New Jersey. Over its lifetime, the mill has produced things such as blankets, wagon wheel hubs, cut stones, barber supplies, organ consoles, and electronic parts. A horizontal Leffel water turbine (c. 1893) is still in place, and the building also shows evidence of a fire set by a Tory raiding party during the American Revolution. The mill is listed on both the State and National Registers of Historic Places.

2. Droescher Mill Park.

Located on the east bank of the Rahway River north of the mill, this county park has several remnants of Severin Droescher's pre-World War I "Lincoln Park" development, including stone walls, a river overlook, a pond, stone bridge supports, and a stone gazebo.

3. The Crane-Phillips House.

Located at 124 North Union Avenue, this building currently houses the museum of the Cranford Historical Society. This 1845 "Little House on the Rahway" is a Victorian country cottage originally assembled from outbuildings located across the street on the Josiah Crane farm. The honeymoon cottage of Josiah Crane, Jr., the house was later owned by inventor Henry Phillips, a seeker of perpetual motion.

4. Josiah Crane Park.

Located at the intersection of Springfield and North Union Avenues, this park is on the site of the early 19th century farm of Josiah Crane, Sr., the "Father of Cranford". An ancient tree and a ruined well are the only remnants of the original farm. The Crane-Phillips House located across the street was built largely from outbuildings taken from this site in the 1840s. The Township's memorial to the residents who died in the September 11, 2001 terrorist attacks is located in the park.

5. First Presbyterian Church.

Located at the intersection of Springfield and North Union Avenues, across from Josiah Crane Park, this church is a local architectural landmark. Completed in 1894, the church is noted for its shingle architecture, interior, and President McKinley stained glass window.

6. The Hanson House.

Located at 38 Springfield Avenue, this building is the former office and home of Cranford pediatrician, Dr. Carl Hanson, a noted researcher in the field of strep throat. The building currently houses the annex, offices, and library of the Cranford Historical Society, as well as numerous other community groups. Mrs. Hanson's Leet organ was manufactured in 1949 by the Leet Organ Company at Droescher's Mill.

7. Cranford Canoe Club.

Located at the intersection of Springfield and Orange Avenues, this is the last remaining canoe club on the Rahway River. Once the center for social life on the river, it was purchased by the Township and is still being operated as a canoe livery.

8. Crane's Mills Site.

Located on the Rahway River just north of the North Union Avenue bridge, this was the site of the two Crane-family mills that gave the village its first name, "Crane's Mills." A gristmill was located on the north bank of the river in what is today's Sperry Park. A sawmill was located on the south bank behind today's Gray's Funeral Home. Both mills flanked the c. 1720 dam known later as "Hansel's Dam" because it was behind the home of Charles Hansel (today's funeral home). Archaeological digs at both mill sites in the early 1970s uncovered foundations, machinery mounts, clay pipes, bottles, buttons, and tools.

9. Revolutionary Cantonment Site.

Located at Sperry Park on Riverside Drive, a marker commemorates the winter of 1779-80 cantonment of Continental troops along the river here, part of a 2,000-man front protecting Washington's troops at Morristown. The front stretched in an arc from Newark to Perth Amboy, with Crane's Mills (Cranford) in the center. Several Continental Army generals headquartered here. Alexander Hamilton visited the Crane's Mills cantonment and Hessian prisoners passed through here.

10. Crane's Ford Monument.

Located on Riverside Drive at Springfield Avenue, the monument marks the site of Crane's Ford, the low-water-crossing place on the Rahway River. Tradition has it that in the Revolution mounted sentinels stationed at this site carried warning of the approaching British to Washington at Morristown. The Township takes its name from this spot.

11. Memorial Park.

This Township park or "green" is on Springfield Avenue at Riverside Drive where memorials to the community's war dead are located. These include World War I, World War II, Korea, and Vietnam. A circular marble monument memorializes P.O.W.s and M.I.A.s. A nearby tree is dedicated to the first Cranford serviceman to fall in Vietnam.

12. The Cranford Hotel.

Located at the intersection of Walnut and South Union Avenues, this is the oldest business in Cranford, still operating after one hundred years. A restaurant and bar occupies the premises today. It originally opened as a hotel for railroad travelers on December 31, 1892.

13. The Cranford Pepperidge Tree.

The official Township tree, located on Lincoln Avenue West, is a much-photographed black gum tree famed for its fiery fall foliage coloration. Once a boundary tree, this 235 year-old specimen is the largest pepperidge tree in the United States and is the National Champion in AMERICAN FORESTS National Register of Big Trees since 1998. When it was measured in 1997, the tree was 67 feet tall, 46.75 inches in diameter (147-inch circumference), and had an average crown spread of 23 feet.

14. The Linwood Carriage House.

Located at 12 Forest Avenue, this large Neo-Jacobean 19th century carriage house was once part of a larger estate known as "Linwood". It is one of only two local structures built directly on the river. The main house still exists and is located at the intersection of Forest and North Union Avenues.

15. The Old Rectory.

This Italianate villa (c. 1860), located at 12 Bloomingdale Avenue, once served as the rectory for the Roman Catholic church that once stood at the corner of Bloomingdale and Elizabeth Avenues.

16. The Pierson-Crane House.

This circa 1737 house, located at 420 Riverside Drive facing Memorial Park, was once occupied by Samuel Pierson, a member of General Washington's Life Guards. It was extensively remodeled and enlarged in the 19th century and again in 1929.

17. The Dunham-Oakey House.

This Revolutionary-era farmhouse with an 1820 addition is located at 1117 Orange Avenue. The home of one of the Dunhams, it was later occupied by Civil War veteran William Oakey. At various times in its history, it functioned as a school, a boarding house, and a brothel.

18. The Vreeland House.

This circa 1840 farmhouse, located at 306 Lincoln Avenue East, was built by James Vreeland just up the road from the mill he owned and operated (the Williams-Droescher Mill).

19. The Denman Homestead Site.

Located at the intersection of Denman Road and Lincoln Avenue West, this is the site of the home and farm of John Denman, the first European to cross the Rahway River and permanently settle in the Cranford area (1720). The third and last Denman house on this spot was razed in 1951. The Denman lands were primarily hardwood forests yielding fine timber well into the 1890s. Timber from the site went into the refitting of the U.S.S. Constitution for the War of 1812.

20. Revolutionary Hospital Site at Union County College.

An army field hospital was located in the northwest portion of Crane's Mills from 1777 to 1780. The site is now part of the Union County College campus, near Princeton Road. The hospital was a log building similar to the reconstruction that can be seen today at Morristown.

Union County College is located on a forty-eight-acre site on Springfield Avenue. It is the home to the oldest community college in the state. The College originally opened in October 1933 with night classes at Roselle's Abraham Clark High School. Day sessions were added in 1942. One year later, the College moved to Cranford and has been headquartered at its current location since 1959.

21. Mastodon Site.

Two tusks (one measuring four feet, three inches) and several bone fragments from an ancient mastodon were found in 1936 in the swampy area directly behind what is now the parking lot of Union County College's main building.

V. GEOLOGY

V. GEOLOGY

GEOLOGIC TIME

The Earth is very old -- 4.5 billion years or more -- according to recent estimates. This vast span of time, called *geologic time* by Earth scientists, is difficult to comprehend in the familiar time units of months and years, or even centuries. The timescale of the history of the Earth has been divided into units of varying magnitude according to the rock types and fossils found in each one. These divisions are arbitrary and are measured in millions of years. The evolution of life on Earth can be divided into two very unequal periods: the very long *Precambrian* (lasting over 3 billion years), when life, for the most part, remained at the microbial stage, and the much shorter *Phanerozoic* (lasting about 540 million years), when much more complex, multicellular life, has flourished.

Eons

As depicted in Table 6, the largest subdivision of the geologic time scale is the *eon*. Geologic time is composed of four eons: *Hadean*, *Archean*, *Proterozoic*, and *Phanerozoic*. The Precambrian time period is made up of the first three eons.

The Hadean Eon

The Hadean Eon began with the formation of the solar system and the Earth. The name says it all — a hellish period lasting some 750 million years, when the Earth was subject to frequent bombardment by comets, asteroids, and other planetary debris. At one point early in this eon, the moon was formed when a Mars-sized body struck the original Earth, pulverizing them both. Incredibly, the first primitive life emerged during this time. The Hadean Eon was characterized by extensive volcanism and formation of the first continents. At its conclusion, the Earth had an atmosphere (unbreathable to most organisms today), and oceans filled with *prokaryotes* (single-cell microorganisms similar to modern-day bacteria).

TABLE 6

THE GEOLOGIC TIME SCALE

Eon
Era
Period
Epoch
Time Span
Duration

Phanerozoic Eon **Cenozoic Era** **Quaternary Period** **Holocene Epoch** Present - 0.01 0.01	→	**Phanerozoic Eon** **Cenozoic Era** **Quaternary Period** **Pleistocene Epoch** 0.01 - 1.6 1.59	→	**Phanerozoic Eon** **Cenozoic Era** **Tertiary Period** **Pliocene Epoch** 1.6 - 5.3 3.70	→
Phanerozoic Eon **Cenozoic Era** **Tertiary Period** **Miocene Epoch** 5.3 - 23.7 18.40	→	**Phanerozoic Eon** **Cenozoic Era** **Tertiary Period** **Oligocene Epoch** 23.7 - 36.6 12.90	→	**Phanerozoic Eon** **Cenozoic Era** **Tertiary Period** **Eocene Epoch** 36.6 -57.8 21.20	→
Phanerozoic Eon **Cenozoic Era** **Tertiary Period** **Paleocene Epoch** 57.8 - 65.0 7.20	→	**Phanerozoic Eon** **Mesozoic Era** **Cretaceous Period** 65.0 - 140.0 75.0	→	**Phanerozoic Eon** **Mesozoic Era** **Jurassic Period** 140.0 - 205.0 65.0	→
Phanerozoic Eon **Mesozoic Era** **Triassic Period** 205.0 - 250.0 45.0	→	**Phanerozoic Eon** **Paleozoic Era** **Permian Period** 250.0 - 290.0 40.0	→	**Phanerozoic Eon** **Paleozoic Era** **Carboniferous Period** 290.0 - 355.0 65.0	→
Phanerozoic Eon **Paleozoic Era** **Devonian Period** 355.0 - 410.0 55.0	→	**Phanerozoic Eon** **Paleozoic Era** **Silurian Period** 410.0 – 438.0 28.0	→	**Phanerozoic Eon** **Paleozoic Era** **Ordovician Period** 438.0 – 510.0 72.0	→

Time Span = Million of years before present **Duration** = Millions of years

Phanerozoic Eon Paleozoic Era Cambrian Period		Proterozoic Eon		Archean Eon	
510.0 - 540.0 30.0	→	540.0 - 2,500.0 1960.0	→	2,500.0 - 3,800.0 1,300.0	→

Hadean Eon
3,800.0 - 4,550.0 750.0

Source: www.geol.ucsb.edu/Outreach/TimeScale/TimeScale.html with the format modified by the Cranford Environmental Commission.

The Archean Eon

The Archean Eon followed the Hadean, and lasted from about 3.6 to 2.5 billion years ago. The Archean Eon was the period of maximum continent formation, with approximately seventy percent of the continental landmasses forming from volcanic activity. Plate tectonics followed a regime of continental drift different from that of later eons. During the Archean Eon, diverse microbial life flourished in the primordial oceans.

These first organisms, called *heterotrophs,* had no free oxygen as there is now. Their atmosphere, which is described as *reducing* or *anaerobic* (nonoxygen dependent), was composed of methane, carbon dioxide, and hydrogen. They used methane or hydrogen, rather than oxygen, in their metabolism. These first organisms derived their food from other organisms or organic matter that they were able to consume. Soon most of the available organic matter was exhausted. Life was close to cannibalizing itself into extinction when a new type of organism, capable of manufacturing its own food, appeared. Known as *autotrophs*, they fed on the pure energy of sunlight. Without them, the continuation of life would have been impossible. Autotrophs are still with us now. We call them "green plants." These very early green plants were actually an extremely primitive form of algae, similar to modern blue-green algae. As with the photosynthesis in today's green plants, autotrophs produced oxygen as a metabolic by-product. The eventual build-up of this highly reactive gas proved fatal to many life-forms, and led to the gradual conversion of the anaerobic atmosphere to the *aerobic* (oxygen dependent) atmosphere that we have today.

The Proterozoic Eon

The Proterozoic Eon followed the Archean. The Proterozoic Eon saw the atmosphere change from reducing to oxygenated, driving the original anaerobic inhabitants of the Earth into a few restricted refuges and enabling the rise of aerobic life. The modern regime of continental drift began during this time, and the ancient supercontinent of Rodinia was formed. The Proterozoic Eon also saw several extensive ice ages, resulting in the "Snowball Earth," a period when the Earth was encased in ice several miles deep.

The Phanerozoic Eon

The Phanerozoic Eon followed the Proterozoic Eon. It is the youngest eon and represents a relatively brief period that constitutes the age of multicellular animal life on Earth. During this time, micro- and multicellular organisms left a detailed fossil record and built up complex and diverse ecosystems, and life evolved through countless transformations and into millions upon millions of species.

Eras

Eons are divided into *eras* that are defined based on the presence or absence of fossils found in the rocks. The Hadean, Archean, and Proterozoic Eons are not usually divided into eras due to absence of fossils, but the Phanerozoic Eon is divided into three: the *Paleozoic* ("ancient life"), the *Mesozoic* ("middle life"), and the *Cenozoic* ("recent life"). Each era has been characterized by profound, worldwide changes in life forms.

The Paleozoic Era

Early in the 300-million-year history of the Paleozoic Era, atmospheric oxygen reached its present levels, generating the ozone shield that screened out ultraviolet radiation and allowed complex life to live in the shallows and finally on land. This era witnessed the age of invertebrates, fish, and, during the era's last stage, reptiles. From about mid-era on, life emerged from the sea to colonize the land, and, in the later Paleozoic, certain types of plants flourished. The generally mild to tropical conditions with their warm shallow seas were interspersed with several ice ages. Toward the end of the Paleozoic, the continents clustered into the supercontinent of Pangea, and, increasingly, aridity meant the end of the great carboniferous swamps and their unique flora and fauna. The Paleozoic was brought to an end by the Permian mass-extinction, perhaps the most severe extinction the planet has ever seen.

The Mesozoic Era

Lasting little more than half the duration of the Paleozoic, this was a spectacular time. The generalized reptiles of the early Mesozoic gave way to the dinosaurs. While dinosaurs dominated the land, diverse sea-reptiles ruled the oceans. Invertebrates, especially ammonites, were extremely diverse. Pterosaurs and, later, birds took to the sky. Mammals, however, remained small and insignificant. Climatic conditions remained warm and tropical worldwide. The supercontinent of Pangea broke up into Laurasia and Gondwana, with different dinosaurian faunas evolving on each. During this era, modern forms of corals, insects, new fish, and flowering plants evolved. At the end of the Mesozoic era, dinosaurs and many other animals abruptly died out, quite likely the result of an asteroid impact and associated, extensive volcanic activity and acid rain.

The Cenozoic Era

With the extinction of dinosaurs and the end of the Mesozoic, mammals swiftly inherited the Earth. Archaic mammals coexisted with birds, modern reptiles, and invertebrates. The current continents emerged, and the initial tropical conditions were replaced by a colder, drier climate. The appearance of grass meant the rise of grazing mammals, and the cooler, drier world allowed modern mammalian groups to evolve, along with other lineages, now extinct, and a few archaic holdovers. Decreasing temperatures and the polar landmass of Antarctica resulted in a new ice age. Most recently, this era saw the extinction of Megafauna, the rise of Man (*Homo erectus*, Neanderthal, and Cro-Magnon), the use of stone tools and fire, and the development of civilization and human activities that have transformed the globe, but at a cost of great environmental destruction.

<u>Periods</u>

Each era of the Phanerozoic Eon is further subdivided into time units known as *periods*. The Paleozoic era has six periods, the Mesozoic three and the Cenozoic two. Periods are sometimes named after the geographical location where they were originally studied (e.g., the Cambrian — 'Cambria' is the Roman name for Wales), or on the characteristics of the strata found (e.g., the Cretaceous — is the Latin word for chalky).

Epochs

Some of the Phanerozoic periods are further divided into smaller time units, known as *epochs*, by the fossils they contain. Epochs are terms mainly used by specialists concerned with very detailed studies of strata and corresponding fossils. Except for the seven epochs which have been named for the periods of the Cenozoic era, those of other periods are not commonly referred to by specific names, but by the terms early, middle and late.

LANDFORMS

New Jersey can be divided into four geologic regions, known as *physiographic provinces*, each of which has distinctive rocks and landforms (see Figure 2). The Township of Cranford lies entirely within the Piedmont subdivision of the Appalachian Physiographic Province. Commonly known as the Piedmont Plateau, or Piedmont Plain, this eastern-most subdivision of the Appalachian Province is approximately 1,500 square miles in area. Sloping from an altitude of approximately 400 feet above mean-sea level at its northwestern extremity to sea level near Newark Bay, the Piedmont presents a low, hilly surface, broken by occasional ridges and gently rounded hills. These hills are separated by wide valleys which slope downward toward the east and southeast. In the Cranford area, the most notable of these ridges is the Watchung Mountains. (Map 4 in Appendix A shows the surficial geology.)

During the late Triassic Epoch, a series of basins in a northeast-to-southwest direction was formed in the Piedmont Plateau from Nova Scotia to North Carolina. Rocks of the Triassic age occupy these basins and are known as the Newark Group. In New Jersey, the Newark Group covers a band 16 to 30 miles in width and is oriented in a northeast-to-southwest direction, covering Cranford in its entirety. Within this band, the Newark Group contains 15,000 to 20,000 feet of various rock types that overlie rocks of the Paleozoic Era and prior eons. All indications are that in the vicinity of Cranford, the Newark Group consists of rocks of late Triassic and early Jurassic Periods. Formerly known as the Brunswick Formation, these deposits were further subdivided in 1980 into four formations, each characterized by its own suite of rock types. The formation underlying Cranford is known as the Passaic Formation. Composed of red sandstone and shale, the Passaic Formation has a characteristic reddish-brown color, the result of iron-bearing minerals that were oxidized during the cyclic wetting and drying of the sediments during their deposition.

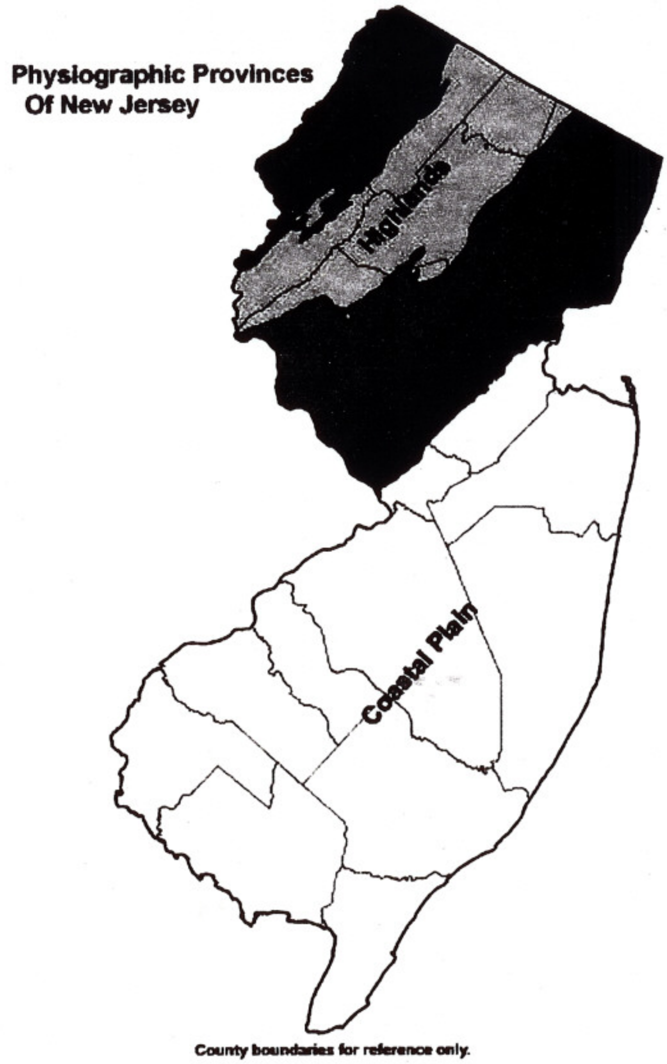

Figure 2: The Physiographic Provinces of New Jersey

Source: New Jersey Geological Survey, 2003.

Remnants of the Pleistocene Epoch are present in Cranford. Commonly known as the Ice Age, this epoch represents the last million years of geologic history. The epoch is divided into four glacial and three interglacial stages. In the last glacial stage, the Wisconsin, ice exceeding one mile in thickness advanced from the north and northeast and covered the eastern two-thirds of Union County. The action of the ice sheet modified the landscape by deeply scouring valleys, wearing down and streamlining bedrock ridges, hills, and slopes, and eroding soil and loose rock. The ice sheet also added to the landscape by depositing materials. A glacier acts like a conveyor belt. As the ice flowed, it carried along material that it had eroded. Similar to a giant bulldozer, it scraped up material and moved it along, and eventually dumped it at the ice front.

Materials transported and deposited by a glacier are called *glacial drift*. The two basic types of glacial drift are *till* (material deposited directly by glacial ice) and *stratified drift* or *outwash* (material deposited directly by glacial meltwater). Glacial till tends to be poorly rounded and not well smoothed, and poorly sorted. Till is deposited as glacial ice melts and drops its load of rock fragments. Stratified drift is well rounded and smoothed, and well sorted according to the size and weight of the fragments. The ice is not capable of such sorting activity; the stratified drift reflects the sorting action of the glacial meltwater that deposited it.

