Prepared by:

Madison Environmental Commission

&

December 2011

- Environmental Resources Inventory (ERI)
- Borough of Madison
- Morris County, New Jersey

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I. FORWARD

In 1968, the New Jersey Legislature passed a law that enabled municipalities to create "Conservation Commissions." These commissions, later renamed "Environmental Commissions," were created to be non-elective, advisory units that would promote the conservation and development of the natural resources within the municipalities. Amended in 1972, the 1968 New Jersey law stipulated that "[t]he governing body of any municipality may by ordinance establish an environmental commission for the protection, development or use of natural resources, including water resources, located within its territorial limits." The State Legislature suggested that environmental commissions, as part of their conservation efforts, prepare natural resource inventories, plans and projects for recommendation of conservation measures to be included by planning boards in master plans for land use.

Pursuant to the provisions of Chapter 245 of the Laws of 1968 of the State of New Jersey, on June 14, 1971, Madison adopted and approved Ordinance 13-71, which was introduced to amend and supplement the Madison Borough Code entitled "Revised Ordinances of the Borough of Madison, New Jersey," adopted May 11, 1970. The Ordinance included a new article, Article 14, entitled "An Ordinance to Establish and Constitute a Conservation Commission in the Borough of Madison, County of Morris, New Jersey." Article 14 established a Madison Conservation Commission (later to be called the Madison Environmental Commission) for "the protection, development, or use of natural resources, including water resources, located within the territorial limits of the Borough of Madison."

The Madison Environmental Commission (MEC) began functioning in January 1972. Three years later, in 1975, passage of the New Jersey Municipal Land Use Law, which required a Land Use Plan Element incorporating resource data as part of a municipal master plan, heightened the need for municipalities to maintain an index of their natural resource information and open space areas for local planning purposes. In 1977, an inventory of the natural resources of Giralda Farms (the former Dodge Estate) was completed and represented the MEC's first contribution to the resource data. Out of necessity for a comprehensive survey of Madison's man-made and natural resources for planning information, the MEC's first Environmental Resource Inventory (ERI) for the Borough of Madison was published in 1982. The 1982 ERI was submitted by the MEC for incorporation into the Land Use Plan Element of the 1982 Master Plan.

According to the Foreword to the 1982 ERI, "[i]nitially there was some reluctance to prepare an ERI in Madison because the Borough was almost fully developed." The basis for that initial reluctance in 1982 was equally evident in 2001; but it had become clear that the justification for creating the ERI in 1982 was even more of a reason for revising it 2001, and ten years later in 2011. As one author of the 2001 ERI stated, "It has become apparent that the need for an ERI exists even in a mature community so that planning may be conducted on an environmentally sound basis, and the public may be aware of the various environmental constraints affecting the quality of life in Madison today."

Since the 2001 ERI, there have been innumerable environmental changes locally and globally in the past 10 years; this revision does its best to update the inventory where appropriate and take advantage of the latest available technology to gather relevant data. In terms of format

and historical information, the 2011 edition of the ERI for the Borough of Madison owes an obvious debt to its two earlier versions (the 1982 ERI and 2001 ERI). Similarly, the current members of the MEC are thankful that their predecessors were able to create such an inspired document, thereby establishing a high standard toward which we have aspired.

This edition of the ERI includes updated fold-out maps that depict locations of environmental resources. The maps are referenced throughout the document, and are included at the end of the report in the "Map Appendix." The maps were created by H2M Associates, Inc., utilizing the most currently available Geographic Information System (GIS) data. A discussion of their source data is provided in the final chapter. It should be noted that since the production of the 2001 ERI, there have been changes to the Borough's municipal boundary, such as the annexed property from Florham Park. The maps included herein reflect the Borough's new municipal borders.

It is critical that the Borough of Madison continue to monitor its natural resources to ensure their protection, and if possible, future expansion. In a time of changing weather patterns, more prevalent natural disasters, and a dwindling supply of natural land areas, the importance of how land is "used" is more evident than ever. Sprawling development patterns, filling in wetlands, and cutting down forests, for example, have long-term and costly negative environmental and economic impacts. One example of the extraordinary impact of over-development is the devastation and intense flooding felt up and down the east coast in late August 2011, as a result of Hurricane Irene. Despite having very little surface water within its borders, Madison was not spared from serious flooding and related damage.

To protect its remaining open space areas and natural resources, and at the same time ensure continued economic growth, the Borough can institute "smart growth" development techniques such as redevelopment and transit-oriented development (TOD). At the same time, the Borough can introduce ordinances and policies that strive to conserve resources and are more "green." Examples include adopting a Sustainability Plan as an element of the Borough's Master Plan, introducing green building ordinances, establishing citizen committees that run environmental programs, and creating incentives for sustainable practices (i.e., green roofs, community gardens, native plants on lawns, walk to school programs, etc.).

Building on its efforts in 1982, 2001, and 2011, Madison can also continue to inventory its natural resources over time to ensure that resource protection is moving in the right direction.

II. INTRODUCTION TO MADISON

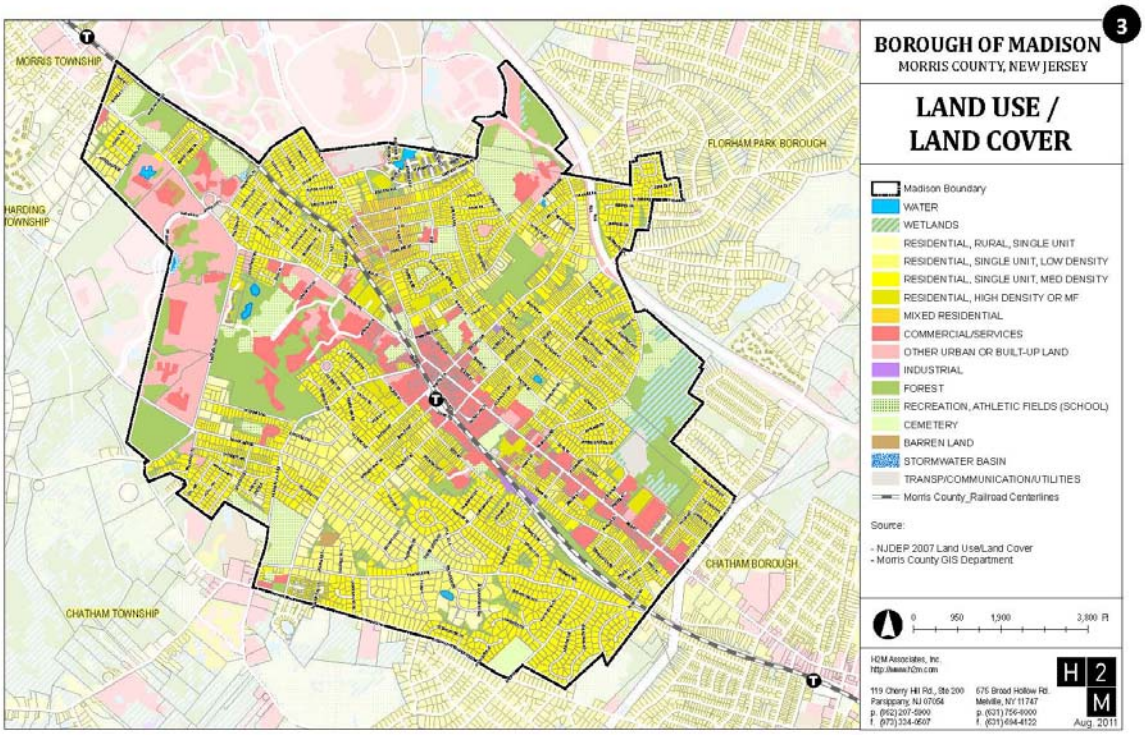
The Borough of Madison lies in the southeastern section of Morris County, approximately 23 miles west of New York City. It is located at approximately 40° 46' north latitude and 74° 26' west longitude. Madison is bounded on the north by the Borough of Florham Park, on the east by the Borough of Chatham, on the south by Chatham Township and on the west by Morris Township. The land area of Madison is 4.205 square miles. (See Map 1)

The Borough is located in the Newark Basin, one of the four major physiographic provinces of the State of New Jersey, and is in the Passaic River watershed. The topography is characterized by gently rolling to hilly terrain, with few slopes or grades over 10 percent. The terminal moraine of the most recent advance of ice, called the Wisconsin Glaciation, curves through town. Elevation varies from 190 to 380 feet above sea level. County Route 124 (also known as Main Street; formerly State Route 24), the major east-west thoroughfare, roughly bisects the Borough as it runs from the southeast to the northwest. (See Map 2)

Madison is predominantly a single-family residential, suburban community with a central business district along Route 124. There is very little industry and almost no vacant land. The Existing Land Use Map (See Map 3) and the table below show existing land use and relative acreages of each land use category. Natural features/areas for parks and recreation, highlighted in the table in yellow, make up just 21.4% of Borough land use, with forested areas accounting for 12.4% and recreation uses and school athletic fields making up 6.4% of Borough land area. The extent of change in land use over time is discussed in the Open Space section of this ERI.