Landforms created by glacial till are called *moraines*. *End moraines* form at the terminus of a glacier. Here, while the ice front is stationary, the glacier continues to deposit large quantities of rock debris, creating a ridge of till tens to hundreds of feet high. The area of land marking the farthest advance of a glacier is known as the *terminal moraine*. The terminal moraine of the Wisconsin glacier is a nearly continuous low ridge that extends across the State in a curved line from Perth Amboy to Belvidere, passing through the western part of Union County. A small section of the terminal moraine, as well as areas of stratified drift, are located in the northwest section of the Township.

Cranford has a direct connection to the Pleistocene Epoch. In 1936, the two tusks and miscellaneous bones of a mastodon were discovered in the Township. These specimens, which now reside in the State Museum in Trenton, were obtained from the bed of a small stream in a swampy area directly behind what is now the parking lot behind the main building of Union County College. The larger tusk measured four feet, three inches. Closely resembling an elephant, mastodons typically lived in the forests that covered Cranford 25,000 years ago and became extinct at the end of the Pleistocene Epoch.

VI. SOILS

VI. SOILS

INTRODUCTION

Soil is an integral part of our environment. Defined as a discrete body produced by interactions of climate, vegetation, and geologic materials found on the earth's surface, soil is a mixture of organic and inorganic particles. The main component of soil is rock particles weathered from local bedrock or transported from other areas by wind or water. These rock particles mix with decaying plant and animal matter, air, and water. The result is what we know as soil.

Soil characteristics vary from location to location, even within very short distances. A soil's composition and structure in any given place is determined by its original geologic material, vegetation cover, amount of weathering, topography, and changes caused by human activity. These differences may range from striking textural variations to subtler color variations. There are two main groups of soils: *residual*, which is soil located in the place in which it was formed; and *transported*, which is soil brought to its location from somewhere else by the action of water, wind, and ice. As a result of several glaciations, most of the soil in Cranford is transported soil.

SOIL CLASSIFICATION

The general texture of a soil is dependant upon individual particle size and the soil's mix of particle sizes. Soil particles are divided into *sand*, *silt,* and *clay*. Sand particles can be seen and felt easily. Silt particles usually require a microscope to be seen and feel like flour when touched. Clay particles cannot be seen by the naked eye and form a gummy substance when wet. Soils are classified according to their proportions of sand, silt, and clay. As described below, there are three broad classifications of soils.

- **Sand**

It is loose and single-grained. If squeezed when dry, it will fall apart. If squeezed when moist, it will form a cast, but will crumble when touched.

- **Clays**

Clay is a fine-textured soil that usually forms very hard lumps or clods when dry and is quite pliable, and usually sticky, when wet.

- **Loams**

Loam is a soil having a relatively even mixture of different grades of sand, silt, and clay. It is mellow with a somewhat gritty feeling, yet fairly smooth and slightly plastic. If squeezed when dry, it will form a firm cast, which can be handled quite freely without breaking. A loam in which sand is dominant is classified as a *sandy loam*. In the same way, there are also *silt loams*, *silt-clay loams* and *clay loams*.

A soil's texture affects the way it interacts with its surrounding environment, particularly its efficiency in storing water and supporting plant growth. Soils with a high percentage of sand are porous and do not store water very well, whereas soils with high percentages of clay retain water; in general, neither of these sustains the growth of most plants. A *soil texture triangle* (Figure 3), which illustrates soil types by their proportions of sand, silt, and clay, is useful in identifying soil classes according to the three texture characteristics.

Soils are classified according to their physical characteristics. As water percolates through the soil, it sorts the soil's components according to their size and texture; it carries finer particles into deeper pore spaces and leaves the coarser particles closer to the surface. This sorting action, which occurs over long-time periods, separates the soil into distinct layers, or *soil horizons*, which are defined as layers of soil, lying approximately parallel to the earth's surface, that possess relatively homogeneous physical, chemical, and biological properties. To obtain a view of these characteristics, soil scientists use a *soil profile* — a vertical cut made to expose the horizons to view. Each profile is evaluated according to its properties, such as depth, color, mottling, texture, structure, consistency, reaction, and boundary.

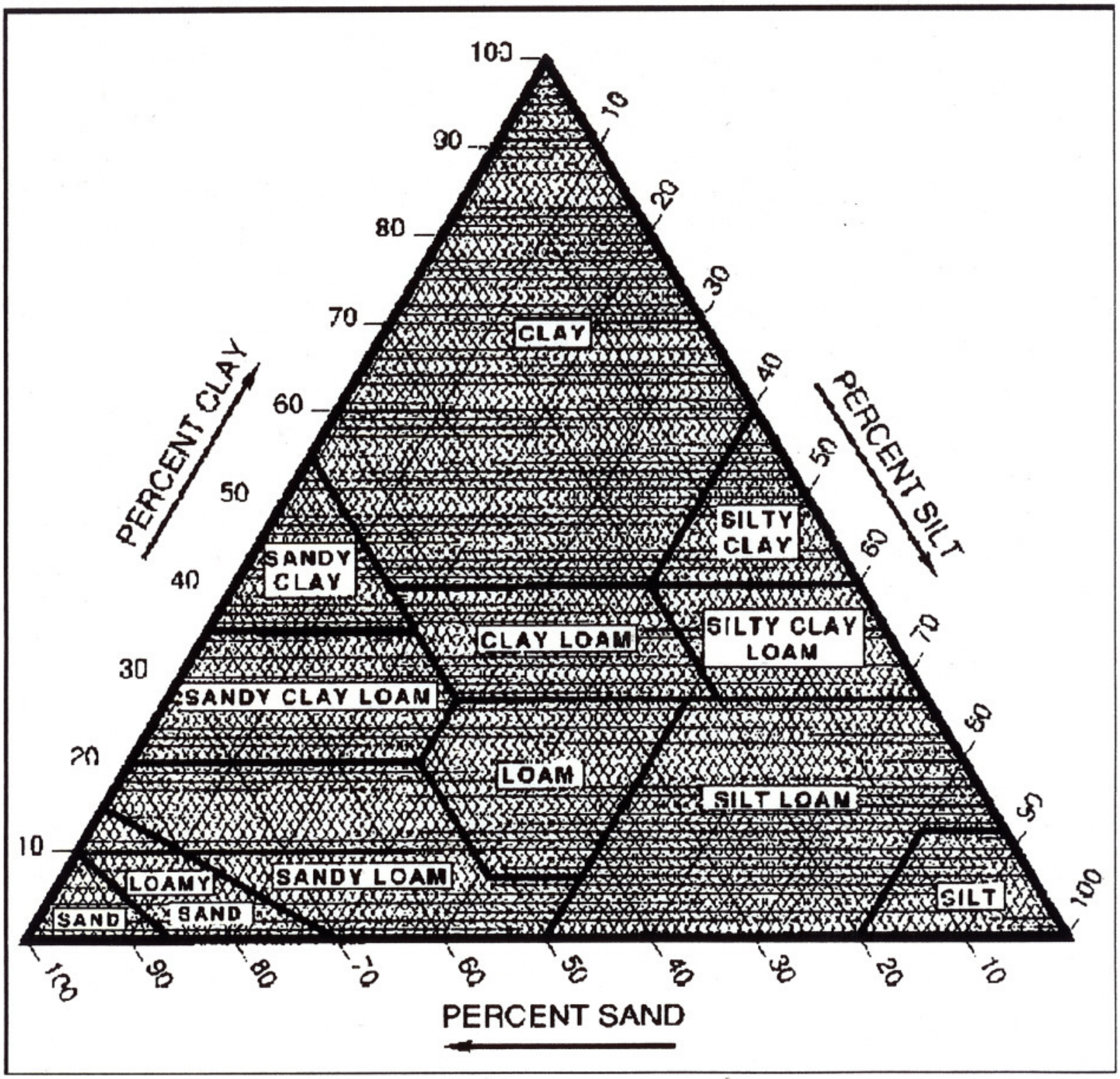

Figure 3: The Soil Triangle.

Soil types that are found to have similar properties are then classified together in soil associations. The main horizons of a typical soil profile are shown in Figure 4 and described below.

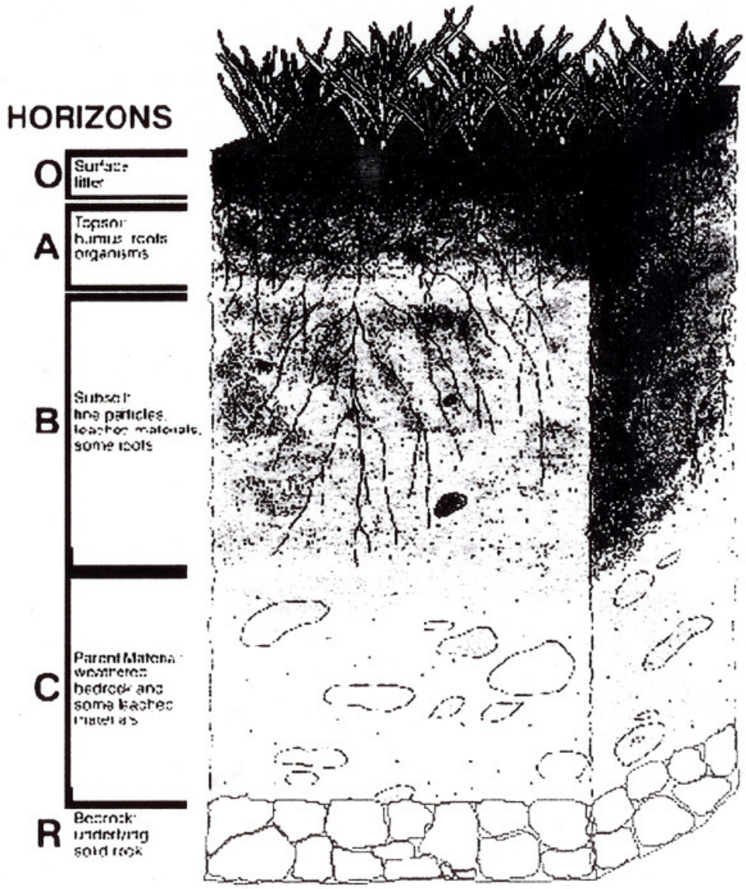

Figure 4: Typical Soil Profile

- <u>**The "O" Horizon**</u>

The "O" horizon is the upper-most layer of most soils. It is composed mainly of plant litter and humus.

- <u>**The "A" Horizon**</u>

The "A" horizon is the layer normally found below the "O" horizon and above the "B" horizon. It is a layer in which humus and other organic materials are mixed with mineral particles, and where *eluviation* (the movement of mineral particles and chemical substances from upper-soil layers to lower-soil layers by the downward movement of water) has removed finer particles and soluble substances. The "A" horizon is commonly called *topsoil*.

- **<u>The "B" Horizon</u>**

The "B" horizon is the layer normally found below the "A" horizon and above the "C" horizon. It is a layer enriched by clay, iron, and aluminum oxides because of *illuviation* (the accumulation of materials from overlying horizons due to eluviation) from the "A" horizon. Typically, the "B" horizon includes accumulation of calcium carbonate, calcium sulfate, and other salts due to eluviation; it has a higher bulk density because of the illuvial deposition of clay particles. The "B" horizon is also called the *subsoil* or *zone of accumulation*.

- **<u>The "C" Horizon</u>**

The "C" horizon is normally found below the "B" horizon and above the "R" horizon. This unconsolidated, or weakly consolidated layer, is composed of weathered bedrock that has not yet been significantly affected by the pedogenic (soil-forming) processes. The "C" horizon retains evidence of rock structure, but lacks diagnostic properties of the overlying horizons. The "C" horizon is commonly called *parent material*, and varies in depth from just a few feet to tens of feet.

- **<u>The "R" Horizon</u>**

The "R" horizon comprises continuous (consolidated) hard or very hard bedrock.

CRANFORD SOILS

In Cranford, soils have been identified, evaluated, and mapped through a cooperative effort of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), the Somerset-Union Soil Conservation District, the New Jersey Agricultural Experiment Station at Cook College, and the New Jersey Department of Agriculture. The *Soil Survey of Union County, New Jersey* was published in 2002.

As depicted in Map 5, Soils Survey, in Appendix A, soils in Cranford comprise the following units:

<u>Boonton-Urban Land-Haledon complex, 0 to 8 percent slopes (BovB)</u>

This unit consists mostly of well-drained or moderately well-drained Boonton soils, areas of Urban land (see below), and somewhat poorly drained Haledon soils. The *permeability* of the Boonton soil is moderate in the surface layer and upper parts of the subsoil, and slow to very slow in the *fragipan* (a very dense, hard-soil horizon that restricts water percolation and root penetration). Its available water capacity is moderate, runoff is medium, and the erosion hazard is moderate. After heavy rains and in winter and early spring, a *perched water table* (a small body of groundwater located above the fragipan) is located at a depth of eighteen to thirty-six inches. Soil here is very strongly acidic. This unit is found in extensively developed areas used for residential, commercial, and industrial purposes. Open portions are used for lawns, gardens, or small parks. This unit has limitations for building sites and other engineering uses. Many areas require drainage improvement to protect against damage to structures such as foundations and retaining walls. Lateral seepage in the fragipan commonly occurs in excavations, resulting in soil instability. Roads severely affected by frost action are also common here. The degree of wetness limits the use of this soil for lawns, gardens, trees, and shrubs. Landscaping plants must tolerate wetness and restricted rooting depths.

Dunellen sandy loam, 3 to 8 percent slopes (DunB)

This soil is gently sloping and well-drained, and is typically found on side slopes of glacial outwash and stream terraces. The permeability of this soil is moderate to rapid, and runoff is slow. Its erosion hazard is moderate, as is its available water capacity. This soil is medium to very strongly acidic. Most areas of this soil are wooded. The trees growing in this soil are predominantly oaks, with minor amounts of maple, black cherry, birch, beech, and sweetgum. This soil is well-suited for urban use, although a concern exists that its rapid permeability may permit groundwater pollution, and any excavation sidewalls would be unstable. This soil is also well-suited for lawns and landscaping, if its upper layer is left intact.

Dunellen-Urban land complex, 0 to 3 percent slopes (DuuA)

This unit consists mostly of well-drained Dunellen soils with a wet *substratum* and areas of Urban land. Slopes are from zero to three percent. This soil's permeability is moderate to rapid, available water capacity is moderate, runoff is slow, and its erosion hazard is moderate. From late winter through spring, a *water table* is located at a depth of forty-eight to seventy-two inches. This soil is medium to very strongly acidic. It is limited for urban use by its rapid permeability, which creates a potential for groundwater pollution, and by the wetness of the substratum. Excavation sidewalls should be considered unstable in this soil and should be shored. This soil is suited for lawns and landscape site-development, using moisture-loving plants. Drainage is difficult to apply in these conditions, and the cost effectiveness of any applied drainage measures would only be marginal.

Fluvaquents, frequently flooded (Fmt)

These soils are somewhat poorly drained or poorly drained, with zero to three percent slopes. They are located along streams of the Rahway River and consist of stratified loamy sediments and organic materials. A water table is located between the surface and a depth of eighteen inches from fall to early summer. These soils have not been extensively developed due to the flooding hazard and the high water table. This unit is severely limited for lawns and landscaping, because of frequent flooding and wetness.

Haledon loam, 0 to 3 percent slopes (HakA)

This soil is nearly level and somewhat poorly drained and is generally located in depressions on the *terminal moraine* and in upland waterways. The lower part of the subsoil is a fragipan about 16 inches thick. Its permeability is moderate above the fragipan, but is slow in the fragipan. Available water capacity is moderate and runoff is slow, with excess water moving laterally across the fragipan. A perched water table is located at a depth of six to eighteen inches from late winter through spring. The hazard of erosion is slight. This soil is very strongly acidic and is suited for use as woodland, although rooting depth is limited by the firm fragipan. Common trees found in this soil include red maple, sweetgum, pin and white oaks, and white ash. Urban uses (e.g., development) in this soil are limited by its slow permeability in the fragipan and the potential for frost action. This soil is also severely limited for lawn and landscaping use by its wetness due to runoff from surrounding higher areas. Landscaping is limited to plants that are tolerant of wetness and restricted rooting depths.

Haledon loam, 3 to 8 percent slopes (HakB)

This soil is gently sloping and somewhat poorly drained, and is generally located on toe slopes of the terminal moraine or on low-convex landscapes. The lower part of the subsoil is a fragipan about sixteen inches thick. Its permeability is moderate above the fragipan, but is slow in the fragipan. Available water capacity is moderate and runoff is slow, with excess water moving laterally across the fragipan. A perched water table is located at a depth of six to eighteen inches from late winter through spring. The hazard of erosion is slight. This soil is very strongly acidic and is suited for use as woodland, although rooting depth is limited by the firm fragipan. Common trees found here include red maple, sweetgum, oak, beech, and white ash. Urban uses in this soil are limited by its slow permeability in the fragipan and by the potential for frost action. This soil is also severely limited for lawn and landscaping use by its wetness. Landscaping is limited to plants that are tolerant of wetness and restricted rooting depths.

Haledon-Urban land-Hasbrouck complex, 0 to 8 percent slopes (HatB)

This unit consists mostly of somewhat poorly drained Haledon soils, areas of Urban land, and poorly drained Hasbrouck soils. The permeability of the Haledon soil is moderate above the fragipan, but slow in the fragipan, with a perched water table at a depth of six to eighteen inches from winter through late spring. Its available water capacity is moderate, runoff is slow, and the erosion hazard is moderate. This soil is very strongly acidic. The permeability of the Hasbrouck soil is moderately slow above the fragipan and very slow in the fragipan, with a perched water table located between the surface and a depth of six inches from fall through early summer. Available water capacity is high, runoff is ponded, and the hazard of erosion is slight. The Haledon-Urban land-Hasbrouck Complex is located in extensively developed areas used for residential, commercial, and industrial purposes. Open portions of this unit are used as lawns or parks. The perched water table above the fragipan, ponding of surface water, and rare flooding severe limit this unit's urban use. Drainage measures are needed to protect structures against damage; perennial plants tolerant of wetness have the best landscaping results.

Hasbrouck silt loam, 0 to 3 percent slopes (HctA)

This soil is nearly level and poorly drained. It is located in depressions and level areas with undulating glacial *till* areas. Its permeability is moderately slow above the fragipan and very slow in the fragipan, and a perched water table is located between the surface and a depth of six inches from fall through early summer. Available water capacity is high, runoff is ponded, and the erosion hazard is slight. Most areas of this soil are wooded. Trees commonly found in this soil include red maple, sweetgum, pin oak, and tulip tree. This soil is severely limited for urban use by its slow permeability, perched water table, frost action potential, and its flooding and ponding hazard. This soil is also severely limited for lawn and landscaping by wetness and runoff from surrounding areas.

Parsippany-Urban land complex, 0 to 3 percent slopes (Pbs)

This unit consists mostly of poorly drained Parsippany soils and areas of Urban land. The permeability of the Parsippany soil is slow and its available water capacity is high. The erosion hazard is slight and runoff is ponded. A water table is located between the surface and a depth of twelve inches from fall through early summer. This soil is very strongly acid near the surface and slightly acid in the subsoil. The Parsippany-Urban land complex is located in extensively developed areas used for residential, commercial, and industrial purposes. Open portions of this unit are used as lawns, wooded areas, or parks. Because of its high silt and clay content, this unit has poor workability, low stability, and poor compaction characteristics, especially when wet. Landscaping in this unit is limited to plants that are tolerant of wetness.

Passaic silt loam (Pcs)

This soil is nearly level and poorly drained. The permeability of this soil is slow in the surface layer and subsoil and rapid in the substratum. A water table is located between the surface and a depth of twelve inches from fall through spring, and available water capacity is high. The erosion hazard is slight and runoff is ponded. This soil is severely limited for urban use by the high water table, slow permeability, and the potential for flooding. Landscaping in this soil is limited to plants that are tolerant of wetness and restricted rooting depth.

Raritan silt loam, 0 to 3 percent slopes (RarA)

This soil is nearly level and somewhat poorly drained. It is located on low-stream terraces and in areas where glacial till grades into outwash areas. Its permeability is moderately slow in the lower part of the subsoil and rapid in the substratum. A perched water table is located at a depth of between six inches and thirty-six inches from fall through early spring and its available water capacity is moderate. The erosion hazard is slight, runoff is slow, and the soil is slightly to moderately acidic. Trees commonly found in this soil include sweetgum, red maple, and oak. This soil is severely limited for urban use by the high water table, moderately slow permeability, and potential for flooding near streams. Landscaping in this soil is limited to plants that are tolerant of wetness.

Udifluvents, frequently flooded (Ucd)

This floodplain soil is moderately well to somewhat poorly drained and is, in most areas, nearly level. Located primarily in areas of the Elizabeth River system, it is mapped in two sections of Cranford: along the Rahway River between South Avenue and approximately Elm Street; and along the Rahway River between the CSX/NS Lehigh Line and the Garden State Parkway. This soil's permeability is moderate to rapid. A water table is located at a depth of between six inches and forty-eight inches. Some filling of this soil has taken place and dikes have been erected, further altering drainage patterns. Commonly used as parkland, this soil has not been extensively developed because of the hazard of flooding and the probability of severe flood damage.

Udorthents, loamy (Udh)

This unit consists of areas that have been cut or filled during grading or other site preparation work for residential development, roadways, or recreational areas. Cuts make up the steep portions of the unit, while fill areas are generally nearly level or gently sloping. The characteristics of this soil are so variable that site-specific investigations are required to determine any potential limitations.

Udorthents, waste substratum (Udz)

This unit consists of areas that have been used for the disposal of debris containing brick, glass, cement, wood, wire, asphalt, plastic containers, cans, and other objects. In Cranford, this unit is mapped at the site of the Conservation Center on Birchwood Avenue. This unit has poor potential for building purposes, as a result of the underlying refuse, which often generates gas. This unit is also subject to subsidence (i.e., sinking to a lower level) as organic materials decay. Because the characteristics of this unit are so variable, any development requires careful on-site investigation.

Urban land (Ur)

This unit is nearly level or gently sloping and consists of areas where more than ninety percent of the surface is covered by impervious surfaces, such as asphalt, concrete, or structures. The remaining ten percent of this unit is so variable that site-specific investigations are required to determine any limitations for development purposes.

VII. HYDROLOGY

VII. HYDROLOGY

INTRODUCTION

Hydrology is the science of the properties, distribution, and circulation of water. As seen from space, one of the Earth's most salient features is the water, in both liquid and frozen forms, that covers approximately 75 percent of the surface of the planet. Believed to have initially arrived on the surface through the emissions of ancient volcanoes, geologic evidence suggests that large amounts of water have likely flowed on Earth for the past 3.8 billion years, which is most of its existence. As a vital substance that sets the Earth apart from the rest of the planets in our solar system, water is a necessary ingredient for the development and nourishment of life.

Water is everywhere on Earth and is the only known substance that can naturally exist as a gas, liquid, and solid within the relatively small range of air temperatures and pressures found at the Earth's surface. The Earth's total water content is about 1.39 billion cubic kilometers (331.5 million cubic miles). The vast bulk of it, about 96.5 percent, is contained in the oceans. Approximately 1.7 percent is stored in the polar icecaps, glaciers, and permanent snow. Another 1.7 percent is stored in groundwater, lakes, rivers, streams, and soil. Finally, a thousandth of one percent exists as water vapor in the Earth's atmosphere (Table 6).

Accurate estimates of groundwater are particularly difficult to obtain and vary widely among sources, with the value shown in Table 6 being near the high end of the range. Using the values in the table, groundwater constitutes approximately 30 percent of fresh water, whereas ice (including ice caps, glaciers, permanent snow, ground ice, and permafrost) constitutes approximately 70 percent of fresh water. Other estimates give groundwater as 22 percent and ice as 78 percent of fresh water.

The *hydrologic cycle* describes the pilgrimage of water as water molecules make their way from the Earth's surface to the atmosphere and back again. This gigantic system, powered by energy from the sun, is a continuous exchange of moisture between the oceans, the atmosphere, and the land (Figure 5).

TABLE 7
ESTIMATED GLOBAL WATER DISTRIBUTION

	Volume (1,000 km^3)	**Percent of Total Water**	**Percent of Fresh Water**
Oceans, seas, and bays	1,338,000	96.5	-
Ice caps, glaciers, and permanent snow	24,064	1.74	68.7
Groundwater	23,400	1.7	-
Fresh	(10,530)	(0.76)	30.1
Saline	(12,870)	(0.94)	-
Soil moisture	16.5	0.001	0.05
Ground ice and permafrost	300	0.022	0.86
Lakes	176.4	0.013	-
Fresh	(91.0)	(0.007)	.26
Saline	(85.4)	(0.006)	-
Atmosphere	12.9	0.001	0.04
Swamp water	11.47	0.0008	0.03
Rivers	2.12	0.0002	0.006
Biological water	1.12	0.0001	0.003
Total	1,385,984	100.0	100.0

Source: Gleick, P. H., *Encyclopedia of Climate and Weather*. Vol. 2, pp. 817-823.

Studies have revealed that the oceans, seas, and other bodies of water (lakes, rivers, and streams) provide nearly 90 percent of the moisture in our atmosphere. Liquid water leaves these sources as a result of *evaporation*, the process by which water changes from a liquid to a gas. In addition, a very small portion of water vapor enters the atmosphere through *sublimation*, the process by which water changes from a solid (ice or snow) to a gas. (The gradual shrinking of a snow bank, even though the temperature remains below freezing, results from sublimation.) The remaining 10 percent of the moisture found in the atmosphere is released by plants through *transpiration*. Plants take in water through their root systems to

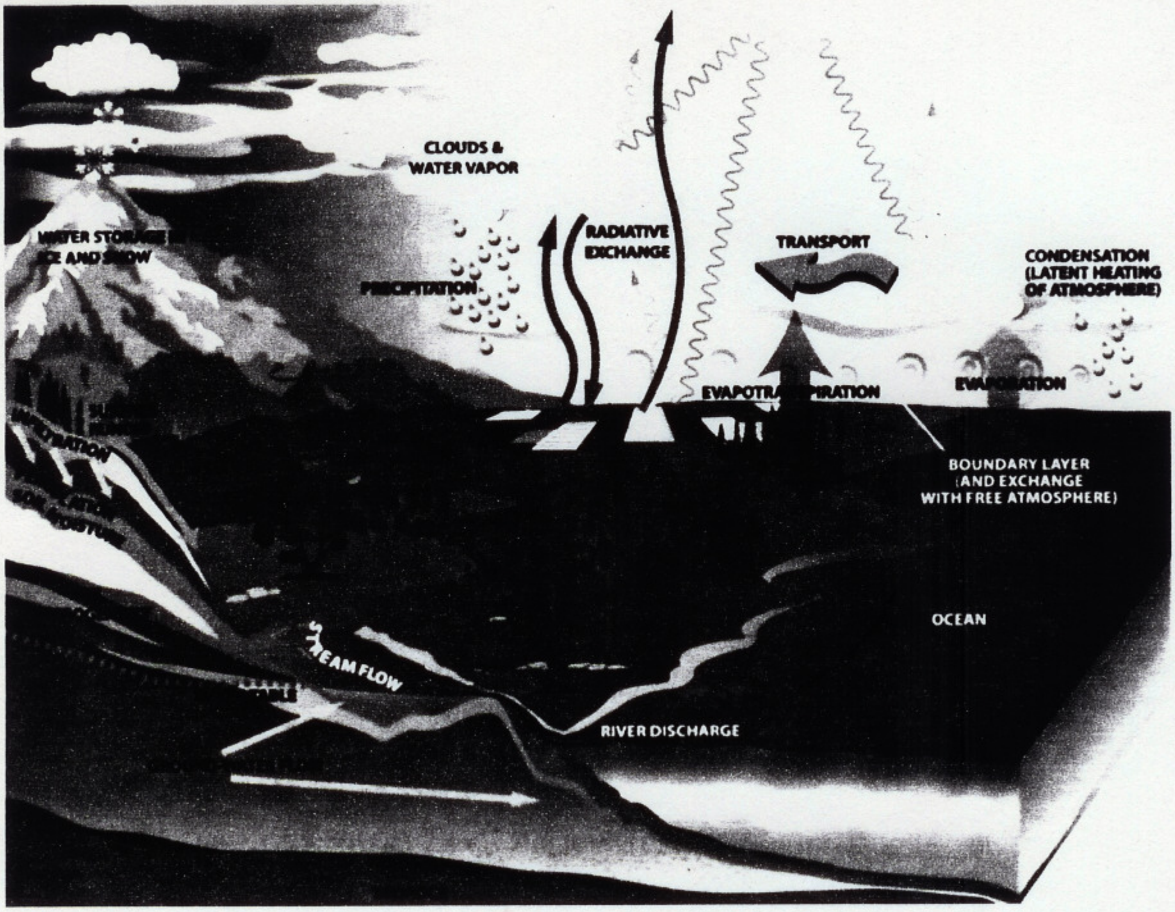

Figure 5. In the hydrologic cycle, individual water molecules travel between the oceans, water vapor in the atmosphere, water and ice on the land, and underground water (USGS).

deliver nutrients to their leaves, then release it through small pores found on the undersides of their leaves. Together, evaporation, sublimation, and transpiration, plus volcanic emissions, account for all the water vapor in the Earth's atmosphere. Evaporation from the oceans is the primary vehicle for driving the surface-to-atmosphere portion of the hydrologic cycle. Transpiration is also a significant process. For example, a cornfield one acre in size can transpire as much as 4,000 gallons of water every day

After the water enters the lower atmosphere, rising air currents carry it upward, often high into the atmosphere, where air is cooler and has a lower capacity to support water vapor. As a result, excess water vapor condenses (i.e., changes from a gas to a liquid) to form cloud droplets, which can eventually grow and produce precipitation (rain, snow, sleet, freezing rain, and hail), the primary mechanism for transporting water from the atmosphere back to the Earth's surface.

When precipitation falls over the land's surface, it follows various routes. Some of it evaporates, returning to the atmosphere, and some seeps into the ground, as soil moisture or *groundwater*. Groundwater is found in two layers of the soil: the *zone of aeration*, where gaps in the soil are filled with both air and water, and, further down, the *zone of saturation*, where the gaps are completely filled with water. The boundary between the two zones is known as the *water table*, which rises or falls as the amount of groundwater increases or decreases (Figure 6). The rest of the water runs off into rivers and streams. Almost all of it eventually flows into the oceans or other bodies of water, where the hydrologic cycle begins anew (or, more accurately, continues). At different stages of this cycle, some water is temporarily intercepted by humans or other life forms.

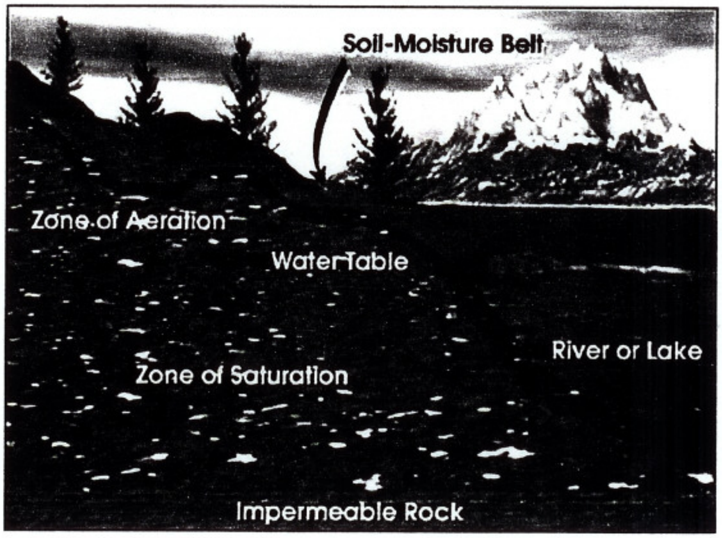

Figure 6. The water table is the top of the zone of saturation and intersects the land surface at lakes and streams. Above the water table lie the zone of aeration and the soil moisture belt, which supply much of the water needed by plants (NASA).

Even though the amount of water in the atmosphere is only 3,095 cubic miles (a minute fraction of Earth's total water supply which, if completely rained out, would cover the Earth's surface to a depth of only 0.98 inches), some 118,750 cubic miles of water are cycled through the atmosphere every year. This would be enough to cover the Earth's surface uniformly to a depth of thirty-eight inches. Water continually evaporates, condenses, and precipitates. Evaporation on a global basis approximately equals global precipitation. So, the total amount of water vapor in the atmosphere remains approximately the same over time.

However, over the continents, precipitation routinely exceeds evaporation, and conversely, over the oceans, evaporation exceeds precipitation. In the case of oceans, excess evaporation would eventually leave them empty if they were not replenished by additional means. Not only are they being replenished, largely through runoff from land, but, over the past 100 years, they have been over-replenished, with sea level around the globe rising by a small amount. Sea level rises because of the ocean warming, causing water expansion and increased volume, and because of a greater mass of water entering the ocean than the amount leaving through evaporation or other means. A primary cause for an increased mass of water entering the ocean is the calving or melting of land ice (ice sheets and glaciers).

Throughout the hydrologic cycle, there are an endless number of paths that a water molecule might follow. Water at the bottom of the Mississippi River may eventually fall as rain in Cranford. Runoff from rain in Cranford may drain into the Rahway River and, ultimately the Atlantic Ocean, and circulate northeastward toward Iceland, destined to become part of a floe of sea ice, or, after evaporation, to the atmosphere and precipitation as snow, part of a glacier. Water molecules can take an immense variety of routes and branching trails that will lead them repeatedly through the three phases of ice, liquid water, and water vapor. For instance, water molecules that once fell 100 years ago as rain on a Nebraska farmhouse might now be falling as snow on a Cranford driveway.

GROUNDWATER

All of the groundwater in Cranford originates from precipitation, which in the Cranford area averages 46.25 inches annually. As precipitation infiltrates into the ground, it becomes stored in rock or *sediment*, the amount depending upon the rock's *porosity* (a measure of the volume of air-and-water-filled pores in a rock) and *permeability* (a rock's ability to transmit fluids).

Areas of rock strata or sediment that allow groundwater to move freely are called *aquifers*. The Passaic Formation is the major aquifer underlying not only Cranford, but most of Union County as well. Water in this formation occurs in joints and fractures, which become progressively tighter and decrease in number with increasing depth. In the Passaic Formation, groundwater occurs under both unconfined and confined conditions. Unconfined groundwater occurs mainly in upland areas where overlying unconsolidated sediments are thin or absent. In the lowlands of eastern Union County, rocks are mantled by unconsolidated Pleistocene deposits that, in most places, contain silt and clay beds, which confine water in the underlying rocks. Whenever such confinement occurs, water beneath the impermeable layers is under *artesian* pressure. When the artesian's head is above the land surface, a flowing well results.

SURFACE WATER

Surface water in Cranford includes the Rahway River, its floodplain and tributaries, as well as wetlands. Cranford lies within the Arthur Kill Watershed (Watershed Management Area No. 7), as shown in Figure 7. A *watershed* is the area of land where all of the water that is under it or drains off it goes into the same place. 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. Watershed Management Area No. 7 is one of twenty in the State.

Measured from its headwaters in South Orange to the City of Rahway, the Rahway River drains an area of forty-one square miles, which includes parts of Middlesex, Union and Essex Counties. The main stem of the river is approximately twenty-four miles long and flows from Union Township to the Arthur Kill in Linden; it is tidal from the Amtrak railroad bridge in Rahway to the Arthur Kill. The river's major impoundments include the Middlesex Reservoir, the Orange Reservoir, the Lower and Upper Echo Lakes, and Diamond Mill Pond.

Refer to Map 6 in Appendix A to view the surface hydrology in Cranford.

WATER QUALITY

The goals for surface-water-quality protection are derived from the Federal Clean Water Act: surface waters should be fishable, swimmable, and potable (after conventional treatment). These goals have been translated into New Jersey's *Surface Water Quality Standards* (N.J.A.C. 7:9B), which establish the goals and policies underlying the management of the state's water quality. The Surface Water Quality Standards (SWQS) designate the use or uses of water and also establish policies and criteria necessary to protect these uses. The Rahway River is classified as FW2-NT (freshwater, nontrout). Designated uses in all FW2 waters include: maintenance, migration, and propagation of the natural and established biota (i.e., fishable); primary and secondary contact recreation (i.e., swimmable); industrial and agricultural water supply; and public potable water supply after such treatment as required by law or regulation (i.e., potable).

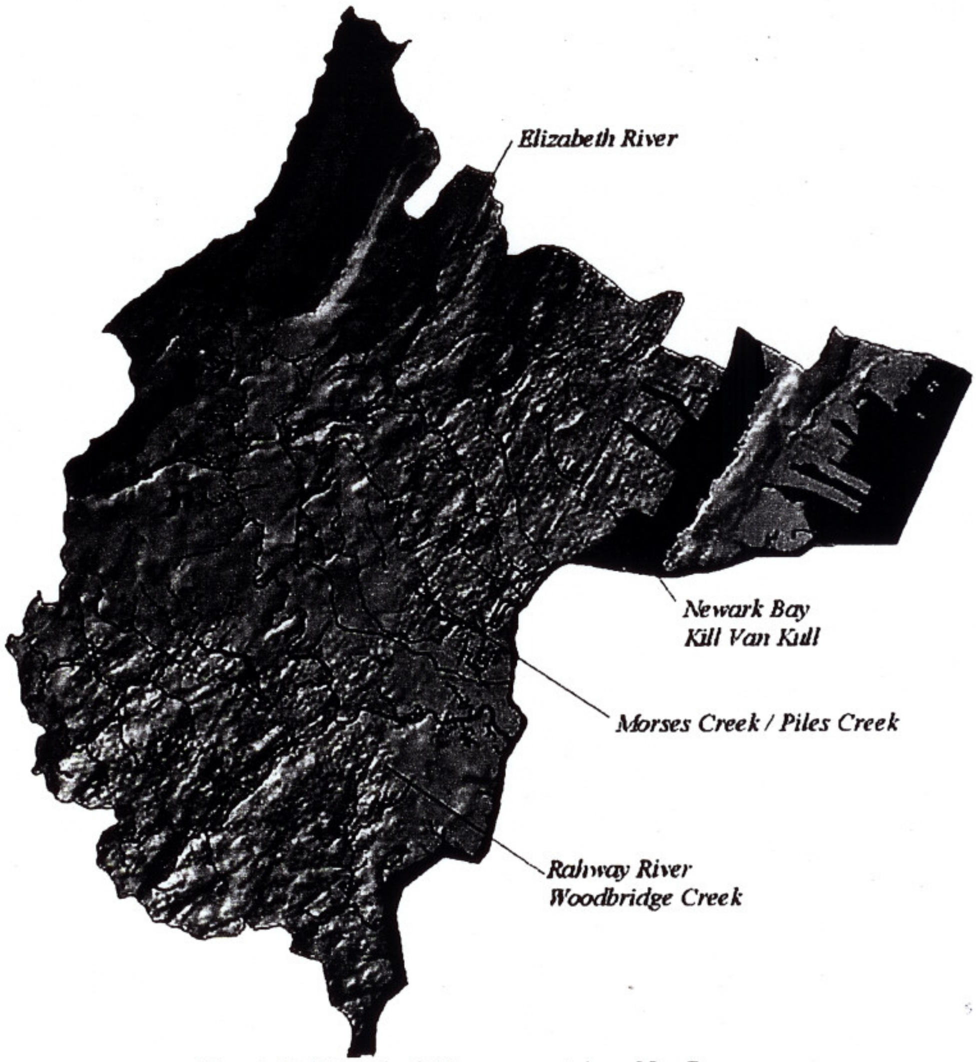

Figure 7: Watershed Management Area No. 7

The State's *Integrated Water Quality Monitoring and Assessment Report* contains assessments of water quality throughout the state. It is used by Congress and the United States Environmental Protection Agency (U.S. EPA) to establish program priorities and funding for federal and state water-resources-management programs. Approximately 430 monitoring stations on 2,308 river miles were assessed for at least one of the following enforce a maximum temperature limit. The Springfield monitoring station did not exceed the SWQS for temperature in 2002.

Fecal Coliform

Fecal coliform bacteria levels in water provide an indication of pollution from human or animal fecal material, which may contain organisms that are harmful to human health. With compliance of permit limits for fecal coliform at wastewater treatment plants high and incidence of treatment plant failures low, it is suspected that most fecal coliform pollution in freshwater rivers is derived from animal wastes. Fecal coliform pollution is suspected to occur primarily from domestic pets, livestock, and wild animal wastes that are transported to rivers and streams by stormwater, overland runoff, and direct contact with water. Although Canada geese population data are not available, significant populations of these birds occur in and around many New Jersey waterways, including the Rahway River in Cranford. In developed areas of the State, domestic pet and bird wastes (e.g., pigeons) contribute to fecal coliform in stormwater. In agricultural areas of the State, manure piles and livestock access to streams can contribute to fecal coliform pollution. The Springfield monitoring station exceeded the SWQS for fecal coliform in 2002.

Nitrate

All surface waters in the State are designated as drinking water supplies under the SWQS, although only a small portion are presently being used as such. Nitrate is used as an indicator of the quality of drinking water, because it is difficult and expensive to remove from potable supplies. The major sources of nitrate in drinking water are: runoff from fertilizer use, leaching from septic tanks, sewage, and erosion of natural deposits. The SWQS for nitrate is 10,000 mg/l. The Springfield monitoring station did not exceed the SWQS for nitrate in 2002.

Total Suspended Solids

Criteria for total suspended solids (TSS) were established in the SWQS to protect aquatic life from excessive sedimentation. TSS measures sediment particles contained within the water column; specifically those particles that are retained on a 0.45 ųm (micrometer) membrane filter. TSS can consist of silt, sediment, industrial, and municipal waste, and decaying plant and animal matter. It is related to *turbidity*. The SWQS for TSS for nontrout enforce a maximum temperature limit. The Springfield monitoring station did not exceed the SWQS for temperature in 2002.

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Un-ionized Ammonia

Ammonia exists in two forms in water — ionized and un-ionized. Together, both forms are called total ammonia nitrogen. Most ammonia is the ionized form used by phytoplankton and other aquatic plants as a nutrient; however, the un-ionized form is toxic to fish and other aquatic life. The Springfield monitoring station did not exceed the SWQS for un-ionized ammonia in 2002.

Metals

Metals, also referred to as trace elements, are a high priority issue in New Jersey due to the historical and present use of metals in the state and their persistence in the environment. The hazardous impact of metals on human and aquatic life is also well-known and continues to be a concern. The metals assessed in 2002 included arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. The Springfield monitoring station did not exceed the SWQS for metals in 2002.