Land Use / Land Cover Acreages in Madison (NJDEP)

LAND USE	AREA (ACRES)	PCT
LAKE	8.0	0.3%
RESIDENTIAL, SINGLE UNIT, RURAL/LOW DENSITY	335.8	12.1%
RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	1,120.7	40.5%
RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	109.2	3.9%
MIXED RESIDENTIAL	37.9	1.4%
COMMERCIAL/SERVICES	256.8	9.3%
INDUSTRIAL	4.1	0.1%
OTHER URBAN OR BUILT-UP LAND	215.4	7.8%
FOREST AREA	344.1	12.4%
FIELD/BRUSH/SHRUBLAND	8.7	0.3%
WETLANDS	55.3	2.0%
RECREATION / ATHLETIC FIELDS	178.1	6.4%
CEMETERY	16.6	0.6%
STORMWATER BASIN	2.1	0.1%
TRANSITIONAL AREAS	6.6	0.2%
TRANSPORTATION/COMMUNICATION/UTILITIES	28.4	1.0%
RAILROADS	23.9	0.9%
ROUTE 24	6.8	0.2%
UPLAND RIGHTS-OF-WAY	9.1	0.3%
TOTAL	2,767.6	100.0%



Madison's conversion of natural land to developed land seems to be outpacing its population growth. The population of Madison increased by 3.2% between 1980 and 1990 (from 15,357 to 15,850), and by an additional 4.3% from 1990 to 2000 to 16,530 residents. However, between 2000 and 2010, Madison's population fell by 4.3%, returning the Borough essentially to its 1990 population. In addition to a decreasing population base, Madison will also need to deal with an aging population. The median age of Madison's population has substantially increased according to US Census figures. In 2010, the median age in Madison was 38 years, compared with a median age of 34.4 years in 2000. This increase in median age is consistent with many parts of the State which are seeing their baby boomer populations' age. Children make up fewer than 35% of the Borough's population, where there are approximately 3,600 school-age children, approximately 1,000 pre-school age children; and 938 children under the age of 5 in 2010.

Racially, the Borough experienced some increase in diversity between 2000 and 2010. The "white alone" population fell from representing 90.1% in 2000 to 86.8% of residents in 2010, while the Borough experienced some growth in its Asian population and persons indentifying as "some other race." The racial breakdown, as tracked by the 2000 and 2010 Census, is as follows:

Race	2000	2010	% Change
Total:	16,530	15,845	-4.3%
White alone	14,891	13,746	-8.3%
Black or African American alone	464	469	1.1%
American Indian and Alaska Native alone	7	19	63.2%
Asian alone	592	873	32.2%
Native Hawaiian and Other Pacific Islander alone	33	2	-1550.0%
Some other race alone	166	371	55.3%
Two or more races	377	365	-3.3%

Housing development in the Borough has increased since 1980, but the growth has tapered off in the last decade, as the population decreased (and the economic slowdown hit). Between 1980 and 1990, housing units increased by an astonishing 11.4% from 4,997 to 5,564 and by another 3.1% to 5,737 units in 2000. In 2010, the total number of housing units rose slightly to 5,775. Of those units, 5,485 (95%) were occupied and 290 vacant.

In 1990, the average value of single-family housing units in Madison was $286,612. In October 2001, the average residential home value had climbed to $427,207. As the size of homes expanded (due to "tear downs" and McMansion development), the average value of homes in the Borough continued to greatly outpace inflation. A healthy economy in the late 1980s and most of the 1990s, plus the introduction in June 1996 of "Midtown Direct" train service (which provided direct service from Madison to Manhattan's Penn Station) contributed to substantially increased property values in the Borough. By 2006, the average home value in Madison had skyrocketed to $664,292 and the median home sale price had risen to $602,550 making it within the 88th percentile rank in New Jersey at the time. Across the State and the Nation, however, housing values and the number of sales have plummeted, since the burst of the housing bubble in 2008.

The average income in the Borough is also increasing. According to 2000 Census, the median household income in 1999 dollars was $82,847. The Census Bureau's 5-Year Estimates show the median household income (in 2009 inflation-adjusted dollars) rose to $103,969, approximately double the median household income of the average household in the United States.

In summary, like many New Jersey communities, the Borough of Madison experienced a population and development boom up until the "Great Recession" hit in 2008. The first decade of the new Century, and particularly the last few years of the decade, have had a quite an impact on land use, demographic and economic conditions in the Borough. Between 2000 and 2010, the following occurred-

- Vacant and natural areas decreased, including the development of 13 acres of forest
- Total population decreased by 4.3%
- Population diversified slightly in race
- The median age of residents increased dramatically from 34.4 to 38
- The housing stock grew by just 38 additional residential units
- Housing values and prices spiked in 2008
- Average income continues to rise

As the Borough updates its Master Plan and land use policies and ordinances, these factors must be considered, along with the Borough's long term goals and objectives towards growth and development.

III. HISTORY

Originally a heavily forested area of hills and swamps interspersed with meadows, Morris County was first inhabited by the peaceable Lenape Indians. The Lenape Indians' famed Minisink Trail ran from the Atlantic Ocean via the present Kings Road and Park Avenue to the Delaware River. Native American artifacts and campsites have been found throughout the area.

In the early 1600s the Dutch laid claim to what now comprises New Jersey by virtue of Dutch explorations of the Hudson and Delaware Rivers and certain purchases from the Indian inhabitants. The Dutch settlements were mainly along the coast and waterways, with some penetration into the inland areas. The English, hotly contesting the Dutch claims, finally won all of the Dutch territory when New Amsterdam (Manhattan) surrendered in 1664.

England's Duke of York granted proprietorship of the land between the Hudson and Delaware Rivers to Lord John Berkeley and Sir George Carteret. In 1676 the province, newly christened Nova Caesarea, was divided into East and West Jersey. At that time, Boards of Proprietors were responsible for buying the land from the Indian inhabitants for staking out large tracts of land that were in turn broken down and sold to smaller landowners.

Whippany became the hub around which the future Morris County was formed, and the entire area became known as "Whippanong." Settlers first came because of iron deposits in the hills to the north and west. They were rapidly followed by Presbyterian settlers from Elizabethtown, Newark, Long Island and New England. Whippanong was then a part of Burlington County in East Jersey. In 1714 northern Burlington County became Hunterdon County. In 1739 citizens of northern Hunterdon petitioned to become Morris County, named after Lewis Morris (1671-1746), appointed Royal Governor of New Jersey in 1738. Morris County then included all of the present Morris, Sussex and Warren Counties.

In 1720 Whippanong formally became Hanover Township, and the areas of the future Chatham and Madison became known as "South Hanover." Sometime during the early 1700s a tavern, located at the crossroads of the present Park and Ridgedale Avenues, and a cluster of nearby farms, came to be known as "Bottle Hill."

In 1740 the future Madison was divided between two townships by a line drawn from east to west along Kings Road and Park Avenue separating Hanover Township and the newly created Morris Township. Citizens residing north of the line paid taxes to Hanover, and those south of the line to Morris. This was not remedied until 1806, at which time Chatham Township was created. Madison remained a part of Chatham Township until Christmas Eve 1889, when Madison Borough was incorporated with definite boundaries and a government of its own.

THE PEOPLE AND CULTURE

In 1747 "South Hanover" became populated enough for churchgoers to break off from the Presbyterian Church at Whippany and form the "Meeting House at Bottle Hill." The first settlers of Whippany and Bottle Hill were almost all Presbyterians of English ancestry. Staunch support of church and school were part of their Puritan heritage, and the first schools in Bottle Hill predated the Revolution.

During the Revolutionary War, Bottle Hill sat midway between the militia headquarters at Morristown and the permanent military outpost at Chatham Crossing. In January 1777 the entire Continental Army under Washington's command came into winter quarters in this area after victories at Trenton and Princeton. Units camped wherever they could around Morristown. Old accounts indicate that the main body camped in the Loantaka Brook Valley around Kitchell Road and Treadwell Avenue, and that several officers were quartered in Bottle Hill. This was the first of two winter encampments in Morristown. The second was at Jockey Hollow during the winter of 1779-1780.

By 1800 Bottle Hill consisted of about twenty small wooden houses, most of them on farms of 12 to 40 acres along the old roads. There were cider mills, due to the large apple crops, and a few gristmills. From 1801 to 1804, toll road from Elizabethtown to Sussex, creating what are now Main Street, lower Madison Avenue and Morris Place. The downtown area began to develop with houses and stores. In 1837 the Morris and Essex Railroad was constructed through the village. This line was at grade level and generally paralleled the tracks of today, which were elevated in 1916.

A small Methodist congregation was formed about 1801. The American Revolution brought Francis Vacher, a Frenchman who came over with the Marquis de Lafayette, and the French Revolution of 1789 brought Boisaubin, Duberceau, Blanchet and others of French ancestry, who were instrumental in founding the Roman Catholic Church. Irish Catholics followed in the 1840s and 1850s.

The French were mostly wealthy plantation owners such as Vincent Boisaubin, whose mansion still stands on Treadwell Avenue in nearby Chatham Township. In the 1830s they were joined by an American plantation owner, William Gibbons, who had inherited from his father vast properties in Georgia, New York and New Jersey. He built a mansion later named Mead Hall on a tract of land that was acquired by Drew University in 1867. Both houses are now listed on the National Register of Historic Places.

Just as Lafayette's nostalgic return visit to Bottle Hill in 1825 ended the Revolutionary War era, the renaming of the village in 1834 as Madison ushered in a new era. By 1854, with a population of 120, Madison contained six stores and five churches: Presbyterian, Methodist, Roman Catholic, Episcopal and African Union. In 1858, when the Reverend Samuel Tuttle sold his property, he stipulated that the "Tuttle Oak" must not be removed to make way for Prospect Street. It stood in the middle of the road until 1996, when it was struck by a passing truck on the night of the town's annual Christmas parade.

Since the colonial period, a small number of African Americans have lived in current Madison. Initially composed of slaves, the African American community in Madison later included freedmen, whose numbers gradually increased after the New Jersey State Legislature passed the Act for Gradual Abolition of Slavery in 1804. By 1840, a separate religious community had formed, which built the first African Union Church in 1850, a successor in 1864, and the existing Bethel African Methodist Episcopal Church in 1885.

William Gibbons paid about $35,000 for the 205 acres called "The Forest," which became Drew Theological Seminary in 1866, a training center for Methodist ministers. In September 1928, Drew admitted its first liberal arts students and it is now known as Drew University. Thomas Kean, former Governor of New Jersey, is currently the President of Drew University.

In 1856 the first of many greenhouses for growing roses was built in Madison. For more than 100 years, rose growing thrived here, at least in part because of the good rail service—Madison has its own train station. More than 45 rose growers thrived in Madison in 1896, at which time the greenhouses included a half-million square feet of glass. At one time 40,000 to 50,000 buds were shipped via Railway Express from Madison each day. Local growers won many prizes for new varieties of roses at national exhibitions, and Madison became known as "The Rose City." In 1950, the local rose industry reached its peak. The industry gradually faded and ultimately disappeared when the final rose range in the Borough closed in 1984, the victim of cheaper imports. Several greenhouses were razed to make way for State Highway 24 and many others were leveled for housing developments.

A few people began traveling to Newark each day on the new railroad soon after it was built. By the mid-19th century Madison had been discovered as a vacation place by city dwellers seeking a healthful month in the country. Madison's clean air, pure water and beautiful vistas first attracted summer boarders. In 1862 the Morris & Essex Railroad was extended from Newark to Hoboken, providing a connecting rail link to New York City. In the years that followed, many wealthy New Yorkers began buying up farms and building estates in the vicinity of Madison. By 1880 the "Gilded Age" had begun.

It was during this period that Madison's thriving Italian American community had its beginnings. Italian gardeners were much sought after on the estates. Their numbers grew as relatives and friends joined them to work on the estates and in the greenhouses.

Among the estate owners, three families deserve special mention due to their generosity to Madison. D. Willis James bought the land for James Park, built and donated the James Public Library in 1899 (now the Museum of Early Trades and Crafts), and gave the James Building on the corner of Main Street and Green Village Road as a business building and assembly hall to be used for the financial support of the library. The 42-acre site of Madison High School was donated by the heirs of Hamilton McKay and Florence Vanderbilt Twombly, whose vast estate "Florham" included the mansion and grounds acquired in 1957 by Fairleigh Dickinson University for its Florham Park-Madison campus.

Geraldine Rockefeller Dodge was perhaps Madison's greatest benefactor. She donated part of Dodge Field as a public playground. She also founded St. Hubert's Giralda as an animal

shelter. Her internationally known Morris & Essex Dogs Shows were held annually on the Dodge property for 30 years, starting in 1927. Mrs. Dodge's largest gift to the Borough was the Hartley Dodge Memorial Building, dedicated in 1935 as a living memorial to her only son, Marcellus Hartley Dodge Jr., who, in 1930, soon after graduating from Princeton University, was killed in an automobile accident in France at the age of 22. The Geraldine R. Dodge Foundation currently provides financial support for many local projects and organizations.

Madison's municipal institutions were formed in the late 19th century, about the time the Borough became a legal entity. The Fire Department was formed in 1881, the Police Department in 1880, and the library in 1900. The 20th century saw Madison grow to a community of over 15,000. For a long time it remained partly rural and partly suburban. Some families have lived here for many generations. There are two universities, Drew and Fairleigh Dickinson, within the Borough's boundaries and another institution of higher education, the College of Saint Elizabeth, in nearby Convent Station.

The bicentennial year 1976 saw a resurgence of pride in heritage. A Bicentennial Ball was held at the Borough Hall and the first "Bottle Hill Day" was inaugurated. It has become an annual event, along with the Little League Parade, the Memorial Day parade and the Christmas parade (held on the Friday after Thanksgiving). As the 20th century drew to a close, the winding down of the millennium gave rise to a Millennium Picnic held at Memorial Field in June 1999 and a New Year's celebration in the downtown business district to ring in the year 2000.

The $101 million State Highway 24 finally opened for traffic in November 1992, after 40 years of planning and delays for environmental and economic reasons. The highway immediately made an impact on old Route 24, now County Route 124, as the average daily volume of vehicular traffic on new Route 24 (estimated in one early study to be 46, 388) reduced the average daily number of vehicles crossing the Madison-Chatham border from 27, 240 in 1990 to 18,487 in late 1992.

Development of the remaining open spaces within the Borough continued throughout the 1990s, but at least two major parcels of land were saved from development as well. The Loantaka Moraine (Terminal Moraine), 23 acres in Madison at the corner of Woodland Road and Loantaka Way, were acquired by the Morris County Park Commission in December 1994 for annexation to the County's 574-acre Loantaka Brook Reservation, located in Chatham, Morris and Harding Townships. In June 1997, Gibbons Pines, three acres of untouched land on Gibbons Place, was saved from development when it was acquired by the Borough with assistance from the Morris County Parks and Land Conservancy. At the time, these three acres represented ten percent of the Borough's remaining vacant land.

Most recently in 2010-2011, the Borough acquired two properties through annexation from neighboring Florham Park, which has reshaped the northeasterly corner of the Borough's municipal boundary. Approximately 10.16 acres owned by the Madison Board of Education was acquired, as was 55.1 acres owned by the Borough of Madison, which had served as access to the Exxon Mobile Foundation property. A survey of the property shows the property contains small areas of freshwater wetlands, which have been confirmed by NJDEP.

IV. GEOLOGY

REGIONAL GEOLOGY

There are four principal physiographic provinces in New Jersey: Valley and Ridge; Highlands; Newark Basin; and Coastal Plain. Madison is located within the Newark Basin.

The Newark Basin is part of a series of basins that formed along the east coast in association with the opening of the Atlantic Ocean during the Triassic–Jurassic Periods (approximately 235 to 175 million years ago (Ma)). These basins are a result of rifting during the breakup of the continent, forming large extensional basins that had long periods of continuous deposition of sediments as rifting continued (Olsen, 1980).

The Newark Basin is a northeast to southwest trending basin that extends from Rockland County, New York to Lancaster County, Pennsylvania (VanHouten, 1988). The Basin is separated from the Highlands to the northwest by the Ramapo Fault (west of Morristown), and is covered to the southeast by the sediments of the Coastal Plain (Drake et al., 1996).

The Newark Basin is filled with red, brown, gray and black clastic and evaporite sediments. These sediments were predominantly deposited in lacustrine (lake) environments, and color changes reflect changes in lake levels and climatic changes (Olsen and Kent, 1990). The bedding planes of the deposits generally trend northeast to southwest and dip gently to the northwest. The sediments are interrupted by igneous rocks (basalt and diabase) that form the higher ridges. These ridges are commonly known as the Watchung Mountains.

MADISON'S GEOLOGY

The shallowest bedrock in Madison is part of the Boonton Formation (Lower Jurassic Period, approximately 190 to 175 Ma), which is the youngest of the depositional cycles of the Newark Basin (Olsen, 1980). The Boonton Formation was deposited on top of the Hook Mountain Basalt (Long Hill is part of this Basalt). Madison is located on the Watchung Syncline within the Newark Basin, where flexure in the bedrock between the Hook Mountain Basalt and the Highlands caused the bedding planes to dip inward on both sides (Drake et. al.,1996). This syncline extends southwest through the Great Swamp, and north through Black Meadows and Troy Meadows.

The Boonton Formation is dominated by red and brown cross-laminated sandstones and siltstones, with units of black shale and gray mudstone (Fedosh and Smoot, 1988). However, the bedrock is not seen in Madison, as it is covered by more recent unconsolidated sediments.