WETLANDS

Generally, wetlands are lands for which saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands are found from the tundra to the tropics and on every continent except Antarctica. Major factors creating wetlands vary throughout the State, but glaciation has played an important role in most areas. Most of northern New Jersey's wetlands were formed in glacial lakes and depressions during the postglacial period. When the glacier receded, the glacial lakes drained and wetlands formed in the basins. In addition, human activity may also create wetlands by altering hydrologic regimes to flood former upland areas. Wetland plants quickly invade these areas to take advantage of the wetter conditions. Wetlands can also form in floodplains along rivers, which is generally the case in Cranford.

Wetlands naturally store flood waters, thereby reducing flood peaks, slowing water velocity, and regulating flow to downstream areas. They filter pollutants from urban runoff that could otherwise enter aquifers and surface waters that supply drinking water; prevent erosion and filter silt from the water; provide habitat for hundreds of resident and migratory wildlife species; and provide extensive sporting and recreational opportunities, including consumptive and nonconsumptive activities involving fish and wildlife. New Jersey uses the three-parameter approach for wetland delineation (hydrophytic vegetation, hydric soils, and evidence of wetland hydrology), as described in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee for Wetland Delineation, 1989).

In 1994, New Jersey became only the second state in the nation (the other being Michigan) to be delegated regulatory authority over wetlands from the EPA. Both the U.S. EPA and the U.S. Army Corps of Engineers (Corps) regulate wetlands in the other forty-eight states. Activity in New Jersey's wetlands is regulated by the state's Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 et seq.) and the Act's implementing regulations (N.J.A.C. 7:7A).

The State's wetland regulations encourage minimal disturbance of wetlands and promote a *No Net Loss Policy.* To achieve no net loss of wetlands, regulations require compensation whenever more than one acre of wetlands is disturbed. Known as *wetland mitigation*, developers are required to provide two acres of wetlands for each acre disturbed. Mitigation can be provided through wetland creation, restoration, or monetary contributions (purchasing credits at wetland mitigation banks).

The Act also establishes buffer zones, or *Transition Areas*, around wetlands to accommodate slight variations in freshwater wetland boundaries over time due to hydrologic or climatologic effects and to keep human activity at a distance so as not to impact wetland functions. A transition area is determined according to the resource value of the wetland surrounding it: Exceptional, Intermediate, or Ordinary, as defined below:

Exceptional Wetlands - Exceptional Wetlands discharge into FW-1 or FW-2 Trout Production waters and their tributaries. Exceptional Wetlands provide a documented habitat or potential habitat for special-status species and score highly in terms of size, water quality, vegetation density, and/or species diversity. Exceptional Wetlands require a 150-foot transition area.

Intermediate Wetlands – Intermediate Wetlands are not defined as Exceptional or Ordinary and require a 50-foot transition area.

Ordinary Wetlands – Ordinary Wetlands are not defined as Exceptional and are typically isolated, man-made drainage facilities, such as ditches, swales, or detention basins. Ordinary Wetlands do not require a transition area.

The following activities are regulated in freshwater wetlands:

- Removing, excavating, disturbing, or dredging of soil, sand, gravel or aggregate material of any kind;
- Draining or disturbing the water level or water table;
- Dumping, discharging, or filling with any materials;
- Driving of pilings;
- Placing of permanent obstructions, including structures that span, but shade, wetlands; and
- Destroying plant life, which would alter the character of a freshwater wetland, including the cutting of trees.

The following activities are regulated in Transition Areas:

- Excavating or disturbing any soil;
- Discharging fill;
- Erecting any structures;
- Placing any pavement; and
- Destroying plant life, which would alter the existing pattern of vegetation.

The following activities are not regulated in Transition Areas:

- Normal maintenance of property and the creation of new gardens of less than 0.25-acre, including trimming of lawns, shrubs, and trees; limited use of nonnative plantings and the maintenance of serviceable structures and pavements;

- Minor and temporary disturbances necessary for construction, such as erection of scaffolding, debris removal by nonmechanized means, and placement of utility lines under or above existing pavements; and
- Temporary structures of less than 150 square feet in area, including fences and sheds not placed on a foundation, and other structures for a maximum of six months.

Wetlands in Cranford are located primarily in Nomahegan and Lenape Parks and along the Rahway River (see Map 7 in Appendix A).

FLOODPLAINS

Flooding is a natural phenomenon that occurs when the amount of water exceeds the capacity of the channel that must carry it. The water then overflows the defined channel and spreads out within an area called the *floodplain* or flood-hazard area. The limits of the floodplain are delineated by the rising slopes of the surrounding land. The floodplain is actually a normal part of the river during times of exceptional storm discharge. Most of the time, however, the floodplain remains free of water.

The flooding process is complicated and influenced by many factors, the most important of which is the increased development within a watershed. The peak flow from any design storm (i.e., the worst-case scenario) will increase as development increases. Precipitation will normally evaporate directly from vegetation surfaces or it is retained in the natural mulch of a forest floor. Its rate of runoff is usually retarded by natural conditions (with a resulting better opportunity to be absorbed into the ground). It, however, runs off the paved and other impervious surfaces with no absorption into the ground and no time-delay or interception by vegetation. Consequently, a greater volume of water arrives at the receiving stream in a shorter time period, thereby raising the height of a flood event and shortening the time that elapses between the onset of rainfall and the peak flow.

The floodplain comprises two parts — the *floodway* and the *flood fringe*. The floodway is the inner area where floodwaters are deep and fast moving. It always includes the stream bed or lake bed where the water normally flows, and usually extends to the top of the bank (if there is a defined bank) and sometimes beyond. The flood fringe is the outer area where flood waters move more slowly, appearing more still, like a lake or pond. A building located in a floodway will block the water's flow, backing up water and causing flooding upstream to worsen. A building in a flood fringe will prevent floodwaters from spreading out, thus forcing floodwaters downstream faster and increasing downstream flooding.

In New Jersey, development in a floodplain is regulated by the Flood Hazard Area Control Act and its implementing regulations (N.J.A.C. 7:13). Under these regulations, the flood hazard area is divided into two zones--the above-mentioned floodway and the flood fringe. During a flood, the floodway would experience water moving at a high velocity. The water alone could seriously damage any structure located in its path, but when combined with debris swept down from upstream, the effects are extremely hazardous. Any structures or fill placed in the floodway would increase the level of the floodwaters and cause damage in areas previously outside the floodplain. Therefore, construction activity in the floodway is severely limited in order to preserve the floodwater-carrying capacity of the stream. The flood-fringe area would not be subject to the velocities experienced in the floodway, but would be subject to ponding water. Filling in this area would not result in significant rises in the water's elevation upstream, but could, through loss of flood-water storage, cause a significant rise in the flood elevations downstream. Therefore, regulation of construction activity in the flood fringe is less restrictive than in the floodway, but such activity is restricted by the amount of fill that can be placed within its borders. Floodplain boundaries in Cranford are depicted in Map 8 in Appendix A.

Over the past few decades, Cranford has experienced significant flooding problems. According to a report prepared for the Township by Camp Dresser & McKee Inc., these problems are the result of two separate and distinct flooding sources:

1. Regional flood flows in the Rahway River that periodically overtop the Township's levee; and

2. Localized flood flows, particularly in the northeast quadrant of the Township, due to undersized storm drains. This problem worsens when flood elevations in the Rahway River also happen to be high.

In total, 30.8 square miles (or almost 20,000 acres) of the Rahway River watershed drains to the outlet at the Lenape Park detention basin. The Rahway River floods Cranford only when it reaches a height to overtop the dike, which occurred in: 1968, 1971, 1972, 1973, and, most recently, in 1999. The Rahway River overtops the dike only under extremely rare rainfall events. For example, over eight inches of rain fell on the watershed during Hurricane Floyd, which led to the overtopping. Flooding occurs more frequently in the northeast quadrant, sometimes regardless of what is occurring in the Rahway River, because of local undersized storm drains. Storms of only three inches of rain are enough to inundate portions of the northeast quadrant.

VIII. CLIMATIC CONDITIONS

VIII. CLIMATIC CONDITIONS

New Jersey's weather and *climate* offer something for everyone. In a month's time, one might observe record high and low temperatures being broken, tornadoes touching down, severe thunderstorms passing through, and a snowstorm blanketing the region. While rare, all occurred in November of 1989. A single year may bring a serious drought, an inundating flood, extreme heat, numbing cold, a damaging hurricane, and a stinging blizzard. All but the cold and snow were exhibited in 1999. A relatively cool summer, sunny fall, manageable winter, and mild spring also are enjoyed from time to time.

This weather and climate potpourri is a result of New Jersey's middle-latitude location. This geographic positioning results in the State being influenced by wet, dry, hot, and cold air streams, making for four relatively well-defined seasons, and leading to the potential meeting of cold and warm air masses, triggering occasional severe conditions.

The climate of Cranford is typical of the Middle Atlantic seaboard. It may be classified as a modified continental-type climate, because the prevailing westerly winds are altered by air masses originating over the ocean and moving on shore. The moderating effect of the ocean is felt during both the winter and summer seasons. During this period, coastal storms accompanied by easterly winds can produce heavy precipitation, although moderate rainfall more commonly occurs.

A major regional-weather characteristic is instability caused by high-pressure air masses that move in from Canada and conflict with low-pressure air masses moving from the south. This results in periodic cool spells during the summer and periods of relatively warm, spring-like weather in winter.

The storms experienced in Cranford are classified into four general groups: thunderstorms, cyclonic or transcontinental storms, extratropical storms, and hurricanes.

Thunderstorms normally occur with the most frequency in the months of July and August. They are usually of brief duration and are limited in area. These storms, when intense, can cause local flooding in areas of the Township where storm sewers are not of sufficient size to accommodate the resulting surge flows. The path of these storms is generally in a northeasterly direction.

During autumn, winter, and spring, cyclonic storms predominate. These storms are due to movements of transcontinental air masses with attendant high and low pressure areas. Intense storms of this type produce potent floods over large areas because of their wide range. These storms can cluster together and last for many days, depositing four, five, or more inches of precipitation. The duration of these storms, coupled with the continuous rainfall, can cause the Rahway River to rise above the storm-sewer-encroachment elevation near the end of the storm event. This slows storm-sewer drainage and causes street flooding. In extreme cases, the Rahway River rises so high that river water will enter the street, causing flooding that will linger until the river recedes below the storm-sewer-encroachment elevation.

Extratropical storms are due to the rapidly convective circulation that results when tropical marine air masses are lifted suddenly on contact with hills and mountains. They usually cause heavy rain in the summer and the autumn.

A hurricane is defined as an intense tropical low-pressure system, with a well-defined circulation and maximum sustained wind speeds of 74 miles per hour (m.p.h.) or greater. Because of its size and duration, a fully developed hurricane is the most destructive storm. Hurricanes only form in certain areas of the earth at specific times of the year. Those affecting the United States form in the eastern Atlantic Ocean, near the Cape Verde Islands, and in the western Caribbean Sea. Hurricane season runs from June 1 to November 30.

METEOROLOGICAL DATA

There are no official meteorological stations located in Cranford. The station on the grounds of Union County College (located at 40°39' North Latitude, 74° 18' West Longitude) is a National Weather Service Cooperative Observing Station. The station's personnel manually take and manually record singular daily temperature and precipitation data. Since it has been in existence for about thirty years, it does not have the long record of observations needed to assess the magnitude of recent events. Observations from Newark are adequate surrogates for Cranford; they are the only local observations for variables other than precipitation and temperature. All variables are automatically recorded instantaneously or hourly, depending upon the parameter, and are electronically entered into the climatic database. The Newark weather station is located at Newark Liberty International Airport, (located at 40° 42' North Latitude, 74° 10' West Longitude). This station measures and keeps records on various weather-related phenomena, such as temperature, barometric pressure, relative humidity, wind, and cloud cover. Summaries of each are presented below:

Temperature

In the last ten-year period, the mean annual temperature at the Newark station decreased from 54.8 degrees to 54.5 degrees Fahrenheit. The coldest month was January, with an average temperature of 31.3 degrees, an increase from 30.6 degrees Fahrenheit in the last ten years. July was the hottest month of the year with an average temperature of 77.2 degrees, which is a decrease from 77.8 degrees Fahrenheit ten years ago (see Table 9a). Temperature readings of above 90 degrees and below zero degrees Fahrenheit are not unusual occurrences. The record high of 105 degrees Fahrenheit was first set in September of 1953 and was equaled during July of 1993 and August 2002. The record low temperature of -8 degrees Fahrenheit was set in January of 1985. The average annual heating-degree days decreased in the past ten years from 4,888 to 4,812 days. The average annual cooling-degree days increased over the past ten-year period from 1,201 to 1,242 days (see Table 9b).

Barometric Pressure

Barometric pressure averaged 1,016.3 millibars annually, with monthly averages ranging from 1,012.9 to 1,019.3 millibars (see Table 10a).

Relative Humidity

Depending upon the time of day, the average annual relative humidity ranged between 53 and 73 percent (see Table 10b).

Precipitation

An average of 46.25 inches of rain fell annually at the Newark station. Normally, this rainfall was distributed evenly throughout the year, with average monthly rainfall ranging from 2.96 to 4.68 inches.

The minimum monthly rainfall was recorded in June of 1949 at 0.07 inches. The maximum rainfall that occurred in a twenty-four-hour period occurred in August of 1971 and amounted to7.84 inches. Rainfall of 0.01 inches or more occurred on an average of 121.3 days annually and ranged from 7.8 to 11.8 days per month. Precipitation data are summarized in Table 11a.

The abundant precipitation in the Cranford area has made groundwater recharge adequate and has helped the area's vegetative-ground cover and tree population to retain water temporarily and minimize erosion.

Precipitation during the winter months often falls in the form of snow, sleet, or ice pellets (see Table 11b). The average annual snowfall in Cranford is approximately 25.9 inches. The monthly maximum of snow for the area had been 29.1 inches, which was recorded in December of 1947. A portion of this amount (26.0 inches) was the result of a record 24-hour snowfall. Since then, however, a new record was set when Newark Airport recorded 33.4 inches of snow in February of 1994. Newark Airport also recorded 31.6 inches of snow in January of 1996, 27.8 inches of which were attributable to the blizzard that occurred on January 7 and 8, 1996. Snow can be expected to fall from October to May. The average monthly snowfall at the Newark station is shown below in Table 8.

TABLE 8

AVERAGE MONTHLY SNOWFALL, ICE PELLETS, SLEET, AND HAIL (Inches)

Month	Snowfall (Inches)
September	0.0
October	Trace
November	0.6
December	2.9
January	8.9
February	8.4
March	4.3
April	0.8
May	Trace
Annual	25.9

Source: National Climatic Data Center, 2003

Snowfall of one inch or more occurred on an average of 6.6 days annually and occurred in a range from zero to 2.4 days per month.

TABLE 9a

TEMPERATURE IN DEGREES FAHRENHEIT

Month	Normal Daily Maximum	Normal Daily Minimum	Monthly Average	Record High	Record Low
January	38.1	24.4	31.3	74	-8
February	41.1	26.6	33.8	76	-7
March	50.1	34.2	42.2	89	6
April	60.8	43.7	52.3	97	16
May	71.4	54.1	62.7	99	33
June	80.2	63.5	71.9	102	43
July	85.2	68.1	77.2	105	52
August	83.2	67.7	75.5	105	45
September	75.7	59.9	67.8	105	35
October	64.7	48.2	56.4	92	28
November	53.7	39.1	46.4	85	15
December	43.0	29.8	36.4	76	-1
Annual	62.3	46.7	54.5	105	-8

TABLE 9b
NORMAL DEGREE DAYS

Month	Heating	Cooling
January	1030	0
February	869	0
March	697	2
April	371	10
May	120	70
June	13	240
July	1	403
August	2	350
September	41	146
October	264	19
November	541	2
December	863	0
Annual	4812	1242

Source: National Climatic Data Center, 2003

TABLE 10a

MONTHLY NORMAL BAROMETRIC PRESSURE

Month	Barometric Pressure (millibars)
January	1016.3
February	1016.3
March	1015.9
April	1012.9
May	1015.6
June	1012.9
July	1015.9
August	1015.9
September	1015.9
October	1019.3
November	1018.6
December	1019.0
Annual	1016.3

TABLE 10b

MONTHLY NORMAL PERCENT RELATIVE HUMIDITY

Month	1:00 AM	7:00 AM	1:00 PM	7:00 PM
January	70	73	58	63
February	68	72	55	60
March	66	69	50	56
April	65	66	47	54
May	71	70	50	58
June	72	70	51	58
July	73	72	51	58
August	75	75	53	62
September	77	78	54	64
October	75	78	52	63
November	72	76	56	64
December	71	74	58	64
Annual	71	73	53	60

Source: National Climatic Data Center, 2003

TABLE 11a

Monthly Average of Normal, Maximum, and Minimum Precipitation (Inches)

Month (days)	Normal	Maximum	Minimum	Daily Maximum
January (11)	3.98	10.10	0.45	3.59
February (10)	2.96	4.94	0.52	2.45
March (11)	4.21	11.14	1.10	2.83
April (11)	3.92	11.14	0.90	3.73
May (12)	4.46	10.22	0.52	4.22
June (10)	3.40	6.40	0.07	2.97
July (10)	4.68	9.98	0.89	4.64
August (9)	4.02	11.84	0.36	7.84
September (8)	4.01	10.28	0.95	6.41
October (8)	3.16	8.20	0.21	4.04
November (10)	3.88	11.53	0.51	7.22
December (11)	3.57	9.47	0.27	2.77
Annual (122)	46.25	11.84	0.07	7.84

TABLE 11b

Monthly Maximum and Daily Maximum of Snow, Ice Pellets, and Hail (Inches)

Month	Maximum	Daily Maximum
January	31.6	27.4
February	33.4	20.0
March	26.0	17.6
April	13.8	12.8
May	Trace	Trace
June	Trace	Trace
July	0.0	0.0
August	Trace	Trace
September	Trace	Trace
October	0.3	0.3
November	5.7	5.7
December	29.1	26.0
Annual	33.4	27.4

Source: National Climatic Data Center, 2003

Wind

The normal prevailing wind direction is generally from the west. The average monthly wind velocity ranged from 8.8 m.p.h. to 11.9 m.p.h., with an annual average of 10.2 m.p.h. The maximum five-second speed recorded at the Newark station was 76 m.p.h. Average and peak wind data are presented in Table 13.

Cloud Cover

The mean annual amount of cloud cover (i.e., portion of the sky covered by clouds) was 62 percent. There is no data for the amount of cloud cover between sunset and sunrise. The following data in Table 12a are a list of daytime cloud cover only:

TABLE 12a

AVERAGE DAYTIME CLOUD COVER

Month	Average Cloud Cover (Percent)
January	65
February	64
March	63
April	64
May	65
June	62
July	62
August	60
September	57
October	55
November	64
December	64
Annual	62

TABLE 12b

AVERAGE NUMBER OF CLEAR, CLOUDY, AND PARTLY CLOUDY DAYS

Month	Clear Days	Partly Cloudy Days	Cloudy Days
January	8	8	16
February	7	8	13
March	8	8	15
April	7	9	14
May	6	11	14
June	7	11	12
July	7	12	12
August	8	12	12
September	10	9	12
October	11	8	12
November	8	8	14
December	8	8	15
Annual	93	112	160

TABLE 13

AVERAGE AND PEAK WIND DATA

Month	Normal Average Speed (mph)	Normal Prevailing Direction	Maximum Two-minute Speed (mph)	Direction	Maximum Five-second Speed (mph)	Direction
January	11.0	WSW	44	W	54	W
February	11.3	WNW	44	W	56	W
March	11.9	WNW	45	WNW	59	WNW
April	11.3	NNW	55	W	76	W
May	10.0	SW	44	WNW	56	WNW
June	9.6	SW	34	WNW	58	NW
July	9.0	SW	47	WNW	59	NW
August	8.8	SW	44	WNW	53	WNW
September	9.1	SW	44	NNE	55	NNW
October	9.5	SW	34	NW	47	NNW
November	10.2	SW	40	NW	53	SSE
December	10.6	WSW	48	W	62	W
Annual	10.2	SW	55	W	76	W

Source: National Climatic Data Center, 2003

Cranford has a wide variety of weather styles which contribute to distinct seasonal differences. These include rainfall, snowfall, thunderstorms, hailstorms, and windstorms and are generally neither extreme nor severe. Table 14 below presents a listing of the average duration of the distinct weather types by month.

TABLE 14

Mean Number of Varying Weather Days

Month	Rainfall (a)	Snowfall (b)	Thunder-storms	Heavy Fog (c)	Clear (d)	Partly Cloudy (d)	Cloudy (d)
January	10.8	2.4	0.3	2.1	7.7	7.7	15.7
February	9.7	1.9	0.3	1.7	7.3	7.6	13.4
March	11.3	1.1	1.1	1.4	8.0	8.4	14.6
April	11.1	0.2	1.6	1.1	7.2	8.9	14.0
May	11.8	0.0	3.6	1.6	6.3	10.6	14.1
June	10.3	0.0	4.9	1.1	6.7	10.9	12.4
July	9.8	0.0	5.8	0.4	6.5	12.2	12.3
August	9.2	0.0	4.5	0.5	7.7	11.7	11.6
September	8.1	0.0	2.4	0.8	9.5	8.9	11.6
October	7.8	0.0	1.1	1.9	10.8	8.4	11.8
November	10.5	0.2	0.5	1.7	7.5	8.2	14.3
December	10.9	0.8	0.2	1.7	7.9	8.0	15.1
Annual	121.3	6.6	26.3	16.0	93.1	111.5	160.9

Notes:

a - 0.01 inches or more.
b - 1.0 inches or more of snow, ice pellets, sleet, and hail.
c - 0.25 mile or less visibility.
d - sunrise to sunset.