After deposition of the Boonton Formation, the next major change in Madison's geology occurred around 60 million years ago during the Tertiary Period when a broad, nearly featureless plain called the Schooley Peneplain was created by streams eroding the high surrounding elevations. During this time the elevation of the plain locally was equal to the present height of Long Hill, a few miles southeast of Madison. During the Tertiary Period, the historic Hudson River flowed southward along the Newark Basin, eroding bedrock and carving water gaps through the

Watchung Mountains. The Boonton Formation was eroded into a topography that includes hills and valleys under Madison's surface sediments.

During the Pleistocene Epoch that began approximately 2 million years ago, three glacial advances reached New Jersey. Locally there is little evidence of the first two, but the last, called the Wisconsinan Glaciation, was responsible for Madison's landform as we know it today. (See Map 4 for the topography of Madison.) The Wisconsinan Glacier began pushing southward some 80,000 years ago. The ice sheet was one mile thick in places, and probably 2,000 feet thick over northern New Jersey. As the glacier moved southward, the weight of the ice created great pressure that scoured bedrock leaving striae marks, and stripping boulders and sediment from the land surface (thereby destroying evidence of earlier glacial deposits). This material was transported by ice and by rivers flowing under, in, and above the ice sheet, and then deposited beneath and at the edge of the ice sheet.

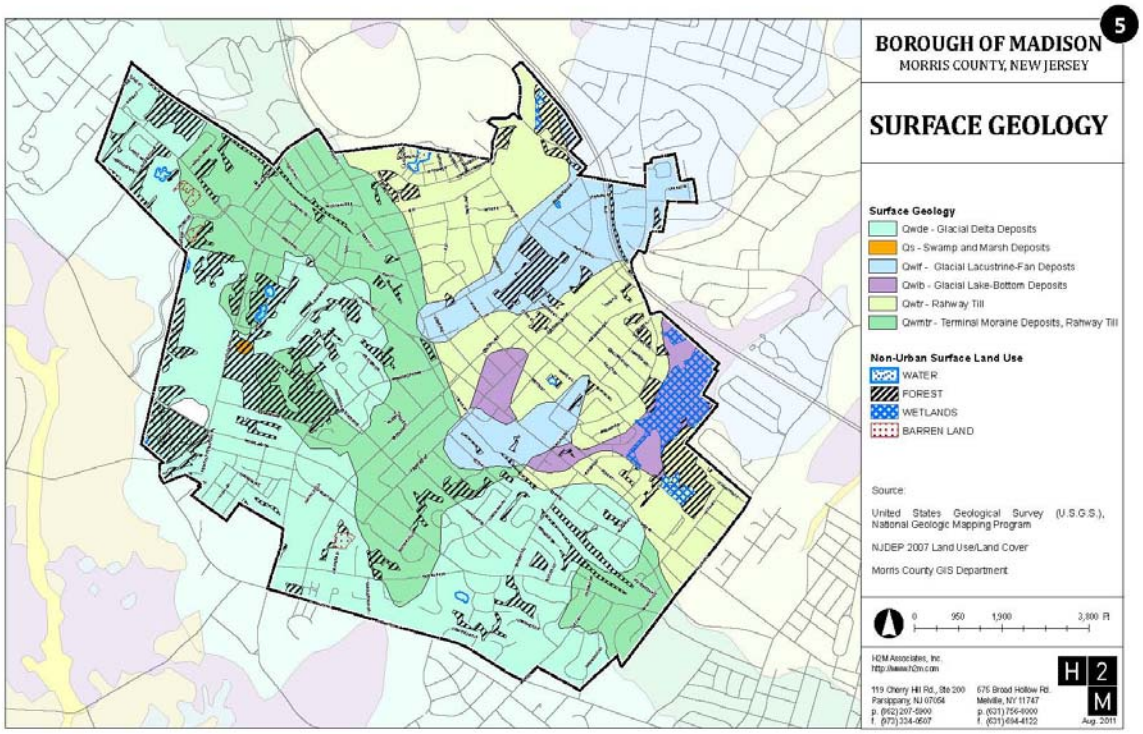
The glacier advanced from the north as far south as Chatham through Madison, Morristown, Dover and Netcong. In front of the glacier, Glacial Lake Passaic formed from its meltwaters. Prior to the advance of the glacier, the outlet of the southern basin of the Passaic River was through the Short Hills Gap. The glacier deposited sand and gravel in the gap, effectively blocking it and creating Glacial Lake Passaic between the ice and the ancient Watchung Mountains. When the glacier retreated northward, the lake, fed by meltwater from the glacier, grew until it was 10 miles wide and 30 miles long. At its maximum extent, Glacial Lake Passaic drained to the south through Moggy Hollow in Far Hills. The retreating glacier finally uncovered another outlet at what is now Little Falls Gap, near Paterson, and then the lake drained out along the present course of the Passaic River. Where there was once a lake, there still are extensive marshes and swamps. The Great Swamp is one of them.

The glacial deposits had a significant impact on Madison. The bedrock surface forms a buried valley in a trend following Main Street and then Park Avenue. Within this valley is a layer of sand and gravel approximately 100 feet thick deposited either prior to glaciation or during several periods of glaciation. This feature is commonly known as the Chatham Buried Valley Aquifer. This is the source of Madison's water supply, with wells located at the Department of Public Works area, and the North Street Area. The aquifer is discussed in more detail in the chapter on Hydrology.

Overlying the Buried Valley and bedrock are other surface glacial deposits. Surficial geologic materials are unconsolidated sediments that overlie bedrock and Coastal Plain formations, and that are the parent material for agronomic soils. In New Jersey, they include glacial, river, marine, windblown, wetland, and hillslope deposits and weathered-rock material. These materials are distinguished and mapped based on their grain size, mineral composition, bedding, physical properties, and landscape position. They are as much as 400 feet thick but are less than 30 feet thick over most of the state. Glacial deposits and weathered-rock material occur in the northern half of the state, marine deposits occur in the coastal areas of southern and central New Jersey, the other deposits occur statewide.

As shown in the Surface Geology Map and the Table below, Late Wisconsin Glacial Deposits make up most of the Borough's Surface Geology (See Map 5). The southern edge of the Wisconsinan Glacier is marked by a great terminal moraine, which is a ridge-like accumulation of

clay, sand, gravel and boulders left when the edge of the glacier stagnated in Morris County for 2,000 to 3,000 years. The southern half of Madison ("the Hill") rests on the terminal moraine. Large portions of the northern half were also affected by the terminal moraine. It is believed that the terminal moraine once leaned against the edge of the glacier. Subsequently, as the ice receded, the terminal moraine collapsed toward the north.



Madison's Surficial Geology in Acres

SYMBOL	AREAS	GEOLOGY NAME	ACRES
Qs	1	SWAMP AND MARSH DEPOSITS	1.9
Qwde	1	LATE WISCONSINAN GLACIAL DELTA DEPOSITS	1,009.7
Qwlb	3	LATE WISCONSINAN GLACIAL LAKE-BOTTOM DEPOSITS	119.2
Qwlf	3	LATE WISCONSINAN GLACIAL LACUSTRINE-FAN DEPOSITS	293.7
Qwmtr	2	LATE WISCONSINAN TERMINAL MORAINE DEPOSITS, RAHWAY TILL	708.3
Qwtr	2	RAHWAY TILL	627.3
TOTAL	12		2,760.1

Excavations in the terminal moraine for the National Methodist Archives Building on the Drew University campus exposed highly stratified layers of sand and clay to a depth of at least 30 feet. In July 1981, the U.S. Geological Survey drilled a borehole through the terminal moraine at an elevation of 370 feet in Niles Park at the corner of Garfield Avenue and Woodland Road. The geologic log from the drilling indicates the moraine contains layers of glacial till, sand, silt and clay. It is likely these layers reflect the advance and retreat of the ice edge over the area several times.

The area roughly north of Main Street is approximately a hundred feet lower in elevation than the terminal moraine area. Near the ground surface is a clay and silt layer about 20 feet thick. It covers a glacial till layer that extends down another 20 to 30 feet. The clay and silt layers are lake deposits formed in Glacial Lake Passaic. In some areas, such as along Ridgedale Avenue, the clay layer is missing or buried by a ridge of glacial outwash deposits running perpendicular to the terminal moraine.

Glacial Lake Passaic covered all of Madison, except the highest elevations that were islands. Wind and waves from the northeast eroded the shoreline into a beach, technically called a "wave-cut terrace." Remnants of this beach can be seen in the area in front of Drew University to the south of Route 124. It is traceable for over a mile between elevations of 340 to 350 feet. Large boulders found near the 340 foot elevation were carried by icebergs in Glacial Lake Passaic. One can still see a line of boulders on the southwest side of Park Avenue and Columbia Turnpike, west of Madison. Another glacial feature in Madison is a broad flat delta or outwash plain built by streams flowing from the ice front into Glacial Lake Passaic. This plain starts at the corner of Loantaka Way and Woodland Road and extends to the northwest for about half a mile along Loantaka Way.

Several depressions, called kettle holes, are still identifiable in Madison. These were formed when large chunks of ice broke off from the retreating glacier and were subsequently buried in the outwash sediments. As the ice melted, the sediments collapsed into the empty spaces, leaving the depressions. An excellent example is the kettle hole in the southwest corner of the Drew Forest Preserve on Glenwild Road near Loantaka Way.

The Madison area owes its soils and landform to glacial activity. The most beneficial gift to Madisonians from this geological event is the Borough's water supply, which is described more fully in the chapter on Hydrology. Thus, events that occurred from thousands to millions of years ago influence our lives today.

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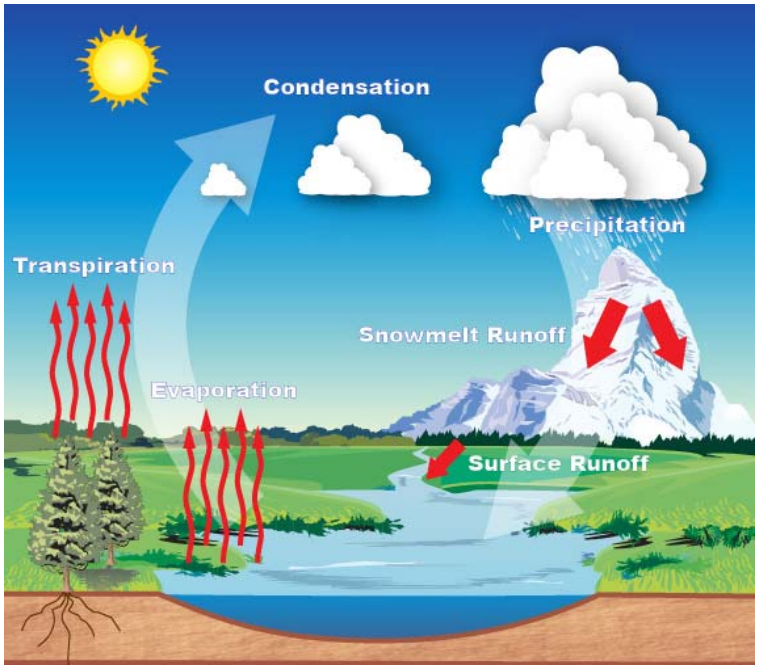
V. HYDROLOGY

Water is the natural resource we know best. The science which deals with the movement and distribution of water on earth is known as hydrology.

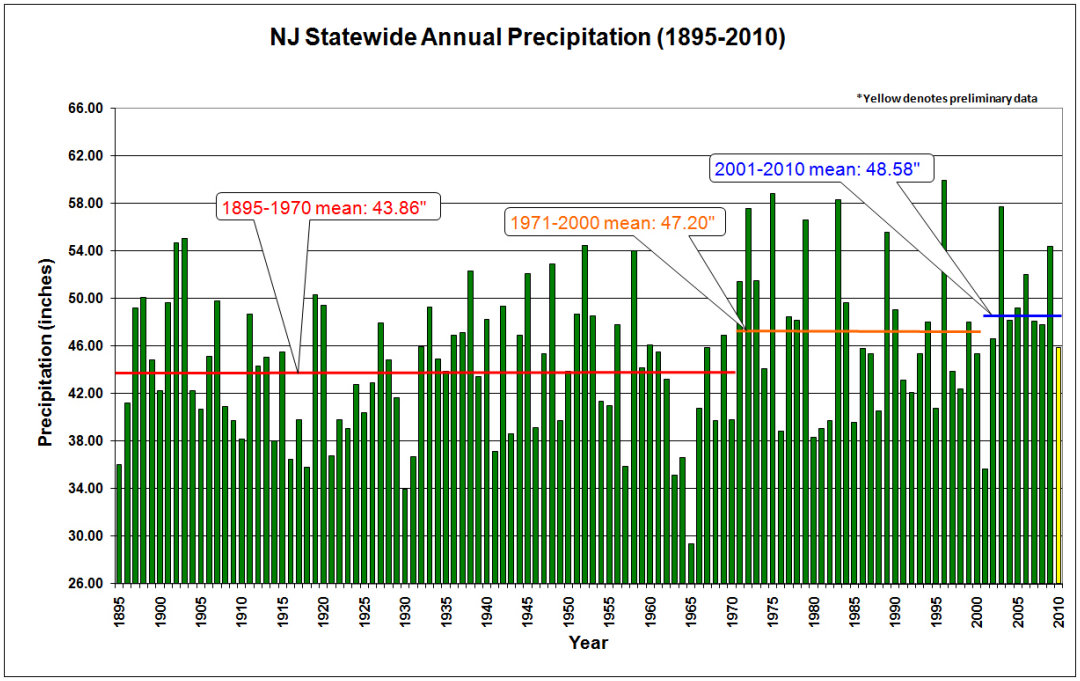
All of the water on earth (vapor, clouds, rain, snow, glaciers, rainwater runoff, rivers, lakes, oceans, groundwater) is part of a continuous physical process known as the hydrologic cycle. Water evaporates into the air from land, plants and water bodies, cooling as it rises. When this water vapor reaches the condensation point, clouds form. Eventually precipitation in the form of rain, snow or sleet occurs, often many miles from the area of evaporation. When the water falls back to earth it may either evaporate or transpire through the trees and plants back into the atmosphere, infiltrate into the soil, or flow across the land (runoff) into streams, rivers, lakes and oceans. The continuous movement of water from oceans to atmosphere to land and back to the sea is the major flow path of the hydrologic cycle. In the subterranean portion of the cycle, underground stores of water called aquifers may discharge some water directly to surface water bodies.

The Hydrologic Cycle



The two major sources of drinking water supply are groundwater and fresh surface water. Groundwater, which is water stored and moving in the ground, is the largest single source of freshwater on earth. Surface water consists of water found in ponds, streams, rivers, lakes and reservoirs. Both groundwater and surface water are recharged directly or indirectly through precipitation. "In New Jersey, an average of 44 inches of precipitation per year replenishes the state's 6,500 miles of streams and rivers, 61,000 acres of lakes and an extensive network of underground aquifers" (NJDEP, 1988). However, average annual precipitation ranges across the state: from about 40 inches along the southeast coast to 51 inches in north-central parts of the

state. Many areas average between 43 and 47 inches. Per the chart below from the Rutgers University Climate Lab, it is clear that the average annual precipitation rates in New Jersey have increased since data collection began in 1895.

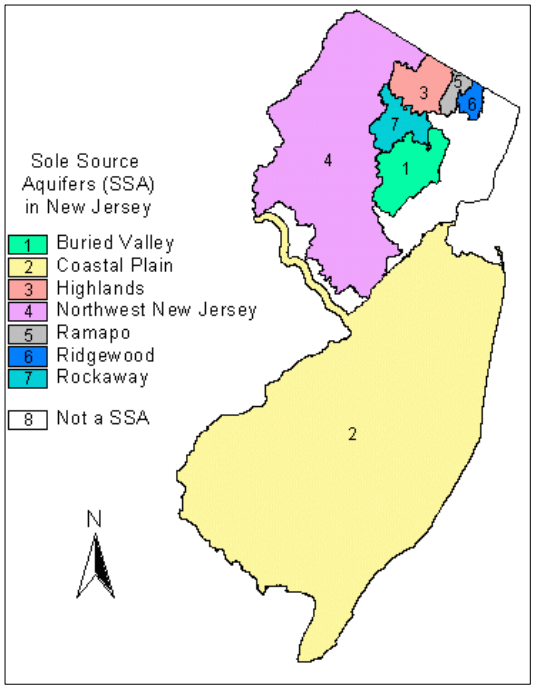


The U.S. Geological Survey estimates the total amount of water on earth at 326,000,000 cubic miles or 1.44 sextillion tons. Ninety seven percent (97%) of this water is in the oceans, two percent (2%) is in the polar ice caps and glaciers, and one percent (1%) in rivers, lakes, groundwater and atmospheric vapor. The greatest amount of all available fresh water can be found in groundwater. Groundwater makes up 96.5% of the one percent (rivers, lakes, groundwater and atmospheric vapor) mentioned above. "In New Jersey, sixty percent of our drinking water comes from underground sources." (Tucker, 1981).

GROUNDWATER

Within the Passaic River Basin, precipitation averages approximately 47 inches of water per year. "On average, evapo-transpiration accounts for about half of this water, about one-quarter runs off, and the remainder becomes groundwater" (Passaic River Coalition, 1993). When rainwater and snow fall onto the ground, some of this water infiltrates into the soil and seeps down into underlying rocks and sediments. This groundwater slowly fills cracks in rocks and spaces between sediment particles. Aquifers occur when storage of groundwater is sufficient to produce a water supply. Groundwater moves through porous soil and rock fractures by complex routes.