Source: National Climatic Data Center, 2003

IX. VEGETATION

IX. VEGETATION

INTRODUCTION

Vegetation is defined as the total plant cover of a region. It comprises different species of plants that grow together.

Vegetation interacts with the other four components of the ecosystem (climate, geology and soil, animals, and people) and is affected by each in a different way. *Climatic factors,* such as precipitation, temperature, wind, and light, impact vegetation in obvious ways.

Geologic processes over millions of years have defined the physical relief of the land which, in turn, impacts vegetation because of its influence on drainage and exposure. Geologic processes also produce the earth's soil, the medium through which vegetation receives nourishment. Soil types differ greatly in their ability to hold water, in their supply of mineral elements, and in their acidity. Each vegetative species has a specific range of both need for and tolerance of these soil characteristics.

The interaction between animals and vegetation can be both beneficial and harmful, and is usually obvious to even the casual observer. Beneficial effects result from the numerous organisms that live in the soil and improve soil quality (e.g., earthworms and bacteria), from birds and insects that are necessary for plant reproduction through pollination and fertilization, and from various animals, such as squirrels and birds that play a vital role in seed transport. Harmful effects include defoliation from animals, such as deer, and the damage that results from insects, such as the gypsy moth or the parasite carried by the elm bark beetle.

Human activity has had the most profound impact upon vegetation. People are both directly and indirectly dependent upon vegetation for food, air quality, water quality, climatic conditions, and many types of clothing. In addition, society's development tendencies result in construction activity that usually clears the landscape of most vegetation and introduces many non-native species through landscaping. Finally, indiscriminate use of pesticides and other chemicals has caused irreparable damage to vegetation in some areas.

VEGETATIVE COMMUNITIES

Based on combinations of environmental factors, such as soil moisture, temperature, water salinity, and peat substrates, the natural land area of New Jersey can be divided into eight major types of plant habitats (Collins and Anderson, 1994). In terms of terrestrial plant habitat, Cranford is located in Type 2 and Type 3 of the Collins and Anderson system, a classification system commonly used by biologists.

Type 2, North Jersey uplands, includes slopes, valleys, and ravines of the Ridge and Valley sections as well as the flats of the Piedmont physiographic province (see Chapter V). There are four different types of plant communities in North Jersey upland areas: successional vegetation, the Mixed Oak forest, the Hemlock-Mixed Hardwoods forest, and the Sugar Maple-Mixed Hardwoods forest. In Cranford, Type 2 habitat is only represented by successional vegetation and the Mixed Oak forest. Type 3, North Jersey freshwater wetlands, occurs in the broad valleys of the larger rivers. In Cranford, Type 3 habitat is found along the floodplain and associated wetlands of the Rahway River. Red maple, American elm, pin oak, swamp white oak, silver maple, sour gum*, and sycamore are the most common trees in Type 3 areas. Typical shrubs include the spicebush, witch hazel, and arrowwood. Common herbs include skunk cabbage, jack-in-the-pulpit, trout lilies, and marsh marigold. Vines include poison ivy, Virginia creeper, Japanese honeysuckle, bittersweet, and wild grape (see Table 15).

Successional Vegetation

Plant succession is a directional, cumulative change in the species that occupy a given area through time (between one and 500 years). If significant changes in species composition for a given area do not occur within this time span, the community is said to be a mature or *climax community*. If a community does exhibit some directional, cumulative, nonrandom change during this time span, it is called a *successional* or *seral community*. Seral communities or species will replace one another until a climax community is achieved. The entire progression of seral stages, from the first one to occupy bare ground (the pioneer community) to the climax community, is called a succession or sere. The most common

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* The tree *Nyssa sylvatica* is known by a number of names: sour gum, black gum, pepperidge, black tupelo, and swamp black gum. Source: Ombrello, 1997

TABLE 15

Vegetation Common to North Jersey Swamp and Floodplain Habitats

Community <u>*Structure*</u>	*Plant* <u>*Species*</u>
Typical trees	Pin oak Red maple White ash American elm Swamp white oak Sour gum Silver maple Also on floodplains Willow Sycamore
Typical Shrubs	Spicebush Witch hazel Arrowwood Others
Typical Herbs	Skunk cabbage Spring herbs Sedges & mosses

Source: Collins and Anderson, 1994

TABLE 16

Vegetation Common to Upland Habitats of North Jersey

Community Structure	*Forest Types Grown on Undisturbed Uplands*			*Successional Upland Communities*
	Mixed Oak	*Sugar Maple-Mixed Hardwoods*	*Hemlock--Mixed Hardwoods*	*Plant Species*
Tree dominants	Red oak White oak Black oak	Sugar maple	Eastern hemlock	*Annual herbs* Ragweed Foxtail Wintercress
Other typical trees	Chestnut oak Scarlet oak Hickories Red maple Sugar maple White ash American beech Tulip tree Others	White oak Red oak Black oak Black birch Yellow birch Red maple American beech Basswood Tulip tree Many others	Black birch Yellow birch Sugar maple Red maple American beech Red oak Black oak Basswood Few others	Large crabgrass Many others *Perennial herbs* Goldenrod Canada thistle Kentucky bluegrass Many others *Dominant trees* Gray birch
Tree understory	Dogwood (dominant) Sassafras Hop hornbeam Ironwood	Hop hornbeam Dogwood Ironwood Sassafras	Few	Black cherry Big-toothed aspen Red cedar Few others
Shrubs	Viburnums Spicebush Others	Viburnums Spicebush Many others	Few	*Shrubs* Sumac Multiflora rose Allegheny blackberry
Herbs	Many spring & fall herbs	Many spring & fall herbs	Few Partridge berry & Mosses	Black raspberry Few others

Source: Collins and Anderson, 1994

reason for vegetational succession is human intervention. Land that was formerly cultivated or otherwise developed is abandoned and left untouched, and, over time, a series of different plant communities occupy the site, culminating in a mature forest. Table 16 illustrates some of the plant species typical of successional upland communities. Several vacant lots along both North and South Avenues are local examples of the initial stages of vegetational succession.

The Mixed Oak Forest

The Mixed Oak forest gets its name from three species that in varying mixtures are most abundant among the large trees that form the forest canopy at heights from about sixty to 100 feet. The three are the red oak, white oak, and black oak (see Table 15). Other typical trees include chestnut and scarlet oaks, several types of hickories, maples, sour gum, and tulip tree. A striking feature of these forests is a lack of a well-developed younger generation of oak trees to replace the older trees in the future. Instead, red maple, ash, and sugar maple are the more abundant younger trees. The dominant understory (second layer) tree is the dogwood, while other typical species include sassafras and ironwood. Typical shrubs include the spicebush and viburnums, such as the arrowwood and black haw, while the most common vines include poison ivy, Virginia creeper, and wild grape. Common herbs usually found in this type of habitat in the spring include the mayapple, spring beauties, jewelweed, jack-in-the-pulpit, and Solomon's seal. In the fall, goldenrod and ferns are common. The Mixed Oak forest is best represented in Cranford by the woods in Nomahegan and Lenape Parks and along the Rahway River Parkway.

TREES

"Trees have provided man with everything from basic food and shelter to aesthetic beauty since he first appeared on Earth. Today trees also reduce air and noise pollution and give texture to our often stark environment of concrete and steel. Most people, however, neither recognize the different species of trees nor appreciate the many uses man has found for them....

"Another reason why you might want to study trees is that even a small woodlot is not just a simple aggregation of trees. There are infinitely complex relationships between trees, other living things, and their environment. Only as we begin to recognize the delicate balance of nature will the intensity with which we disrupt nature be abated" (Ombrello).

As is the case with most older suburban towns, Cranford has an abundance of trees, not only along most of its streets, but in places such as Nomahegan Park and along the Rahway River as well. A common way to identify these trees is by examining the leaf; bark traits, tree habit, and specific winter-twig characteristics also are key indicators.

Cranford's parkland contains a mix of established indigenous tree species and younger trees selected for particular traits, such as ornamental attractiveness, greater resistance to pests and diseases, and improved vigor; within this tree population are a small number of trees, which have been donated by Cranford residents. The following is a partial listing of tree species located in the Township's largest parks and parks along the Rahway River:

Droescher's Mill Park

American beech, American sweetgum, black cherry, black locust, green ash, Norway maple, red maple, sugar maple, pin oak, red oak, white oak, sycamore, white pine, white mulberry, and flowering dogwood.

Girl Scout Park

American sweetgum, bitternut hickory, white ash, cherry plum, Douglas fir, kousa dogwood, Japanese maple, Norway maple, red maple, pin oak, red oak, Sargent cherry, and weeping higan cherry.

Hampton Park

American elm, common beech, American sweetgum, pin oak, red oak, red maple, sugar maple, white pine, sassafras, flowering dogwood, and slippery elm.

Hanson Park (County property)

American sweetgum, black locust, tulip tree, common horsechestnut, red maple, silver maple, sugar maple, oriental cherry, red oak, white oak, shagbark hickory, green ash, white pine, flowering dogwood, and sassafras.

McConnell Park

American sweetgum, tulip tree, red oak, white oak, red maple, sugar maple, American elm, white pine, flowering dogwood, green ash, black cherry, oriental cherry, Sargent cherry, callery pear, white mulberry, and thornspur hawthorn.

Nomahegan Park

Sycamore, American beech, American sweetgum, green ash, oriental cherry, black cherry, weeping higan cherry, callery pear, red oak, swamp white oak, white oak, littleleaf linden, ironwood, black locust, Norway maple, red maple, sugar maple, and American elm.

Sperry Park

American sweetgum, Norway maple, red maple, silver maple, pin oak, sycamore, tulip tree, ginkgo, green ash, oriental cherry, kousa dogwood, American beech, basswood, common horsechestnut, American elm, and sassafras.

Unami Park

American beech, American sweetgum, sycamore, ironwood, tulip tree, red oak, white oak, red maple, sugar maple, thornless honey locust, white pine, flowering dogwood, mockernut hickory, sassafras, Japanese zelkova, downy hawthorn, and eastern redbud.

In 1999, the Township conducted a street-tree inventory. The total population was almost 8,600 and there were over 60 species of trees. Over 40 percent of the trees were maples, with Norway maple (16.0 percent) and red maple (14.6 percent) the most common individual species. Other species representing 1.0 percent or more included:

Sweetgum	6.1%	Honey locust	2.4%
Pear	5.9	Cherry	1.8
Zelkova	3.9	Linden	1.6
Black cherry	3.7	Japanese maple	1.5
London planetree	3.0	Sycamore	1.4
Dogwood	2.6	Mulberry	1.1
Ash	2.5	Crabapple	1.0
Red oak	2.4		

Over 65 percent of the trees were found to be in good condition, while only 5 percent were listed as in poor condition. Almost 2,100 future planting locations were identified, demonstrating that Cranford's urban forest is almost 20 percent understocked.

The appraised value of Cranford's street trees was estimated to be about $42 million.

The value was calculated based upon the Guide for Establishing Values of Trees and Other Plants prepared by the Council of Tree and Landscape Appraisers and published by the International Society of Arboriculture.

From the completion of the inventory through Spring 2003, 259 existing trees were removed, while 703 new street trees were planted. Additions included: 'Patmore' and 'Marshall Seedless' green ashes, 'Cleveland Select' and 'Redspire' pears, 'Ivory Silk' Japanese tree lilac, 'Greenspire' littleleaf linden, 'Sterling' silver linden, 'Green Vase' and 'Village Green' zelkovas, 'Fastigiata' European hornbeam, sawtooth oak, 'Prairie Pride' hackberry, 'Prospector' elm and 'Rosea' Carolina silverbell. These selections reflect a serious commitment by the Township's Department of Public Works officials to increasing species diversity in the community forest — something that became a priority once the inventory data had been interpreted.

Some of the oldest trees in the Township include: "Old Peppy", a 235 year-old sour gum located on Lincoln Avenue West at Lincoln Park; a 300 year-old white oak located at 32 Rutgers Road; a 200 year-old bur oak located at Cleveland Plaza; a 175 year-old shagbark hickory located at 15 Norman Place; a 150 year-old northern catawba located at 1 Bloomingdale Avenue; a 200 year-old pin oak located at 726 Gallows Hill Road adjacent to the tennis courts; and a 150 year-old tulip tree in McConnell Park.

On the Union County College campus, there is The Historic Tree Grove located near the Sperry Observatory. Each of the trees is a seed or cutting-grown offspring of a tree noteworthy in American or New Jersey history. There are about seventy-five trees in the grove with names ranging from Robin Hood English oak to Martin Luther King Jr. sycamore. In the College's Kellogg Greenhouse and the nursery near it, seedlings of trees significant in New Jersey's history are growing before the parent trees are lost forever. One seedling of each historic tree will be transplanted from the nursery into the grove. The seedlings are available to schools, municipalities, and historic organizations in Union County and throughout the state. In addition, the College campus is an arboretum for more than 140 different tree species (see Table 17).

TABLE 17

TREES OF THE UNION COUNTY COLLEGE ARBORETUM[1]

Apple: common; sweet crabapple
Japanese apricot
Arborvitae
Ash: European; green; white
American basswood
Beech: American, European
Birch: black; gray; river
Yellow buckeye
Eastern catalpa
Cedar: Cedar of Lebanon; blue atlas; Japanese; red; white
Cherry: black; Kwanzan flowering; weeping, Yoshino
Chinese chestnut
Kentucky coffeetree
Cypress: bald; hinoki; leyland
Dogwood: flowering; kousa; Rutgers hybrid
Elm: American; Camperdown; Chinese; Siberian
Empress tree
Fir: Douglas; Fraser; white
Franklinia
White fringetree
Goldenchain tree
Goldenrain tree
Gum: black; sweet
Hawthorn: species; Washington
Tree of Heaven
Eastern hemlock
Hercules-club
Hickory: bitternut; shagbark
American holly
Hornbeam: American; European
Horsechestnut: common; red
Juneberry
Katsura
Japanese larch
Linden: European; littleleaf; silver
Locust: black; honey
Magnolia: cucumbertree; saucer; southern; star; sweetbay
Maidenhair tree
Maple: amur; Japanese; Norway; paperbark; purpleblow; red; silver; sugar; sycamore

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[1] Source: Ombrello, 1997

TABLE 17 (continued)

TREES OF THE UNION COUNTY COLLEGE ARBORETUM

European mountainash
Mulberry: red; weeping
Oak: bur; English; pin; red; sawtooth; swamp white; white; willow
Orange: osage; trifoliate
Poplar: Androscoggin; Lombardy, white
Japanese Pagoda tree
Common pawpaw
Pear: Bradford ornamental; common
Persian parrotia
Common persimmon
Pine: Austrian; bristlecone; Himalayan; Japanese red; Japanese white; lacebark; limber; mugo; pitch; Scotch; white
London planetree
Thundercloud plum
Eastern redbud
Redwood: dawn; Sierra
Sassafras
Silk tree
Carolina silverbell
Common smoketree
Snowbell: fragrant; Japanese
Sorrel tree
Spruce: Colorado; Norway; white
Japanese stewartia
American sycamore
Tulip tree
Black walnut
Willow: black; corkscrew; weeping
Common witchhazel
American yellowwood
Zelkova: Chinese; Japanese

A fairly unusual tree found in the Township is the ginkgo (*Ginkgo biloba*). This ornamental was introduced in the 18th century from China where it was considered sacred. It is the only living species in its class (*Ginkgoöpsida*) and is the last remaining species in its order (*Ginkgoales*) . The ginkgo is a true gymnosperm. Its pollen swims through rain or dew, instead of being blown by wind or carried by insects. Trees are separately sexed. Female ginkgos do not produce seed for twenty to fifty years; their seed coats produce a noxious odor every fall. Consequently, male trees are preferred for plantings and must be vegetatively propagated. The gingko's deciduous, fan-shaped leaves look like, but are not related to, the leaflets of a maidenhair fern. The superficial resemblance of their leaves explains the origin of the common name of the tree: the maidenhair tree. Unlike other trees today, the ginkgo is a survivor from the age of dinosaurs. Its appearance has remained basically unchanged for more than 250 million years. Cultivation has kept it from extinction. There are many ginkgo trees in Cranford, including one at 10 Manor Avenue and another on North Union Avenue opposite Riverside Drive.

UNION COUNY PARKLAND AND NATIVE VEGETATION

Located within Cranford are approximately 314 acres of Union County parkland. Included in this acreage are: parts of Lenape Park and Unami Park; all of Nomahegan Park; McConnell Park; and the Rahway River Parkway, Cranford Section. The latter section includes the area adjacent to the Township's Hanson House property, Sperry Park, and the bike path extension behind the Municipal Building and continuing to the river bank at South Avenue and Lincoln Park East Avenue, then to and across the river from Droescher's Mill at Lincoln Avenue and High Street. Also included is the area known as Mohawk Drive (including Munsee Pond, also known as Sperry Pond), which is adjacent to the Garden State Parkway. This greenway-park system was designed by the Olmsted Brothers Landscape Architect Firm.

In 1999, Union County in partnership with Urban Conservation Action Partnership, the Cranford League of Women Voters and the Township of Cranford, and with the help of local residents, River Committee members, and Scout groups, established shoreline restoration plantings along the Rahway River in sections of Union County's Rahway River Parkway. Two sites, one across the river from Droescher's Mill at High Street and Lincoln

Avenue and a second, adjacent to the Hanson House property and across the river on Springfield Avenue, were chosen. These projects, whose goal is to reduce nonpoint source pollutants that enter the waterway, were funded in part by a grant from NJDEP. Over a period of four years, native vegetation was planted along the banks on three different occasions to buffer pollutants and, in some cases, deter Canada geese.

In September 2003, much of the planting area along the river near Droescher Mill was intensively weeded and selectively thinned out by County personnel and volunteers from the community. At Hanson Park on a weekend in October 2003, County and Township personnel were joined by resident volunteers to remove invasive plants, apply mulch and collect samples for identification and further study.

Native vegetation that were planted includes:

- Pussy willow (*Salix discolor*)
- Silky dogwood (*Cornus amomum*)
- Highbush blueberry (*Vaccinium corymbosum*)
- Shadbush (*Amelancheir canadensis*)
- American elder (*Sambucus canadensis*)
- Inkberry (*Ilex glabra*)
- Sweetspire (*Itea viginica*)
- Arrowwood viburnum (*Viburnum dentatum*)
- Sweet pepperbush (*Clethra alnifolia*)
- Black chokeberry (*Aronia melanocarpa*)
- Winterberry (*Ilex verticillata*)

Exotic/invasive plants (plants that compete aggressively with native vegetation and significantly reduce biodiversity) present at the site near Hanson House include:

- Oriental bittersweet (*Celastrus orbiculatus*)
- Japanese knotweed (*Polygonum cuspidatum*)
- Curly dock (*Rumex crispus*)
- Poison-ivy (*Toxicodendron radicans*)
- English ivy (*Hedera helix*)

- Garlic mustard (*Alliaria petiolata*)
- Japanese wisteria (*Wisteria floribunda*)
- Wild cucumber (*Echinocystis lobata*)
- Canada thistle (*Cirsium arvense*)
- Mugwort (*Artemisia vulgaris*)
- Black Locust (*Robinia psuedoacacia*)
- Giant ragweed (*Ambrosia trifida*)
- Wild Grapevine (*Vitis spp.*)
- Burcucumber (*Sicyos angulatus*)
- Common ragweed (*Ambrosia artemisiifolia*)
- Tatarian honeysuckle (*Lonicera tatarica*)

These plants have been manually removed by Scout groups, the Union County Master Gardeners, the Union County's Sheriff's Labor Assistance Program (SLAP), the Cranford Environmental Commission, the League of Women Voters, the River Committee, and other local residents and students. In addition, once the plants resprouted, the County Horticulture staff applied the systemic herbicide, Rodeo, to deter the spread of invasives. While these actions have made a big difference, and freed much of the native vegetation, efforts need to be continued through the County's Adopt-A-Park program to maintain these important native plantings. Additionally, more education is necessary in order to control invasives.

X. WILDLIFE

X. WILDLIFE

"Loss of habitat has been the single greatest cause of decline and extirpation of animal species in New Jersey. Consequently, the inventory and protection of wildlife habitats is of extreme importance if we are to protect our remaining heritage." (Kane, 1981)

INTRODUCTION

Cranford is, for the most part, completely built out. There are few remaining undeveloped lots and fewer large privately owned undeveloped tracts of land. Cranford is fortunate, though, to have a wealth of protected parkland and natural waterways that serve as wildlife corridors and breeding habitat for many types of animals. The land defined by Nomahegan Park, and neighboring Lenape Park, which Cranford shares with four other Union County communities, comprises the largest parcel of undeveloped land in Cranford. It is here that much of the species diversity of Cranford can be observed, although the Rahway River and the many parks along it in town are responsible for attracting wildlife to many neighborhoods as well. In 1996, Lenape Park was selected by the New Jersey Department of Environmental Protection for inclusion in the first edition of the New Jersey Wildlife Viewing Guide. The Cranford Environmental Commission nominated Lenape Park based on the diversity of wildlife in the park and its accessibility to the public.

BIRDS IDENTIFIED AT LENAPE PARK

Evidence of the biodiversity present in a suburban New Jersey community can be found in the following list of bird species observed in a single day - May 11, 1996 - at Lenape Park. The list is grouped by family, then species name, and finally by the number of birds of that species present. An "X" represents individuals of a species present but not counted.