The aquifers underlying the Central Valley of the Passaic River in New Jersey are called the "Buried Valley Aquifers." They occur in valleys cut in the bedrock and prior glacial deposits. During the Ice Age, the Wisconsin glacier filled these valleys with glacial outwash sand and gravel deposits. These unconsolidated deposits contain groundwater in large quantities because of the large spaces between the sand and gravel particles. The Buried Valley Aquifers are the principal source of high-quality drinking water supply for more than 600,000 people and many businesses. All of the valley aquifers in the Passaic River Basin have been designated by the U.S. Environmental Protection Agency as "sole source aquifers" in accordance with the Safe Drinking Water Act of 1974. Therefore, on federally funded projects (i.e., highways, sewers), environmental impact assessment of groundwater is required.



The Buried Valley Aquifers occur in a series of interconnected valleys. They range from in width from 0.5 to 1.5 miles and in thickness from less than 1 foot to 100 feet. Glacial till, lake deposits of clay and silt, and swamp muck ranging in thickness from 10 to 80 feet overlie the aquifers and function as a confining layer (Meisler, 1976). Harold Meisler, a hydrologist with the U.S. Geological Survey, reported that core samples from Madison's wells show lake deposits in the layer just above the aquifer, and till above the lake deposits.

The Chatham Valley Aquifer, in which the wells of Madison, Florham Park and Chatham Borough are located, traverses the other aquifers and does not coincide with a surface valley. It underlies, and in part parallels, the terminal moraine. The land surface elevations overlying the aquifer range from 180 to 240 feet above sea level. Where the aquifer is overlain by terminal moraine, the land surface elevations range from 200 to 360 feet above sea level (Meisler, 1976).

As shown in the tables below, 31 municipalities and twelve (12) Public Water Supply Systems, including the Madison Water Department, utilize the Buried Valley Aquifer System.

Municipalities Utilizing the Buried Valley Aquifer System

Municipality	County	% GW	% SW	Water Co. *
Chatham	Morris	100		
Chatham Twp	Morris			X
East Hanover	Morris	100		
Florham Park	Morris	100		
Hanover	Morris	100		
Harding Twp	Morris	100		
Madison	Morris	100		
Montville	Morris	100		
Morris Plains	Morris	100		
Morristown	Morris	100		
Morris Twp	Morris	100		
Parsippany-Troy Hills	Morris	65		
Passaic Twp	Morris			X
Caldwell	Essex		100	
East Orange	Essex		100	
Essex Falls	Essex		100	
Fairfield	Essex		100	
Irvington	Essex			X
Livingston Twp	Essex		100	
Maplewood	Essex			X
Millburn	Essex	100		X
North Caldwell	Essex	100		
Roseland	Essex		100	
West Caldwell	Essex			
West Orange	Essex			X
Berkeley Heights	Union			X
New Providence	Union			X
Springfield	Union			X
Summit	Union			X
Bernards Twp	Somerset			
Warren Twp	Somerset			

GW – Groundwater; SW – Surface water;
Water Co – Obtains its water from both groundwater and surface water sources
Source: http://www.epa.gov/region2/water/aquifer/burval/buryval.htm

Public Water Supply Systems Utilizing the Buried Valley Aquifer System

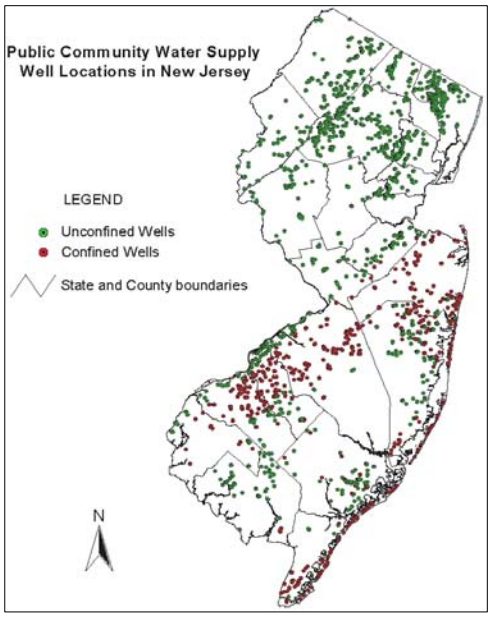
No.	Source
1	Livingston Twp Water Dept.
2	Southeast Morris County MUA
3	East Orange Water Dept.
4	Florham Park Water Dept.
5	Madison Water Dept.
6	Chatham Borough Water Dept.
7	Commonwealth Water Dept.
8	East Hanover Water Dept.
9	Parsippany-Troy Hill Water Dept.
10	Montville Water Dept.
11	Essex Fells Water Dept.
12	Fairfield Water Dept.

Source: http://www.epa.gov/region2/water/aquifer/burval/buryval.htm

MADISON'S WELLS & WELL HISTORY

Madison's five (5) wells (Wells "A" through "E") are the source of the Borough's drinking water. The five wells draw groundwater from the Buried Valley Aquifer System. The wells were drilled between 1952 and 1968, and are presently in use today. The Madison Water Department is a "Public Community Water Supply System" that manages water produced from the five wells, as well as water supplied from four (4) purchased ground water sources (Florham Park Water Department, Morris County MUA, Chatham Water Department, and the NJ American Water Company Short Hills.)

In the year 1898, the first five wells in the municipal water system were drilled in Madison. These were flowing artesian wells. An artesian well is a well deriving its water from a confined aquifer under sufficient pressure for groundwater to rise above the confining strata. In some instances the water pressure is sufficient enough to push the groundwater from the aquifer and up to the surface of the ground, giving rise to free flowing wells. The Borough's wells draw water from the Buried Valley Sole Source Aquifer System.



As the groundwater level dropped, the supply of free flowing water diminished. Later, all of the wells were linked together using a vacuum system. Ground water was sucked from the wells and pumped into twin tanks located on Midwood Terrace. Gravity flow supplied water to users throughout the Borough. Four

more wells were drilled in 1912, and three more in 1929. None of these early wells are still in use.

The Borough's public water supply system (Madison Water Department, PWSID 1417001) has a water allocation permit from the New Jersey Department of Environmental Protection (NJDEP) to operate these wells with a Water Supply Firm Capacity of 5.904 MGD (million gallons per day). The capacity of the each well ranges from 1.1 million gallons per day (MGD) to 1.9 MGD, per the table below. The wells discharge into a system of underground piping which also contains two water tanks. The Madison Avenue tank holds 500,000 gallons and the Midwood Terrace tank holds 750,000 gallons (Madison Water Department, 2011 Water Quality Report).

Well Capacity of Madison Wells

Well	Capacity (GPM)	Capacity (MGD)
A	800	1.15
B	1,100	1.58
C	1,300	1.87
D	1,200	1.73
E	1,200	1.73
Total	5,600	8.06

Treatability Study July 1999 by Elson T Killam Associates of Millburn NJ

WATER SUPPLY & DEMAND

As reported in the July 1999 *Treatability Study* by Elson T. Killam Associates, the actual pumpage rate for each of Madison's five wells was tracked for a five year period between 1993 and 1998. A summary of the average annual pumpage from each well over the five year period is presented in the table below. The *Treatability Study* reports, "Since the air stripper for Wells A and B was placed into service in August 1995, the Borough has satisfied approximately 40 to 60 percent of the system demands using Well A, 30 to 50 percent using Well C with the remainder of the demand being met using Wells B and E. Well D has not been used in the last 3 years because VOC levels exceed NJDEP maximum contaminant levels and treatment is required." Since the time of the Study, Well D has been equipped with a "packed tower aeration" treatment method utilizing an 8-foot-diameter 28-foot-high tower capable of treating 40% of the municipal water demands.

Average Annual Pump Yield (1993 – 1998)

Well	Percent of Total	Ave. Day (MGD)
A	31.9%	0.646549
B	3.7%	0.07499
C	45.0%	0.912259
D	0.6%	0.012205
E	18.9%	0.382986
Total	100.1%	2.028988

Treatability Study July 1999 by Elson T Killam Associates of Millburn NJ

The 1999 Report made the following projections:

- Average Day Demand 2.2 MGD (802 MG per Year).
- Maximum Day Demand 4.5 MGD
- Maximum Month Demand 3.0 MGD

Per NJDEP requirements, the system must be equipped with sufficient capacity to satisfy the maximum day demand with the largest single unit out of service. The Report assumes that the Borough would continue to operate Wells A and B similar to historical yield, with Wells C and D responsible for approximately 40% of total supply and Well E being maintained as a back-up source of supply.

Projected Demand

Well	Annual Average Production (MG)	Average System Production
A	441.1	55%
B	40.1	5%
C	280.7	35%
D	40.1	5%
E	0	0%
Total	802	100%

Treatability Study July 1999 by Elson T Killam Associates of Millburn NJ

The actual water supply and operating demand is tracked by the NJDEP's Division of Water Supply. The agency determines if public water suppliers are operating in a water supply "surplus" or a "deficit." A deficit indicates a shortfall in "firm capacity" or available supplies through bulk purchase agreements. Firm Capacity means adequate pumping equipment and/or treatment capacity (excluding coagulation, flocculation, and sedimentation) to meet peak daily demand, when the largest pumping station or treatment unit is out of service. As of 2009, the Madison Water Department was operating with a water demand well below the allocation limits, and is therefore operating at a surplus, as indicated in the figure below for a September 2009 snapshot in time.

Madison Water Department Deficit/Surplus (9/28/2009)

Water Supply Firm Capacity: 5.904 MGD

Available Water Supply Limits

	Allocation	Contract	Total
Monthly Limit	108.500 MGM	N/A MGM	108.500 MGM
Yearly Limit	900.000 MGY	N/A MGY	900.000 MGY

Water Demand

	Current Peak	Date	Committed Peak	Total Peak
Daily Demand	3.079 MGD	08/2005	0.039 MGD	3.118 MGD
Monthly Demand	95.442 MGM	08/2005	0.605 MGM	96.047 MGM
Yearly Demand	768.250 MGY	2005	4.745 MGY	772.995 MGY

Water Supply Deficit or Surplus

Firm Capacity	Water Allocation Permit
2.786 MGD	12.453 MGM
	127.005 MGY

WELL PROTECTION

In accordance with the 1986 and 1996 Federal Safe Drinking Water Act Amendments, all States must have a Well Head Protection Program (WHPP) in place for its public and nonpublic water supply wells. The goal of a WHPP Plan is to prevent contamination of ground-water resources. The purpose of the NJ WHPP is to minimize the risk of water supply well pollution due to the discharges of pollutants by controlling both potential pollutant sources (PPS) and the location of new wells, at all levels of government and by the private sector.

The delineation of Well Head Protection Areas (WHPA's) is a major component of the Act. A WHPA is the area from which a well draws its water within a specified timeframe. More technically, it is an area around a Public Community Water Supply (PCWS) well that delineates the horizontal extent of ground water captured by a well pumping at a specified rate over a two-, five- and twelve-year period of time. A WHPA consists of three tiers, each based on the time of travel of the ground water to a pumping well. The time it takes a given particle of ground water to flow to a pumping well is known as the time of travel (TOT). The outer boundaries of these tiers have the following times of travel:

- Tier 1 = two years (730 days)
- Tier 2 = five years (1,826 days)
- Tier 3 = twelve years (4,383 days)

NJDEP used a hydro-geological model approved by the EPA under the 2002 SWAP program to delineate the WHPA tiers. The time of travel distance varies for each well, depending on the rate of the pumping, depth to well, hydrogeolocial flow and characteristics of the aquifer, such as transmissivity, porosity, aquifer thickness, and hydraulic gradient. If a municipality would like to develop their *own* WHPA model, the Division of Water Supply & Geosciences sets specific requirements. It must be a strong model with hydro-geological data that has been tested or observed and has changed, or a circumstance where new data is available.

The tiers are used to assess the relative risk of contamination to the well by placing a higher priority on pollution sources, prevention and remedies in the tiers closest to the wells. Potential sources of ground water contamination include storm water runoff, unsecured landfills, underground storage tanks and leaky drums, above ground storage tanks, chemical spills from industry, waste disposal lagoons, septic systems, highway deicers, road salt piles, etc. Activities that introduce pollutants within the designated WHPA are most likely to contaminate drinking water sources. Therefore, these delineated areas become a top priority in efforts to prevent and clean up ground-water contamination. Furthermore, protective land uses, such as preserved open space should be targeted for these areas. As the remediation of groundwater or development of new groundwater sources is extremely difficult and cost prohibitive, pollution prevention is clearly the most economical approach to maintaining ground water resources.

The Wellhead Protection Areas Map shows the location of the water supply wells and the wellhead protection areas, as well as their proximity to "known contaminated sites" (See Map 6). As indicated on the map, the protection areas (Tier 1, Tier 2, and Tier 3) do not follow municipal boundaries or political boundaries. Well protection areas for the five Madison wells extend into

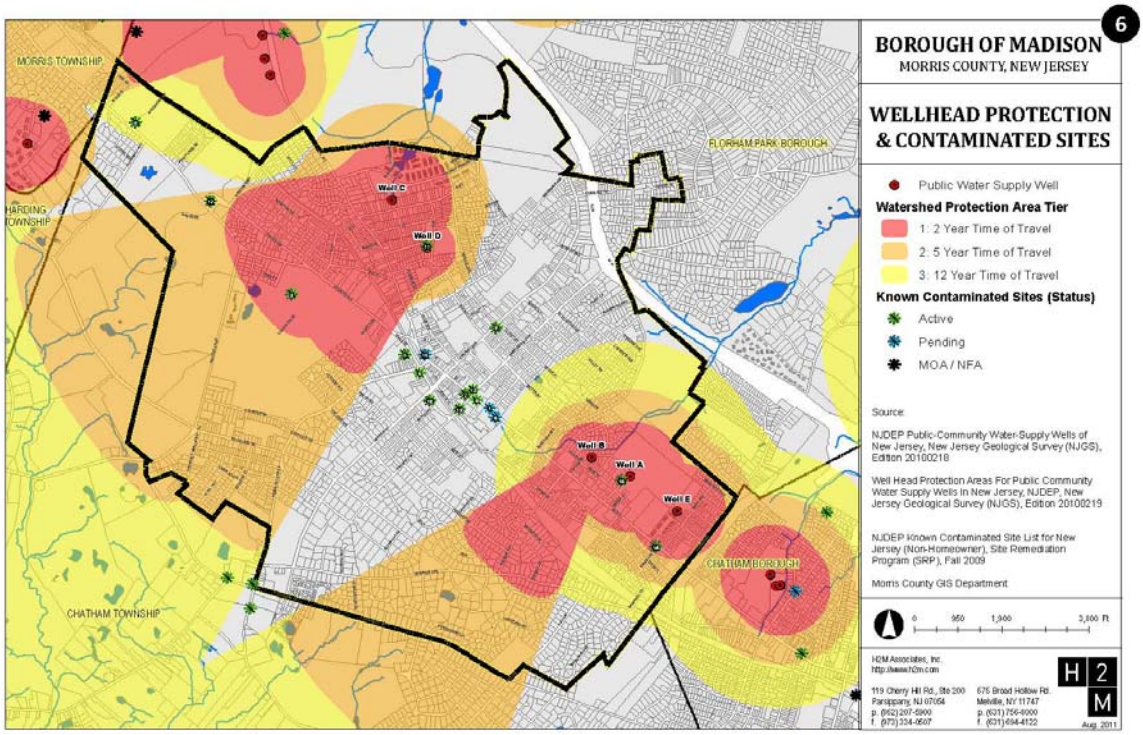
neighboring municipalities, and the protection areas for wells in adjacent municipalities extend into Madison. The table below lists the known contaminated sites (kcs) in Madison, using data published by NJDEP at the time of this report, and found at: http://www.nj.gov/dep/srp/kcsnj/.

Known Contaminated Sites in Madison (See Map 6)

MAP NO.	NAME	ADDRESS	STATUS	STAT DATE	LEVEL
1	MAIN AUTO SALES INC	134 MAIN ST	Pending	8/1/1995	C2
2	CHATHAM MADISON MOVING & STORAGE INC	73 CENTRAL AVE	Active	4/9/2009	B
3	DREW UNIVERSITY	36 MADISON AVE	Active	11/22/1993	C1
4	ROSE CITY HONDA	139 MAIN ST	Pending	5/20/1998	C1
5	MANTONE'S MOBIL SERVICE STATION	14 KINGS RD	Active	6/23/1992	C2
6	T&J SERVICE CENTER INC	31 KINGS RD	Active	8/17/2000	C2
7	ROSE CITY PETROLEUM INC	103 MAIN ST	Active	8/19/1993	C2
8	MOBIL R/S #30097	RTE 24 (122 MAIN ST)	Active	5/27/1999	C2
9	FAIRLEIGH DICKINSON UNIVERSITY	285 MADISON AVE	Active	10/25/2000	C1
10	MADISON BORO HALL	50 KINGS RD	Active	5/19/1992	C2
11	MADISON BORO WATER DEPARTMENT WELL D	LOVELAND ST	Active	5/22/2003	C3
12	KARLS SALE & SERVICE CENTER FORMER	10 PROSPECT ST	Active	7/25/2007	C1
13	HEILMANNS GULF SERVICE	112 MAIN ST	Active	12/21/2000	C2
14	SOMERSET TIRE SERVICE	319 MAIN ST	Active	6/13/2003	C1
15	S&S JAMES BLDGSOLU ETALS	14 MAIN ST	Pending	7/20/1994	C1
16	MADISON BORO WATER DEPT WELLFIELD	JOHN AVE & LOVELAND	Active	5/10/2005	C3
17	BAYLEY ELLARD FIELD	MADISON & DANFORTH	Active	9/8/2010	C1