Birds Identified May 11, 1996, Lenape Park, Cranford, NJ

Waders:
- Great Egret, 2
- Black-crowned Night-Heron, 2
- Great Blue Heron, 1
- Green-backed Heron, 1

Blackbirds:
- Red-winged Blackbird, X
- Baltimore Oriole, 6
- Orchard Oriole, 2
- Common Grackle, X
- Brown-headed Cowbird, X

Doves, Cuckoos:
- Mourning Dove, X
- Rock Dove, X
- Black-billed Cuckoo, 4

Thrushes and Mimics:
- Hermit Thrush, 1
- American Robin, X
- Swainson's Thrush, 1
- Veery, 3
- Wood Thrush, 2
- Gray Catbird, X

Finches:
- American Goldfinch, X
- House Sparrow, 2

Flycatchers:
- Great Crested Flycatcher, 3
- Willow Flycatcher, 1
- Eastern Kingbird, 2
- Eastern Wood-Peewee, 1

Gulls:
- Herring Gull, 2
- Ring-billed Gull, 2

Raptors:
- Red-tailed Hawk, 2

Jays, Crows:
- Blue Jay, X
- American Crow, X

Sandpipers, Plovers:
- Killdeer, 1
- Solitary Sandpiper, 1
- Spotted Sandpiper, 1
- Semi-palmated Sandpiper, 6

Tanagers, Sparrows:
- Scarlet Tanager, 5
- Northern Cardinal, X
- Rose-breasted Grosbeak, 1
- Indigo Bunting, 2
- Song Sparrow, X
- Swamp Sparrow, 2
- White-throated Sparrow, 2
- European Starling, X

Swallows, Swifts:
- Barn Swallow, X
- Tree Swallow, X
- Chimney Swift, 2

Waterfowl:
- Mallard, X
- Wood Duck, 2
- Canada Goose, X

Vireos:
- Warbling Vireo, 1

Wood Warblers:
- American Redstart, 2
- Black & White Warbler, 3
- Black-throated Blue Warbler, 2
- Blackburnian Warbler, 1
- Blackpoll, 2
- Canada Warbler, 2
- Chestnut-sided Warbler, 1
- Magnolia Warbler, 4
- Yellow-rumped Warbler, 1
- Northern Parula Warbler, 2
- Yellow Warbler, X
- Common Yellowthroat, X
- Ovenbird, 1

Woodpeckers:
- Downy Woodpecker, 1
- Red-bellied Woodpecker, 1
- Northern Flicker, X

Titmice, Chickadees:
- Tufted Titmouse, 2

Wrens:
- Carolina Wren, 3
- House Wren, 1

TRENDS IN WILDLIFE BIODIVERSITY

Since the first edition of the Natural Resources Inventory in 1993, a variety of factors has influenced the wildlife populations in Cranford. Among these are: habitat destruction and degradation along migration routes, and, in breeding areas, competition from non-native species, weather and climate changes resulting from global warming, increased use of open space for recreation and outdoor adventure activities, and a human population in the region which continues to grow. Certain species of animals seem to be adapting favorably to the increasingly human-altered environment. One such animal is the white-tailed deer (*Odocoilius virginiana*). As is true throughout the state and region, the white-tailed deer population is thriving due to a variety of factors including lack of predation, an abundance of food, and hunting practices that encourage growth of the deer herd. White-tailed deer, or their telltale signs, such as scat and browsed vegetation, may now be seen in many neighborhoods in Cranford. Also on the increase is a variety of resident songbirds, primarily seed eaters, which are reaping the benefit of the explosion in the popularity of bird feeding. Birds, such as goldfinches, chickadees, titmice, nuthatches, blue jays, and cardinals, have increased their visibility, if not their numbers, by using feeding stations throughout the year. An unfortunate by-product of the widespread use of bird feeders is the growth of non-native bird populations of such species as the (English) house sparrow and European starling. These species aggressively compete with native songbirds for resources.

Animal species on the decline include many neotropical songbirds, whose wintering habitats, migration routes, and nesting habitats continue to suffer destruction and degradation. Specific problems include: forest fragmentation, competition from non-native species, and ecologically destructive development practices. Other bird species in decline include those that are being displaced as a result of global warming, such as the northern flicker. Traditionally, more southern species, such as the red-bellied woodpecker, Carolina wren, cardinal, and mockingbird, have become resident species in the last fifty years. Gray catbirds and yellow-rumped warblers are extending the length of their stay in our area as well, occasionally even overwintering. Grassland birds, such as meadowlarks, bobolink and a number of sparrows, are also on the decline. This is due to loss of farmland throughout the region. While most of it has been developed for housing or commercial space, other farmland has followed succession and become forest.

Also declining throughout the region is the bat population, primarily through the destruction of roost sites, such as caves, and, more specific to Cranford, large tree cavities, old carriage houses, barns, and sheds. While bats are not viewed favorably by much of the public, they perform many ecologically important functions, including limiting the population of flying insects such as mosquitoes. Bats can consume over 3000 insects each night, reducing occurrences of West Nile virus and similar illnesses spread by mosquitoes. The bat population should be protected and encouraged, especially in towns with significant watercourses and wetlands, such as Cranford.

ENDANGERED, THREATENED AND SPECIES OF SPECIAL CONCERN

The classifications in the New Jersey State list of threatened and endangered species, and species of special concern are defined as follows:

- *Endangered Species* are those species whose prospects for survival within the state are in immediate danger due to one or several factors, such as loss or degradation of habitat, overexploitation, predation, competition, disease, or environmental pollution. An endangered species likely requires immediate action to avoid extinction within New Jersey.
- *Threatened Species* are those that may become endangered if conditions surrounding it begin or continue to deteriorate. A threatened species is one that is already vulnerable as a result of restricted range, small population size, narrow-habitat affinities, significant population declines, and the like.
- *Species of Special Concern* are 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. This category also is applied to species that meet the foregoing criteria and for which there is little understanding of their current population in the state.

A number of endangered and threatened species have been sighted in Cranford, including the peregrine falcon, Cooper's hawk, red-shouldered hawk, black-crowned night-heron (breeding populations only), and red-headed woodpecker. Interestingly, these are all bird species, and the recognition of their presence in the town may be due to the current popularity of bird watching.

If as much effort were expended looking for other families of animals, it is entirely possible that endangered or threatened reptiles, amphibians and invertebrates might also make the list of wildlife native to or sighted in Cranford. Of the aforementioned species, only the black-crowned night-heron is known to breed in Cranford. It is believed that the others are migratory or wintering visitors.

Species of special concern known to exist in Cranford include the following birds: pied-billed grebe, American bittern, little blue heron, northern harrier, sharp-shinned hawk, and yellow-breasted chat. None of these is known to be a breeding population. The only other known species of special concern occurring in Cranford is a member of the reptile family, the eastern box turtle. This is clearly a breeding population.

SPECIES DIVERSITY - WILDLIFE TABLES

Species diversity is generally high in Cranford, as demonstrated in the following tables of animals observed or expected to occur within the town borders. There is a particularly large number of bird species, due to Cranford's location along a prime migratory route from the shore to the mountains of northern New Jersey. Many birds follow the greenway that surrounds the Rahway River as it runs from Verona, in Essex County, to Carteret on the Arthur Kill. Cranford is fortunate to have a significant number of county and municipal parks along the Rahway River, which offer resting and feeding habitat to migrating birds. The table of birds differs in its format from the other tables. Reflecting the facts that many of the bird species seen are migratory, and good records have been kept of their appearances, the table of birds includes seasonal information and their relative frequency of appearance. This is a standard bird-watching-checklist format.

TABLE 18A - MAMMALS

Species Known or Expected to Occur in Cranford

COMMON NAME	SCIENTIFIC NAME
Order: Marsupialia (Marsupials)	
Virginia Opossum	*Didelphis virginiana*
Order: Insectivora (Shrews & Moles)	
Masked Shrew	*Sorex cinereus*
Northern Short-tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Eastern Mole	*Scalopus aquaticus*
Star-nosed Mole	*Condylura cristata*
Order: Chiroptera (Bats)	
Little Brown Myotis	*Myotis lucifugus*
Eastern Small-footed Myotis	*Myotis leibii*
Silver-haired Bat	*Lasionycteris noctivagans*
Eastern Pipistrelle	*Pipistrellus subflavus*
Big Brown Bat	*Eptesicus fuscus*
Eastern Red Bat	*Lasiurus borealis*
Hoary Bat	*Lasiurus cinereus*
Order: Lagomorpha (Rabbits)	
Eastern Cottontail	*Sylvilagus floridanus*
New England Cottontail	*Sylvilagus transitionalis*
Order: Rodentia (Rodents)	
Eastern Chipmunk	*Tamias striatus*
Woodchuck	*Marmota monax*
Eastern Gray Squirrel	*Sciurus carolinensis*
Southern Flying Squirrel	*Glaucomys volans*
White-footed Mouse	*Peromyscus leucopus*
Meadow Vole (Field Mouse)	*Microtus pennsylvanicus*
Woodland Vole	*Microtus pinetorum*
Common Muskrat	*Ondatra zibethicus*
Black Rat (non-native)	*Rattus rattus*
Norway Rat (non-native)	*Rattus norvegicus*
House Mouse (non-native)	*Mus musculus*
Order: Carnivora (Carnivores)	
Red Fox	*Vulpes fulva*
Common Raccoon	*Procyon lotor*
Long-tailed Weasel	*Mustela frenata*
Striped Skunk	*Mephitis mephitis*
Order: Artiodactyla (Even-toed Hoofed Mammals)	
White-tailed Deer	*Odocoileus virginianus*

TABLE 18B - REPTILES

Species Known or Expected to Occur in Cranford

COMMON NAME	SCIENTIFIC NAME
Order: Testudines (Turtles)	
Common Snapping Turtle	*Chelydra serpentina*
Stinkpot (Musk Turtle)	*Sternotherus odoratus*
Eastern Mud Turtle	*Kinosternon subrubrum subrubrum*
Spotted Turtle	*Clemmys guttata*
Wood Turtle	*Clemmys insculpta*
Eastern Box Turtle	*Terrapene carolina carolina*
Red-eared Turtle (introduced)	*Chrysemys scripta elegans*
Red-bellied Turtle	*Chrysemys rubriventris*
Eastern Painted Turtle	*Chrysemys picta picta*
Chicken Turtle (introduced)	*Deirochelys reticularia*
Order: Squamata (Lizards & Snakes)	
Five-lined Skink	*Eumeces fasciatus*
Northern Water Snake	*Nerodia sipedon sipedon*
Northern Brown Snake	*Storeria dekayi dekayi*
Red-bellied Snake	*Storeria occipitomaculata*
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*
Eastern Ribbon Snake	*Thamnophis sauritus sauritus*
Smooth Earth Snake	*Virginia valeriae*
Eastern Hognose Snake	*Heterodon platyrhinos*
Northern Ringneck Snake	*Diadophis punctatus edwardsi*
Eastern Worm Snake	*Carphophis amoenus amoenus*
Northern Black Racer	*Coluber constrictor constrictor*
Eastern Smooth Green Snake	*Opheodrys vernalis vernalis*
Black Rat Snake	*Elaphe obsoleta obsoleta*
Eastern Kingsnake	*Lampropeltis getulus getulus*
Eastern Milk Snake	*Lampropeltis triangulum triangulum*

TABLE 18C - AMPHIBIANS

Species Known or Expected to Occur in Cranford

COMMON NAME	SCIENTIFIC NAME
Order: Caudata (Salamanders)	
Marbled Salamander	*Ambystoma opacum*
Red-spotted Newt	*Notophthalmus viridescens viridescens*
Spotted Salamander	*Ambystoma maculatum*
Northern Dusky Salamander	*Desmognathus fuscus fuscus*
Red-backed Salamander	*Plethodon cinereus*
Slimy Salamander	*Plethodon glutinosus glutinosus*
Four-toed Salamander	*Hemidactylium scutatum*
Northern Red Salamander	*Pseudotriton ruber ruber*
Northern Two-lined Salamander	*Eurycea bislineata bislineata*
Order: Anura (Toads and Frogs)	
Eastern Spadefoot Toad	*Scaphiopus holbrooki holbrooki*
American Toad `	*Bufo americanus*
Fowler's Toad	*Bufo woodhousei fowleri*
Northern Cricket Frog	*Acris crepitans crepitans*
Northern Spring Peeper	*Hyla crucifer crucifer*
Common Gray Treefrog	*Hyla versicolor*
New Jersey Chorus Frog	*Pseudacris triseriata kalmi*
Bullfrog	*Rana catesbeiana*
Green Frog	*Rana clamitans melanota*
Wood Frog	*Rana sylvatica*
Southern Leopard Frog	*Rana sphenocephala*
Pickerel Frog	*Rana palustris*

TABLE 18D - FISH

Species Known or Expected to Occur in Cranford

COMMON NAME	SCIENTIFIC NAME
Order: Esocidae (Pike Family)	
Redfin Pickerel	*Esox americanus*
Chain Pickerel	*Esox niger*
Order: Cyprinidae (Carp & Minnow Family)	
Golden Shiner	*Notemigonus crysoleucas*
Common Shiner	*Luxilus cornutus*
Spottail Shiner	*Notropis hudsonius*
Blacknose Dace	*Rhinichthys atratulus*
Creek Chub	*Semotilus atromaculatus*
Fallfish	*Semotilus corporalis*
Carp (introduced)	*Cyprinus carpio*
Goldfish (introduced)	*Carassius auratus*
Order: Catostomidae (Sucker Family)	
White Sucker	*Catostomus commersonnii*
Order: Cyprinodontidae (Killifish Family)	
Banded Killifish	*Fundulus diaphanus*
Mummichog	*Fundulus heteroclitus*
Order: Ictaluridae (Catfish Family)	
Black Bullhead (introduced)	*Ameiurus melas*
Brown Bullhead	*Ameiurus nebulosus*
Order: Percidae (Perch Family)	
Tessellated Darter	*Etheostoma olmstedi*
Yellow Perch	*Perca flavescens*
Order: Salmonidae (Trout Family)	
Rainbow Trout (stocked in season)	*Oncorhynchus mykiss*
Brook Trout (stocked in season)	*Salvelinus fontinalis*
Order: Anguillidae (Eel Family)	
American Eel	*Anguilla rostrata*
Order: Centrarchidae (Sunfish Family)	
Largemouth Bass	*Micropterus salmoides*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Pumpkinseed	*Lepomis gibbosus*
Black Crappie	*Pomoxis nigromaculatus*
White Crappie	*Pomoxis annularis*

TABLE 18E - BUTTERFLIES

Species Known or Expected to Occur in Cranford

COMMON NAME	SCIENTIFIC NAME
Family: Swallowtails	
Black Swallowtail	*Papilio polyxenes*
Eastern Yellow Swallowtail	*Papilio glaucus*
Spicebush Swallowtail	*Papilio troilus*
Family: Whites & Sulfurs	
Cabbage White	*Pieris rapae*
Clouded Sulphur	*Colias philodice*
Orange Sulfur	*Colias eurytheme*
Family: Harvesters & Coppers	
American Copper	*Lycaena phlaeas*
Family: Hairstreaks & Elfins	
Banded Hairstreak	*Satyrium calanus*
Coral Hairstreak	*Satyrium titus*
Gray Hairstreak	*Strymon melinus*
Juniper Hairstreak	*Callophrys gryneus*
Striped Hairstreak	*Satyrium liparops*
Family: Snouts & Brushfoots	
Great Spangled Fritillary	*Speyeria cybele*
Pearl Crescent	*Phyciodes tharos*
Question Mark	*Polygonia interrogationis*
American Lady	*Vanessa virginiensis*
Painted Lady	*Vanessa cardui*
Mourning Cloak	*Nymphalis antiopa*
Red Admiral	*Vanessa atalanta*
Red-spotted Purple	*Limenitis arthemis astyanax*
Viceroy	*Limenitis archippus*
Family: Satyrs and Wood Nymphs	
Appalachian Brown	*Satyrodes appalachia*
Little Wood Satyr	*Megisto cymela*
Common Wood-Nymph	*Cercyonis pegala*
Family: Milkweed Butterflies	
Monarch	*Danaus plexippus*

TABLE 18E - BUTTERFLIES (continued)

Family: Skippers	
Crossline Skipper	*Polites origenes*
European Skipper	*Thymelicus lineola*
Hobomok Skipper	*Poanes hobomok*
Least Skipper	*Ancyloxphya numitor*
Peck's Skipper	*Polites peckius*
Silver-Spotted Skipper	*Epargyreus clarus*
Swarthy Skipper	*Nastra lherminier*
Zabulon Skipper	*Poanes zabulon*
Dreamy Duskywing	*Erynnis icelus*
Juvenal's Duskywing	*Erynnis juvenalis*
Wild Indigo Duskywing	*Erynnis baptisiae*
Common Sootywing	*Phyolisora catullus*
Little Glassywing	*Pompeius verna*
Northern Broken-Dash	*Wallengrenia egeremet*
Family: Blues & Azures	
Eastern Tailed Blue	*Everes comyntas*
Northern Azure	*Celastrina sp.*
Spring Azure	*Celastrina ladon*
Summer Azure	*Celastrina neglecta*

TABLE 18F - BIRDS

Species Known or Expected to Occur in Cranford

SEASON

Many of the birds on this list are seasonal or migratory visitors. Their seasonal occurrence is coded as follows:

- **s** Spring (March, April, May)
- **S** Summer (June, July)
- **F** Fall (August to mid-November)
- **W** Winter (Mid-November to February)

RELATIVE ABUNDANCE

a	Abundant	Very numerous species
c	Common	Certain to be present
u	Uncommon	May not be seen
o	Occasional	Infrequently seen
r	Rare	Not present every year

KEY

bold/Italics - denotes known breeding species

	s	S	F	W
DIVERS				
Common Loon..................	o	-	o	-
Pied-billed Grebe..................	r	-	r	-
Double-crested Cormorant.....	u	u	u	-
WADERS				
Great Blue Heron..................	c	c	c	c
Little Blue Heron..................	-	-	r	-
Great Egret..........................	u	u	u	-
Snowy Egret..........................	o	o	o	-
Black-crowned Night-Heron .	u	c	o	-
Green-backed Heron..............	u	u	u	-
American Bittern..................	r	-	r	-
Glossy Ibis..........................	o	-	o	-
Virginia Rail..........................	r	-	r	-
BLACKBIRDS, ORIOLES, MEADOWLARKS				
Red-winged Blackbird...........	a	c	a	-
Brown-headed Cowbird........	c	c	u	-
Rusty Blackbird....................	u	-	c	c
Common Grackle..................	a	a	a	o
Bobolink...............................	u	-	u	-
Eastern Meadowlark.............	r	-	u	-
Orchard Oriole......................	c	c	o	-
Baltimore Oriole................	c	c	u	-
DOVES, CUCKOOS				
Black-billed Cuckoo..............	o	u	o	-
Yellow-billed Cuckoo............	o	u	o	-
Mourning Dove.....................	a	a	a	a
Rock Dove............................	a	a	a	a
THRUSHES & MIMICS				
Eastern Bluebird..................	u	u	u	u
Golden-crowned Kinglet.........	o	-	c	u
Ruby-crowned Kinglet...........	o	-	c	u
Blue-gray Gnatcatcher...........	u	-	u	-
Brown Thrasher....................	o	o	o	-
Hermit Thrush........................	c	-	c	-

	s	S	F	W
THRUSHES & MIMICS(continued)				
American Robin....................	a	c	a	o
Swainson's Thrush.................	c	u	c	-
Gray-cheeked Thrush............	c	u	c	-
Veery....................................	c	u	c	-
Wood Thrush........................	c	u	c	-
Northern Mockingbird..........	c	c	c	c
Gray Catbird.........................	a	a	a	o
Northern Shrike..................	-	-	r	r
FINCHES				
American Goldfinch.............	a	a	a	c
European Goldfinch..............	-	r	r	-
House Finch.........................	a	a	a	a
Purple Finch..........................	u	-	u	u
Common Redpoll................	-	-	r	r
House Sparrow......................	o	o	o	o
FLYCATCHERS				
Eastern Kingbird....................	c	c	c	-
Great Crested Flycatcher.......	u	c	u	-
Eastern Phoebe.....................	c	-	c	-
Eastern Wood-Pewee..........	u	c	u	-
Say's Phoebe........................	-	r	r	-
Acadian Flycatcher................	o	-	o	-
Yellow-bellied Flycatcher.......	o	-	o	-
Least Flycatcher....................	u	c	u	-
Willow Flycatcher.................	u	c	u	-
GULLS, TERNS				
Great Black-backed Gull.....	o	o	o	u
Herring Gull..........................	u	u	c	c
Ring-billed Gull.....................	c	o	c	c
RAPTORS, OWLS				
Sharp-shinned Hawk............	c	-	c	c
Cooper's Hawk......................	u	-	u	u
Northern Harrier...................	r	-	r	r
Red-tailed Hawk....................	c	c	c	c

	s	S	F	W
RAPTORS, OWLS (continued)				
Red-shouldered Hawk	o	-	o	-
Broad-winged Hawk	o	-	o	-
Turkey Vulture	u	u	u	o
Black Vulture	r	-	r	-
Kestrel	u	o	u	-
Merlin	-	o	u	u
Peregrine Falcon	-	-	r	r
Eastern Screech-Owl	u	o	u	u
Great Horned Owl	u	r	u	u
JAYS, CROWS, GOATSUCKERS				
Blue Jay	a	a	a	a
American Crow	a	a	a	a
Fish Crow	c	c	c	c
Common Nighthawk	u	c	u	-
Whip-poor-will	r	r	r	-
HUMMINGBIRD, KINGFISHER				
Ruby-throated Hummingbird	u	c	u	-
Belted Kingfisher	c	c	c	u
SANDPIPERS, PLOVERS				
Killdeer	u	c	u	-
American Woodcock	u	-	o	-
Common Snipe	u	o	u	-
Greater Yellowlegs	u	-	u	-
Lesser Yellowlegs	u	-	u	-
Solitary Sandpiper	u	-	u	-
Purple Sandpiper	r	-	r	-
Spotted Sandpiper	u	c	u	-
Least Sandpiper	u	-	u	-
Semi-palmated Sandpiper	u	-	u	-
Western Sandpiper	o	-	o	-
TANAGERS, SPARROWS. GROSBEAKS				
Scarlet Tanager	c	-	u	-
Northern Cardinal	a	a	a	a
Rose-breasted Grosbeak	u	u	u	-
Indigo Bunting	c	u	u	-
Eastern Towhee	o	-	c	-
Chipping Sparrow	o	u	o	-
Field Sparrow	r	-	u	u
Fox Sparrow	u	-	c	-
Grasshopper Sparrow	r	-	r	-
Lincoln's Sparrow	-	-	o	-
Savannah Sparrow	o	-	u	-
Song Sparrow	a	a	a	u
Swamp Sparrow	o	-	u	-
Tree Sparrow	o	-	c	c
White-crowned Sparrow	o	-	o	-
White-throated Sparrow	c	-	c	a
Dickcissel	u	-	u	-
Dark-eyed Junco	u	-	u	a
American Pipit	-	-	r	-

	s	S	F	W
WAXWING, STARLING, TURKEY				
Cedar Waxwing	c	c	c	r
European Starling	a	a	a	a
Wild Turkey	u	u	u	u
SWALLOWS, SWIFTS				
Barn Swallow	c	a	u	-
N. Rough-winged Swallow	u	c	o	-
Bank Swallow	r	-	r	-
Tree Swallow	c	c	o	-
Cliff Swallow	o	o	o	-
Chimney Swift	u	c	u	-
WATERFOWL				
American Black Duck	o	o	o	-
American Widgeon	r	-	-	r
Canvasback	r	-	r	-
Mallard	a	a	a	c
Northern Shoveler	r	-	r	r
Common Pintail	r	-	-	r
Ring-necked Duck	o	-	o	-
Wood Duck	c	c	c	o
Gadwall	r	-	r	o
Bufflehead	o	-	o	-
Common Goldeneye	r	-	r	-
Canada Goose	a	a	a	a
Snow Goose	r	-	r	r
Blue-winged Teal	o	-	u	o
Green-winged Teal	o	-	u	o
Common Merganser	o	-	o	-
Hooded Merganser	o	-	o	o
Mute Swan	o	o	o	-
VIREOS				
Philadelphia Vireo	o	-	o	-
White-eyed Vireo	o	-	o	-
Red-eyed Vireo	u	c	u	-
Blue-headed Vireo	u	-	u	-
Warbling Vireo	c	c	o	-
Yellow-throated Vireo	o	-	o	-
WARBLERS				
American Redstart	c	u	c	-
Bay-breasted Warbler	o	-	o	-
Black & White Warbler	c	u	c	-
Black-thr. Blue Warbler	u	-	u	-
Black-thr. Green Warbler	c	-	c	-
Blackburnian Warbler	o	-	o	-
Blackpoll	u	-	o	-
Blue-winged Warbler	c	o	c	-
Brewster's Warbler	-	-	r	-
Canada Warbler	u	-	u	-
Chestnut-sided Warbler	c	-	c	-
Connecticut Warbler	o	-	o	-
Kentucky Warbler	o	-	o	-

	s	S	F	W
WARBLERS (continued)				
Magnolia Warbler	c	o	c	-
Mourning Warbler	o	-	o	-
Nashville Warbler	o	-	o	-
Northern Parula Warbler	u	-	u	-
Palm Warbler	u	-	u	-
Pine Warbler	o	-	o	-
Prairie Warbler	o	-	o	-
Tennessee Warbler	o	-	o	-
Wilson's Warbler	o	-	o	-
Worm-eating Warbler	o	-	-	-
Yellow Warbler	a	a	c	-
Common Yellowthroat	c	c	c	-
Yellow-rumped Warbler	c	-	a	u
Yellow-throated Warbler	r	-	-	-
Yellow-breasted Chat	u	-	r	-
Northern Waterthrush	u	-	u	-
Louisiana Waterthrush	o	-	o	-
Ovenbird	c	-	u	-

	s	S	F	W
WOODPECKERS				
Red-headed Woodpecker	u	-	u	u
Pileated Woodpecker	o	o	o	o
Northern Flicker	c	c	a	c
Red-bellied Woodpecker	c	c	c	c
Yellow-bellied Sapsucker	-	r	u	o
Downy Woodpecker	c	c	c	c
Hairy Woodpecker	u	u	c	c
TITMOUSE, NUTHATCHES, WRENS				
Tufted Titmouse	c	c	c	c
Black-capped Chickadee	c	c	c	c
White-breasted Nuthatch	c	u	c	c
Red-breasted Nuthatch	-	-	r	r
Brown Creeper	u	u	u	o
Carolina Wren	c	c	c	u
House Wren	u	c	u	-
Marsh Wren	r	-	r	-
Winter Wren	o	-	o	u

XI. GLOSSARY

GLOSSARY

This chapter contains only a partial listing of terms used in the NRI. Other terms are defined in the text. These terms and the terms in this glossary appear in italics. The reader is encouraged to conduct further research to enhance the educational experience.

Aquifer	A body of permeable sediment or rock through which groundwater moves easily.
Artesian	A groundwater system in which the groundwater is isolated from the surface by a confining layer and the water is under pressure.
Cenozoic Era	A time span on the geologic calendar beginning about 65 million years ago and including the present time.
Climate	A description of aggregate weather conditions; the sum of all statistical weather information that helps to describe a place or region.
Ecosystem	A particular type of biological system in which climate, geology and soil, animals and human beings are related to each other and affected by their interactions.
Eon	The longest division of geologic time, containing two or more eras.
Epoch	A unit of the geologic calendar that is a subdivision of a period.
Era	A major subdivision on the geologic calendar; eras are divided into shorter units called periods.
Floodplain	The flat, low-lying portion of a stream valley subject to periodic inundation; the flood hazard area.
Floodway	The stream channel and the immediately adjacent portions of the floodplain that carry the bulk of the flood flow during storm events.
Flood Fringe	The portion of the floodplain located outside the floodway.

Fragipan	A natural soil subsurface horizon with high bulk density relative to the horizons above it.
Ginkgoales	The Latin name used in taxonomy for the order category of the ginkgo or maidenhair tree; an order is composed of one or more classes.
Ginkgoöpsida	The Latin name used in taxonomy for the class category of the ginkgo or maidenhair tree; a class is composed of one or more families.
Groundwater	Water found beneath the surface of the earth within the zone of saturation.
Hydrologic Cycle	The circulation of water from the oceans to the atmosphere and back to the oceans by way of evaporation, runoff from streams and rivers, and groundwater flow.
Mesozoic Era	A time span on the geologic calendar between the Paleozoic and Cenozoic eras, or from about 225 to 65 million years ago.
Meteoric Water	Water derived from the atmosphere.
Moraine	Sediments deposited directly by the ice of a glacier.
Paleozoic Era	A time span on the geologic calendar between the Precambrian and Mesozoic eras, or from about 540 to 250 million years ago.
Permeability	A measure of a material's ability to transmit fluid.
Perched Water Table	A localized zone of saturation above the main water table created by an impermeable layer.
Period	A basic unit of the geologic calendar that is a subdivision of an era; periods may be divided into smaller units called epochs.

GLOSSARY (continued)

Physiographic Province	A region characterized by a particular assemblage of landforms, climate and geomorphic history.
Porosity	The percentage of void (empty space) in earth material such as soil or rock.
Precambrian	All geologic time before the Paleozoic era.
Sediment	The accumulation of soil particles that have settled out of flowing water.
Silt	Finely divided particles of soil or rock often carried in cloudy suspension in water and eventually deposited as sediment.
Soil Horizon	A layer of soil that has identifiable characteristics produced by chemical weathering and other soil-forming processes.
Soil Profile	A vertical section through a soil showing its succession of horizons and the underlying parent material.
Substratum	A layer of earth beneath the surface soil.
Taxonomy	The science of classifying relationships and naming organisms, which is broken down into a defined, hierarchical series of internationally understood categories.
Terminal Moraine	The area of land marking the farthest advance of a glacier.
Till	Unsorted sediment composed of a heterogeneous mixture of clay, sand, gravel, and boulders deposited directly by a glacier.
Turbidity	A state in which sediment or foreign particles are stirred up or suspended.

GLOSSARY (continued)

Vegetative Succession	A directional, cumulative change in the species that occupy a given area, through time.
Water Table	The upper level of the saturated zone of groundwater.
Zone of Aeration	Zone in which gaps in the soil are filled with both air and water.
Zone of Saturation	Zone in which all open spaces in sediment and rock are completely filled with water.

XII. REFERENCES

REFERENCES

Anderson, H.R. Special Report No. 27: Groundwater Resources of the Rahway Area, N.J. Trenton, N.J.: Division of Water Policy and Supply, n.d.

Association of New Jersey Environmental Commissions. The Environmental Manual for Municipal Officials. 2nd ed. Mendham, N.J.: Association of New Jersey Environmental Commissions, 1998.

Banino, George M., Frank J. Markewicz, and Joseph W Miller. Geologic, Hydrologic, and Well Drilling Characteristics of the Rocks of Northern and Central New Jersey. Trenton, N.J.: Bureau of Geology and Topography, 1970.

Bat Conservation International. U.S. Bats by State – New Jersey. September 2002. July 10, 2003 <http://www.batcon.org/discover/species/nj.html>.

Batty, Sandy. Environmental Commissioners' Handbook. 4th ed. Mendham, N.J.: Association of New Jersey Environmental Commissions, 1997.

Behler, John L., and F. Wayne King. The Audubon Society Field Guide to North American Reptiles and Amphibians. New York: Knopf, 1989.

Buell, Murray F., and Beryl Robichaud. Vegetation of New Jersey: A Study of Landscape Diversity. New Brunswick, N.J.: Rutgers University Press, 1983.

Burt, William H., and Richard P. Grossenheider. A Field Guide to the Mammals of America North of Mexico. Boston: Houghton Mifflin, 1976.

Barbour, Michael G., Jack H. Burk, and Wanna D. Pitts. Terrestrial Plant Ecology. 2nd ed. Menlo Park, Calif.: Benjamin/Cummings, 1987.

Camp Dresser & McKee Inc. Township of Cranford, NJ - Review of Flood Control Measures - Final Report. Edison, N.J.: Camp Dresser & McKee Inc., 2001.

Collins, Beryl, and Karl Anderson. Plant Communities of New Jersey - A Study in Landscaping Diversity. New Brunswick, N.J.: Rutgers University Press, 1994.

Coombes, Allen J. Trees. New York: Dorling Kindersley, 1992.

Cranford, Township of. Community Forestry Management Plan. Cranford, N.J.: Township of Cranford, 2000.

REFERENCES, Con't.

Dirr, Michael. Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. 5th ed. Champaign, Ill.: Stipes Publishing, 1998.

Fridlington, Robert, and Lawrence Fuhro. Images of America: Cranford. Dover, N.H.: Arcadia Publishing, 1995.

Gleason, Henry A., and Arthur Cronquist. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd ed. Bronx, N.Y.: The New York Botanical Garden, 1991.

Gleick, P.H. Encyclopedia of Climate and Weather. Vol. 2. Ed. S.H. Schneider. New York: Oxford University Press, 1996. 2 vols.

Glimn-Lacy, Janice, and Peter B. Kaufman. Botany Illustrated: Introduction to Plants, Major Groups, Flowering Plant Families. New York: Van Nostrand Reinhold, 1984.

Gochfeld, Michael, and Joanna Burger. Butterflies of New Jersey: A Guide to their Status, Distribution, Conservation, and Appreciation. New Brunswick, N.J.: Rutgers University Press, 1997.

Harlow, William Morehouse, Ellwood S. Harrar, and Fred M. White. Textbook of Dendrology, Covering the Important Forest Trees of the United States and Canada. 6th ed. New York: McGraw-Hill, 1979.

Havens and Emerson, Inc. The New Jersey Statewide Water Supply Master Plan, Source Material, Task VII—Watershed Management. Trenton: New Jersey Department of Environmental Protection, 1980.

---. The New Jersey Statewide Water Supply Plan, Source Material, Task VII—Watershed Management, Groundwater Management Appendices. Trenton: New Jersey Department of Environmental Protection, 1980.

Keller, Edward A., and E. M. Burt. Environmental Geology. Columbus, Ohio: Merrill, 1976.

Kümmel, Henry B., and J. Volney Lewis. The Geology of New Jersey. Bulletin 50, Geological ser. Trenton, N.J.: Department of Conservation and Development, 1940.

Little, Elbert L. The Audubon Society Field Guide to North American Trees (Eastern Region). New York: Knopf, 1980.

Loewer, Peter. Solving Weed Problems. Guilford, Conn.: Lyons, 2001.

REFERENCES, Con't.

Lucey, Carol S. Geology of Essex and Union Counties In Brief. Trenton, N.J.: Bureau of Geology and Topography, 1976.

McHarg, Ian L. Design with Nature. Garden City, N.Y.: Doubleday, 1971.

Miller, David W. The New Jersey Ground-Water Situation. Hackensack, N.J.: Geraghty & Miller, n.d.

Mitchell, Alan F., and David More. The Trees of North America. New York: Facts on File Publications, 1987.

Nemickas, Bronius. Geology and Ground-Water Resources of Union County, New Jersey. Water-Resources Investigation 76-73. Trenton, N.J.: U.S. Geological Survey, 1976.

New Jersey Department of Environmental Protection. 2002 Integrated Water Quality Monitoring and Assessment Report. June 3, 2003. September 30, 2003 <http://state.nj.us/dep/wmm/sgwqt/wat/integratedlist/integratedlist.htm>.

---. Freshwater Wetlands Protection Act Rules, N.J.A.C. 7:7A et seq. Trenton, N.J.: Division of Coastal Resources, 1989.

---. Mammals of New Jersey. June 30, 2003. July 12, 2003 <http://nj.gov/dep/fgw/chkmamls.htm>.

---. Reptiles of New Jersey. June 30, 2003. July 12, 2003 <http://nj.gov/dep/fgw/chkrept.htm>.

---. Amphibians of New Jersey. June 30, 2003. July 12, 2003 <http://nj.gov/dep/fgw/chkamph.htm.>

---. Threatened and Endangered Lists for New Jersey. June 30, 2003. July 12, 2003 <http://nj.gov/dep/fgw/tandespp.htm>.

Olson, Gerald W. Soils and the Environment: A Guide to Soil Surveys and their Applications. New York: Chapman and Hall, 1981.

Olsen, Paul E. "Triassic and Jurassic Formations of the Newark Basin." In Field Studies of New Jersey Geology and Guide to Field Trips: 52nd Annual Meeting of the New York State Geological Association, edited by Warren Manspeizer. Newark, N.J.: Rutgers University Geology Department, 1980.

REFERENCES, Con't.

Ombrello, Thomas M. The Trees of Union College. 2nd ed. Cranford, N.J.: Union County College, 1997.

---. A Guide to Union County College's Historic Tree Project. Cranford, N.J.: Union County College, 2000.

Osborn, Henry Fairfield, and Mabel Rice Percy. Proboscidea: A monograph of the discovery, evolution, migration and extinction of the mastodonts and elephants of the world. 2 vols. New York: The American Museum Press, 1936-1942.

Parlapiano, Thomas W. Field Notes of Lenape Park Birding Surveys. Unpublished, 1994-7.

Peterson, Roger T. A Field Guide to the Birds. Boston: Houghton Mifflin, 1980.

Petrides, George A. A Field Guide to Eastern Trees. Boston: Houghton Mifflin, 1988.

Phillips, Roger. Trees of North America and Europe. New York: Random House, 1978.

Randall, John M., and Janet Marinelli, eds. Invasive Plants. Brooklyn, N.Y.: Brooklyn Botanic Garden, 1996.

Richards, Horace G. "Some Recent Discoveries of Pleistocene Mammals from New Jersey." In Bulletin No. 60, Short Geologic Papers. Trenton, N.J.: Department of Conservation and Economic Development, Division of Planning and Development, 1951.

Rogers, F.C., et al. Engineering Soil Survey of New Jersey, Report No. 5, Union County. New Brunswick, N.J.: Rutgers University Engineering Department, 1952.

Scotch Plains Environmental Commission. Environmental Resources Inventory. Scotch Plains, N.J.: Scotch Plains Environmental Commission, 1991.

Symonds, George W.D. The Tree Identification Book. New York: Quill, 1958.

Tarbuck, Edward J., and Frederick K. Lutgens. Earth Science. Columbus, Ohio: Merrill, 1988.

Tiner, Ralph W., Jr. Wetlands of New Jersey. National Wetlands Inventory. Newton Corner, Mass.: U.S. Dept. of the Interior, Fish and Wildlife Service, 1985.

Tuttle, Merlin D. America's Neighborhood Bats. Austin: University of Texas Press, 1989.

REFERENCES, Con't.

University of California, Santa Barbara — Department of Geological Sciences. Geologic Time Scale. November 15, 2003 <http://www.geol.ucsb.edu/Outreach/TimeScale/TimeScale.html>.

United States Department of Agriculture, Soil Natural Resources Conservation Service. Soil Survey of Union County, New Jersey. Bridgewater, N.J.: USDA, NRCS, 2003.

United States Department of Commerce, National Oceanic and Atmospheric Administration. National Climatic Data Center. Local Climatological Data-Annual Summary With Comparative Data, Newark, New Jersey. 2002. August 31, 2003 <http://www.ncdc.noaa.gov>.

---. National Weather Service Forecast Office, Upton, New York. Climate Summary-Newark, NJ. January-December 2002. August 31,2003 <http://www.erh.noaa.gov/er/okx>.

United States. National Aeronautics and Space Administration-Goddard Space Flight Center. September 30, 2003 <http://www.gsfc.nasa.gov>.

Uva, Richard H., Joseph C. Neal and Joseph M. DiTomaso. Weeds of the Northeast. Ithaca, N.Y.: Cornell University Press, 1997.

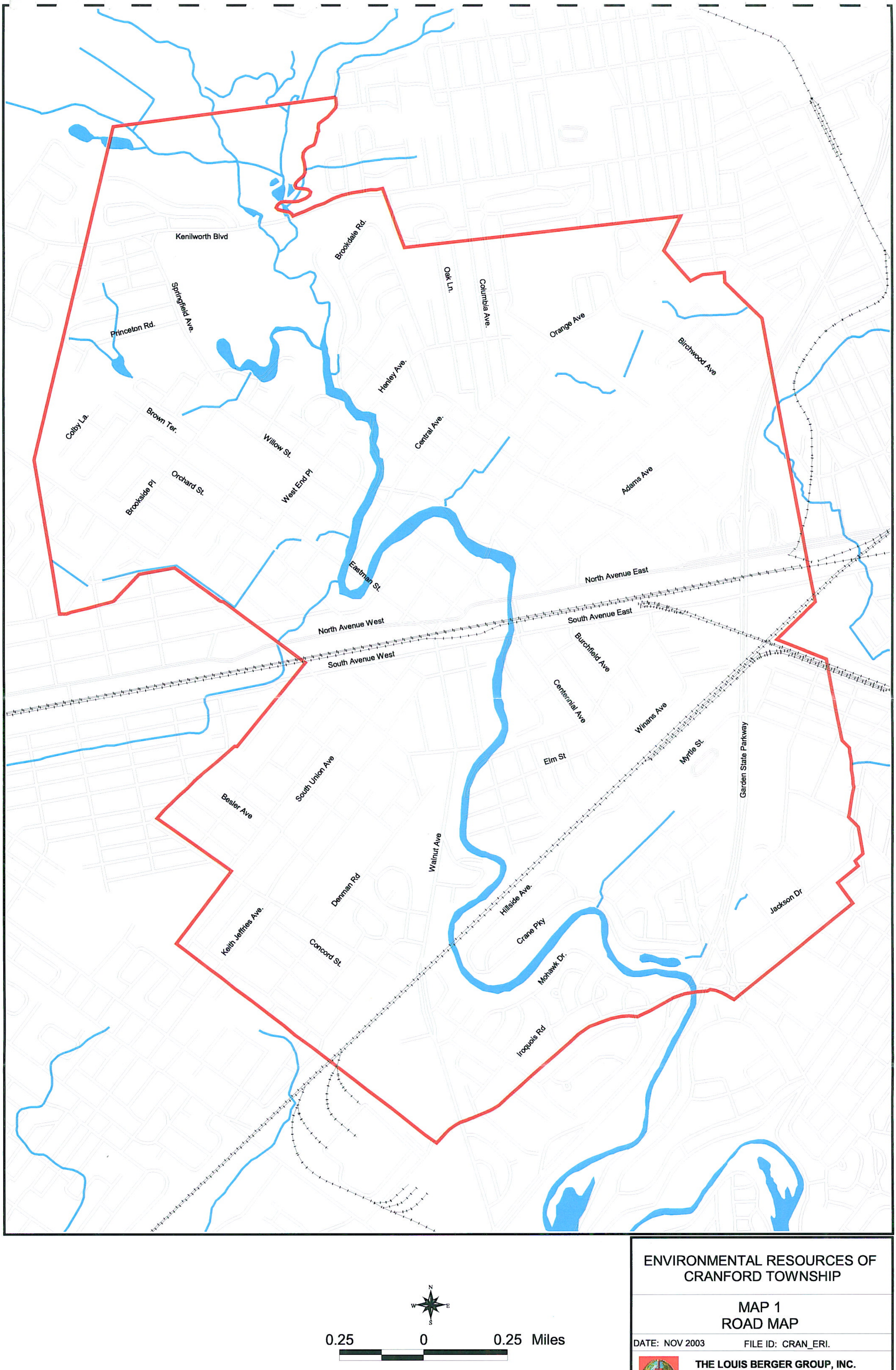
Walden, Howard T., 2nd. Familiar Freshwater Fishes of America. New York: Harper & Row, 1964.

Whitaker, John O., Jr. The Audubon Society Field Guide to North American Mammals. New York: Alfred A. Knopf, 1980.

Whitworth, Walter R. Freshwater Fishes of Connecticut. Hartford, Conn.: DEP Technical Publications Program, 1996.

APPENDIX A

MAPS

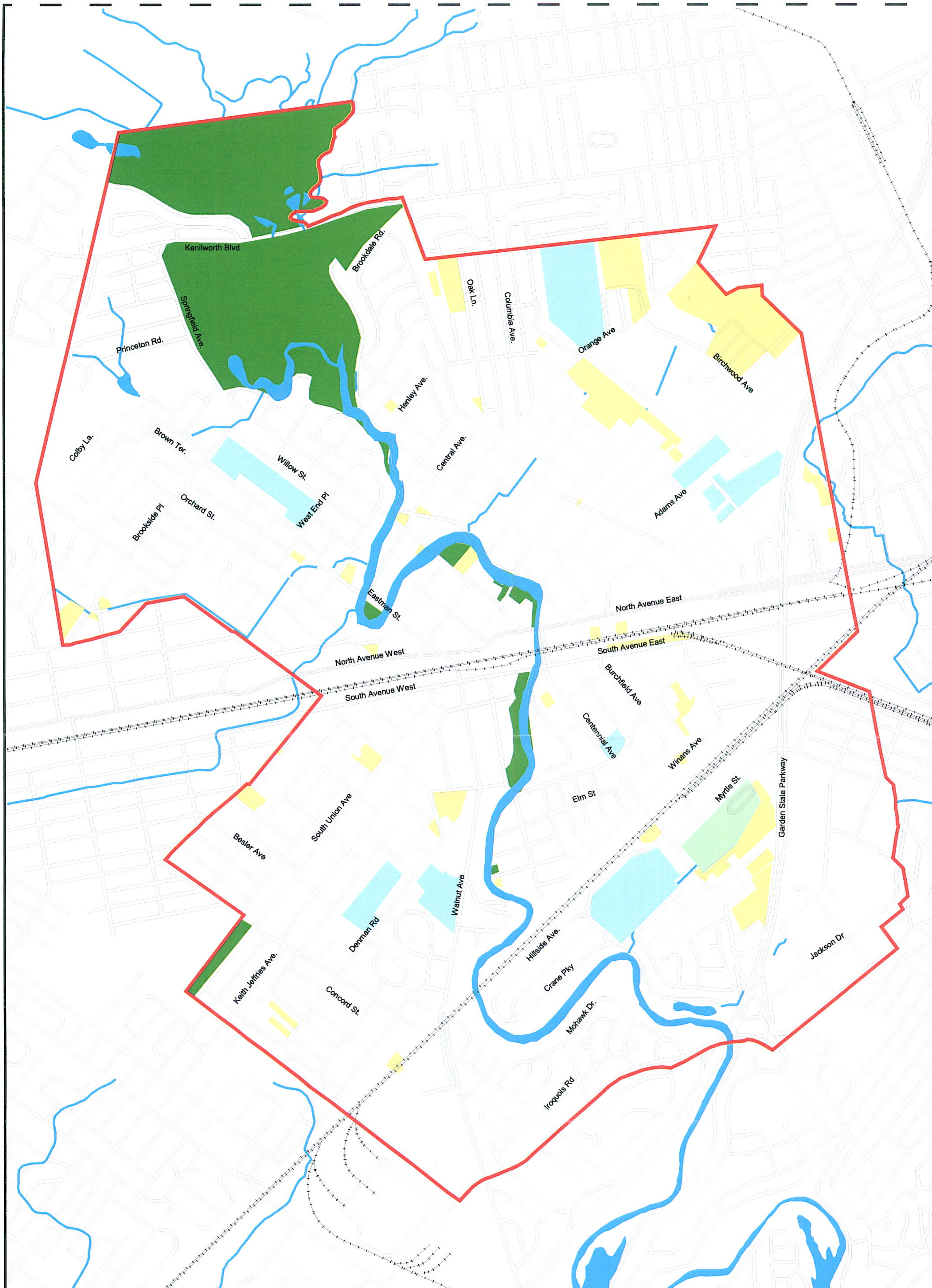


ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 1
ROAD MAP

DATE: NOV 2003 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018



Openspace

- Municipal Owned
- Township Park Land
- Union County Park Land
- Board of Education

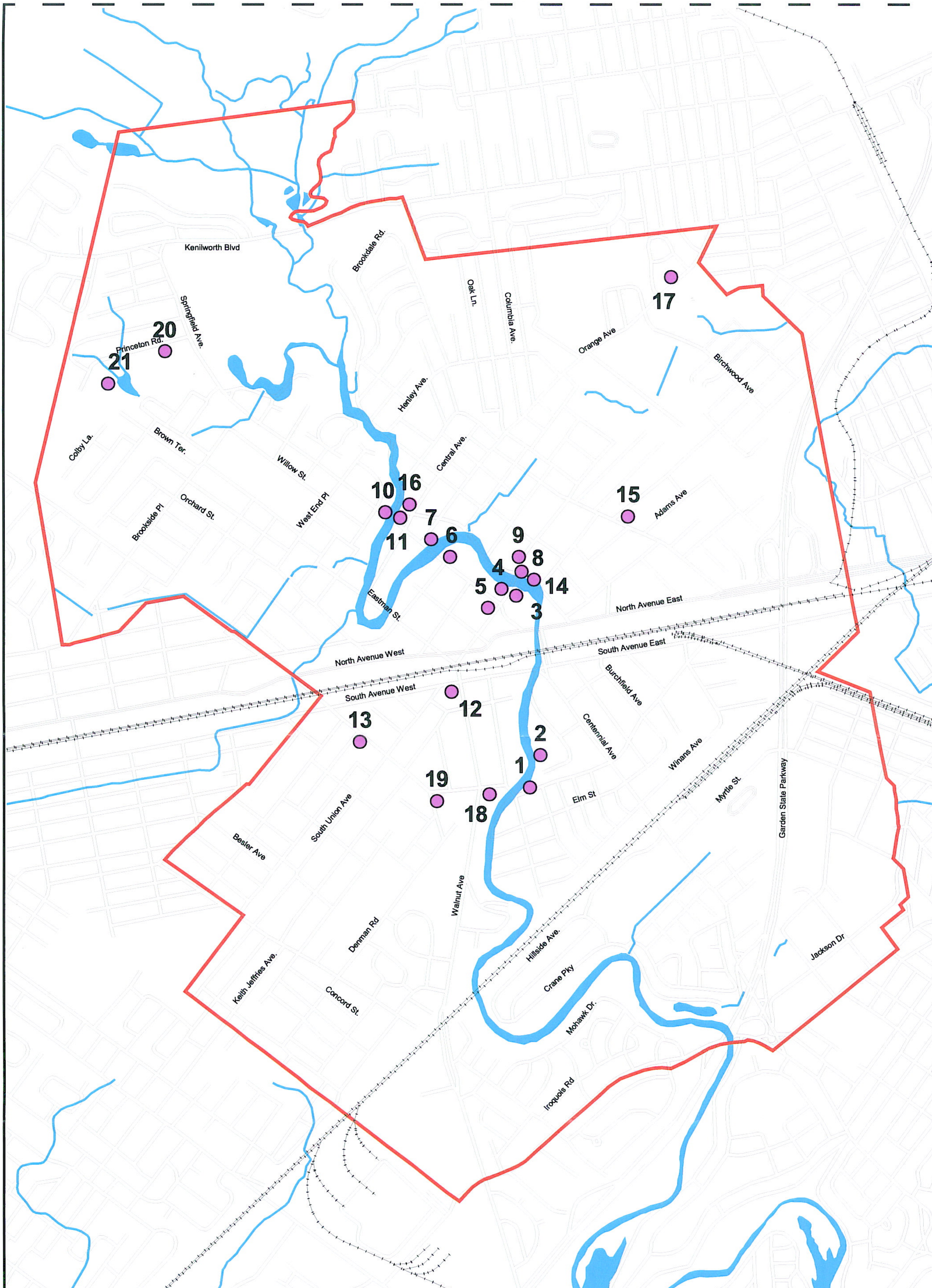
0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 2
OPENSPACE

DATE: NOV 2003 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018



0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 3
HISTORIC SITES

DATE: NOV 2003 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018

LEGEND

MUNICIPAL BOUNDARY
SURFICIAL GEOLOGY
WATER
NO SURFICIAL DEPOSITS

0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 4
SURFICIAL GEOLOGY

DATE: NOV 2002 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018

LEGEND

MUNICIPAL BOUNDARY

SOIL BOUNDARIES

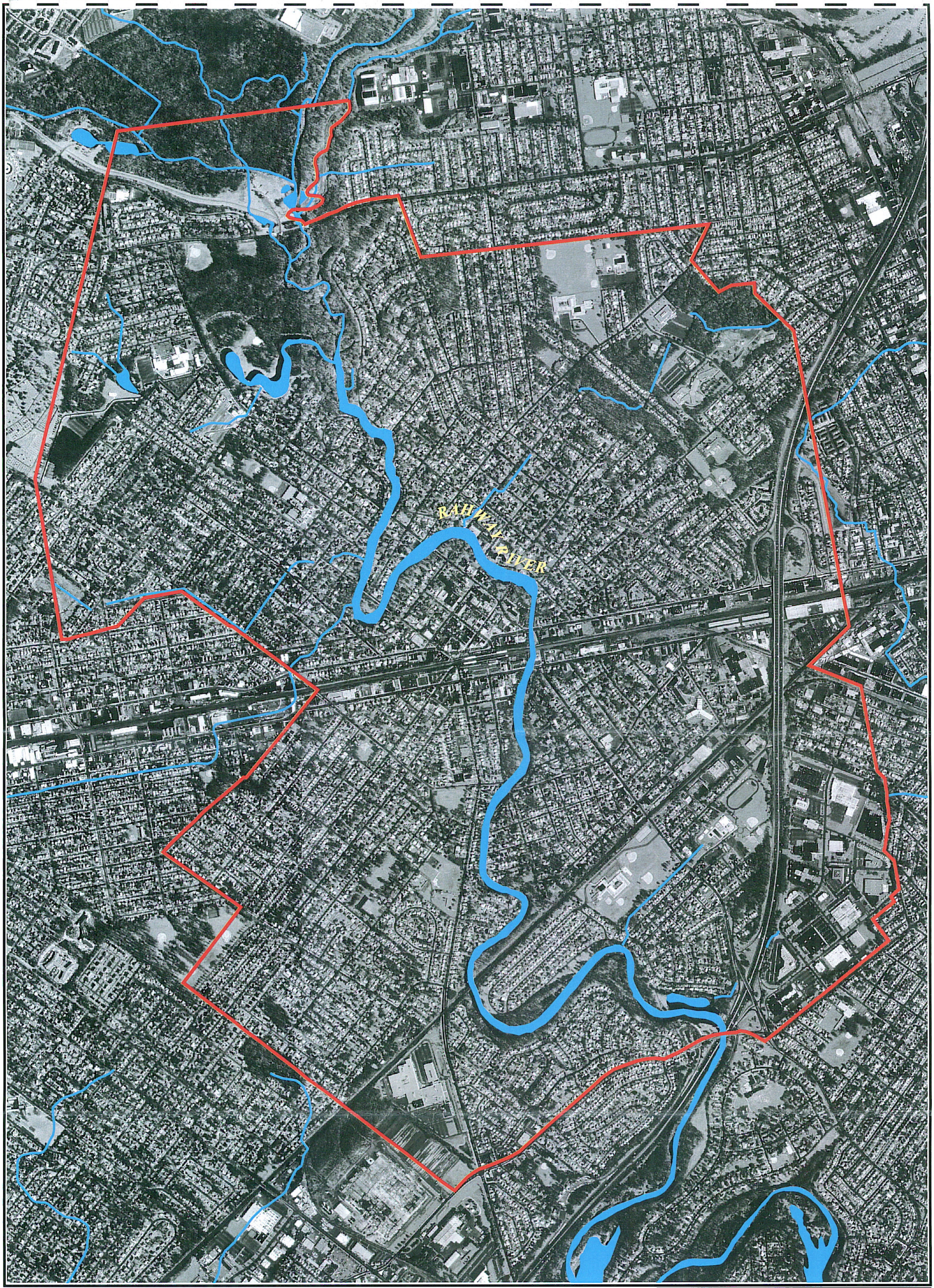
0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 5
SOIL SURVEY

DATE: NOV 2002 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018



LEGEND

MUNICIPAL BOUNDARY

SURFACE HYDROLOGY

WATER

0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 6

SURFACE HYDROLOGY

DATE: NOV 2002 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018

LEGEND

MUNICIPAL BOUNDARY

WETLANDS
- DECIDUOUS SCRUB/SHRUB WETLANDS
- DECIDUOUS WOODED WETLANDS
- HERBACEOUS WETLANDS
- MANAGED WETLANDS (MODIFIED)
- NATURAL LAKES, STREAMS AND CANALS

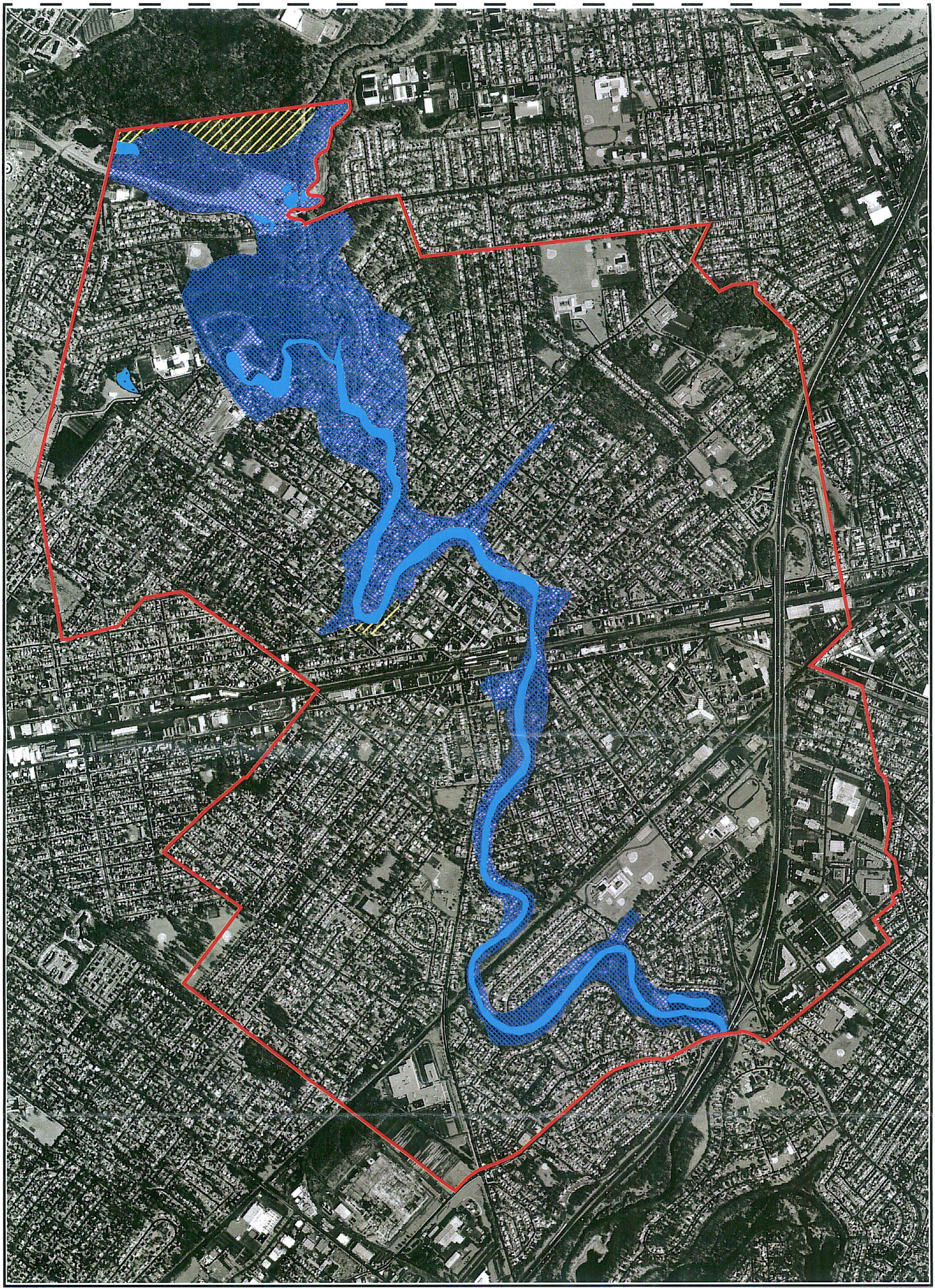
0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 7
NJDEP WETLANDS

DATE: NOV 2002 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018



LEGEND

MUNICIPAL BOUNDARY

FLOODPLAIN

Documented Floodprone Area

Undocumented Floodprone Area

Surface Water

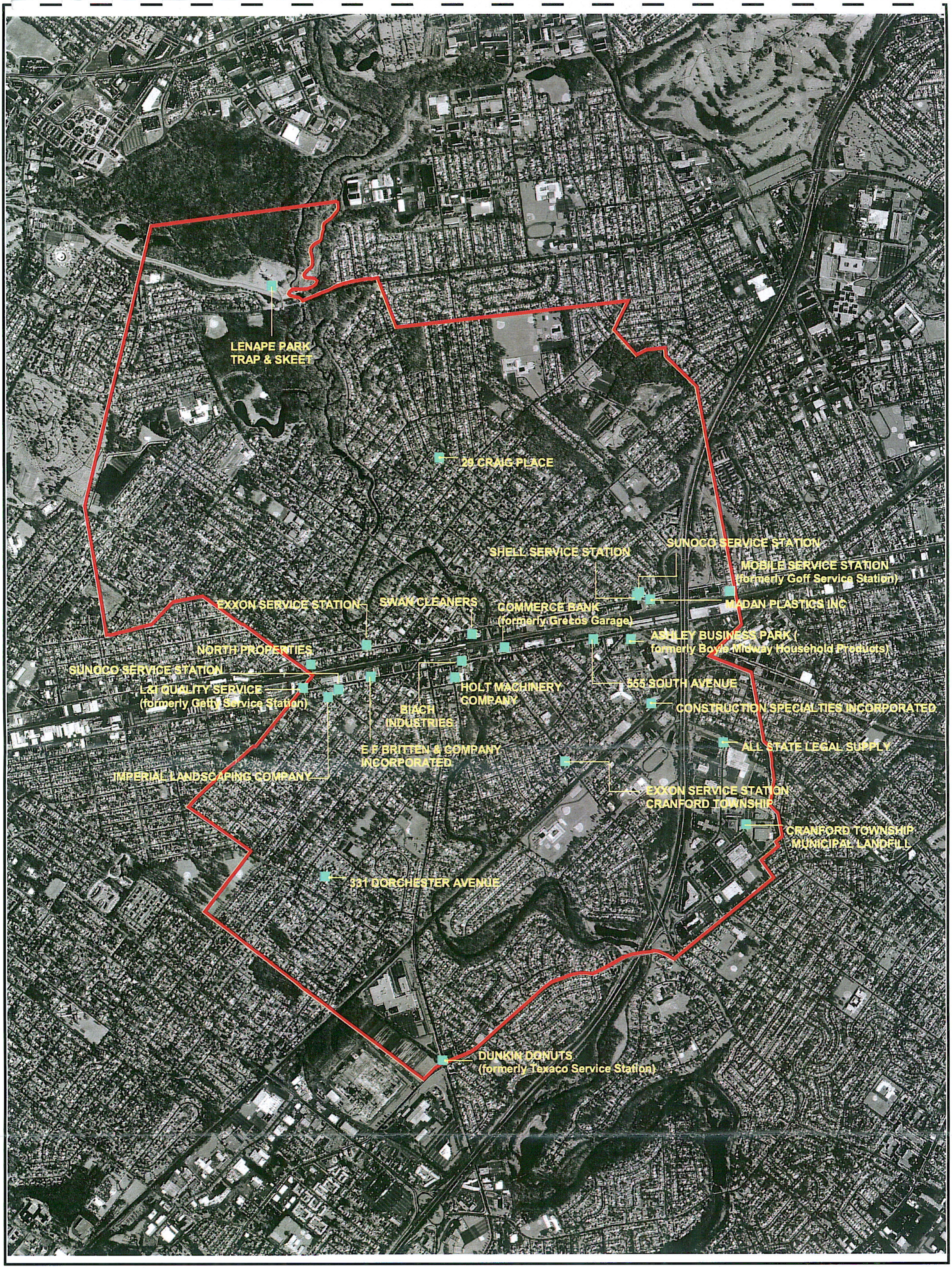
0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 8
FLOODPLAINS

DATE: NOV 2002 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018



LEGEND

- MUNICIPAL BOUNDARY
- KNOWN CONTAMINATED SITES

0.25 0 0.25 Miles

ENVIRONMENTAL RESOURCES OF CRANFORD TOWNSHIP

MAP 9
2001 KNOWN
CONTAMINATED SITES

DATE: October 2003 FILE ID: CRAN_ERI.

THE LOUIS BERGER GROUP, INC.
100 HALSTED STREET
EAST ORANGE, NJ 07018