The level of remediation needed at each site is categorized as “C1,” “C2,” “C3,” or “B” as follows:

- C1: No Formal Design - Source Known or Identified-Potential GW Contamination
- C2: Formal Design - Known Source or Release with GW Contamination
- C3: Multi-Phased RA - Unknown or Uncontrolled Discharge to Soil or GW
- B: Single Phase RA - Single Contamination Affecting Only Soils



DRINKING WATER QUALITY

Because of the Madison Water Department's designation as a "public community water supply system," the Borough's drinking water quality is regulated by the NJDEP and must meet the current New Jersey Drinking Water Standards and Federal standards. These standards are listed as Maximum Contaminant Levels (MCLs) which the finished (treated and ready for distribution and consumption) drinking water cannot exceed. There are "primary standards," which are health-related and "secondary standards," which are primarily aesthetic. The seven categories of contaminants, as well as Radon, are defined below:

- Pathogens: Disease-causing organisms such as bacteria and viruses. Common sources are animal and human fecal wastes, which can come from sewage treatment plants, septic systems, agricultural livestock and wildlife.
- Nutrients: Compounds, minerals and elements that aid growth, that are both naturally occurring and man-made. Examples include nitrogen and phosphorus, which can come from sewage effluent, septic field discharges, animal waste, agricultural runoff, residential fertilizer.
- Volatile Organic Compounds: Man-made chemicals used as solvents, degreasers, and gasoline components. Examples include benzene, methyl tertiary butyl ether (MTBE), and vinyl chloride. They can be by-products of industrial processes and petroleum production, and can come from gas stations, storm water runoff and septic systems
- Pesticides: Man-made chemicals used to control pests, weeds and fungus in agriculture or for residential use. Common sources include land application and manufacturing

centers of pesticides. Examples include herbicides such as atrazine, and insecticides such as chlordane.

- Inorganics: Mineral-based compounds that are both naturally occurring and man-made. Examples include arsenic, asbestos, copper, lead, and nitrate. These are salts and metals from stormwater runoff, industrial or domestic wastewater discharges, releases from contaminated sites, naturally occurring sources, oil and gas production.
- Radionuclides: Radioactive substances that are both naturally occurring and man-made. Examples include radium and uranium.
- Radon: Colorless, odorless, cancer-causing gas that occurs naturally in the environment. At present, there is no federal regulation for radon levels in drinking water. However, exposure to air transmitted radon over a long period of time may cause adverse health effects.
- Disinfection Byproduct Precursors: These byproducts are formed when the disinfectants (usually chlorine) used to kill pathogens react with dissolved organic material (for example leaves) present in surface water.

The Madison Borough Water Department routinely monitors for drinking water contaminants according to Federal and State laws. In order to ensure that tap water is safe to drink, the EPA prescribes regulations which limit the amount of certain contaminants in water provided by public water systems. Food and Drug Administration regulations establish limits for contaminants in bottled water, which must provide the same protection for public health. The "Maximum Allowed" (MCL) is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology. Maximum Contaminant Level "Goal" (MCLG) is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that the water poses a health risk. The table below shows the monitoring results for the period of January 1st to December 31st, 2010.

Annual Drinking Water Quality Report
Test Results from the Year 2010

Contaminant	Violation	Level Detected	Unit	MCLG	MCL	Likely Source of Contaminant
Coliform (6/1/2010)	Y	1 positive result		0		Coliforms are bacteria that are naturally present in the environment and are used as an indicator that other, potentially-harmful, bacteria may be present. Coliforms were found in more samples than allowed and this was a warning of potential problems.

Contaminant	Violation	Level Detected	Unit	MCLG	MCL	Likely Source of Contaminant
RADIOACTIVE CONTAMINANTS						
Alpha emitters (2008)						
Well A	N	1.79	pCi/L	0	15	Erosion of Natural Deposits
Well B	N	4.9	pCi/L	0	15	Erosion of Natural Deposits
Well C	N	1.4	pCi/L	0	15	Erosion of Natural Deposits
Well D	N	2.5	pCi/L	0	15	Erosion of Natural Deposits
Well E	N	2.1	pCi/L	0	15	Erosion of Natural Deposits
Radium 228 (2008)						
Well A	N	0.12	pCi/L	0	5	Erosion of Natural Deposits
Well B	N	0.06	pCi/L	0	5	Erosion of Natural Deposits
Well C	N	0.2	pCi/L	0	5	Erosion of Natural Deposits
Well D	N	0.09	pCi/L	0	5	Erosion of Natural Deposits
Well E	N	1	pCi/L	0	5	Erosion of Natural Deposits
INORGANIC CONTAMINANTS						
Arsenic (2008)	N	Range = ND -2 Highest detected = .003	ppb	N/A	50	Erosion of Natural Deposits; runoff from orchards, glass and electronics production wastes
Iron (2010)	N	0.1	ppm	0.05	0.3	Natural Deposits
Manganese (2010)	N	0.05	ppm	0.01	0.05	Erosion of Natural Deposits
Barium (2008)	N	Range=0.015-0.031 Highest detected = 0.03	ppm	2	2	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Fluoride (2008)	N	Range=0.05-0.2 Highest detected= 0.2	ppm	4	4	Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories
Copper (2009)	N	0.1 No samples exceeded action level	ppm	1.3	AL= 1.3	Corrosion of household plumbing systems
Lead (2009)	N	3 No samples exceeded action level	ppb	0	AL= 1.5	Corrosion of household plumbing systems, erosion of natural deposits
Nitrate (as nitrogen) (2010)	N	Range 1.52 - 1.75 Highest detected=1.75	ppm	10	10	Runoff from fertilizer use; leaching from septic tanks; sewage; erosion or natural deposits
VOLATILE ORGANIC COMPOUNDS						
ITHM (total trihalomethanes) 2010	N	Range 3.5- 5.4 Highest average = 5.4	ppb	N/A	80	By-product d drinking water disinfection
HHA (haloaacetic acids) 2010	N	Highest average=0	ppb	N/A	60	By-product d drinking water disinfection
UNREGULATED CONTAMINANTS						
DCPA acid metabolites (2001)	N	Range = ND - 3.7 Highest detected = 3.7	ppb	N/A	N/A	Unregulated contaminant monitoring

As shown in the table above, the Madison Water Department was not issued violations for any contaminant above maximum levels, except one positive result for Coliform. While there is currently no federal regulation for radon levels in drinking water, radon has been detected in the finished water supply in 5 out of 5 samples tested with a sampling range of 2.2 - 3.0 pCi/L. Exposure to air transmitted radon over a long period of time may cause adverse health effects. The Safe Drinking Water Act regulations also allow monitoring *waivers* to reduce or eliminate the monitoring requirements for asbestos, volatile organic chemicals (VOCs) and synthetic organic chemicals. Madison's system received monitoring waivers for asbestos and synthetic organic chemicals.

Volatile Organic Compounds (VOCs)

In 1982, the NJDEP enacted amendments to the Safe Drinking Water Act, referred to as the A-280 Standards, which required public community water systems to monitor for various volatile organic chemicals (VOCs). In 1986 the US Environmental Protection Agency (EPA) amended the federal Safe Drinking Water Act to include MCLs for many VOCs currently being monitored under New Jersey's A-280 program. In the late 1980's VOC's were detected at several of the Borough's wells, and at many other wells in surrounding communities. The Townships of Livingston, East Hanover and Hanover, to name a few, have all provided treatment of their groundwater supplies for the removal of VOCs.

Due to the presence of the VOC contamination, the Borough proceeded with the design and construction of an air stripper facility (Killam, 1993) to treat the most contaminated wells (Wells A and B). The air stripping facility has been in operation since 1995, and has a capacity of approximately 2,100 gallons per minute or 3.0 million gallons per day. Provisions were made to allow Well E to be connected into the air stripping facility in the future, but the connection has not been made since Well E has not shown significant VOC contamination. As indicated previously, Well D has also since been equipped with a "packed tower aeration" treatment method and is now capable of treating 40% of the municipal water demands. The Borough continues to monitor the various sources of ground water supply for VOC's.

Source Water Assessment Program (SWAP)

Each year, the Madison Water Department prepares an Annual Drinking Water Quality Report, which is mailed to all Borough residents and submitted to NJDEP. In accordance with Federal Requirements, NJDEP then consolidates information from such reports from all Community Water Systems throughout New Jersey, and prepares Source Water Assessment Reports and Summaries. The Source Water Assessment Program (SWAP) is administered by the NJDEP's Bureau of Safe Drinking Water, Water Supply Administration.

The SWAP requires that Madison Water Department provide "Susceptibility Ratings" for the seven contaminant categories (and radon) for each source of water (i.e., each well and the purchased water sources) within the system. The table below is from the 2011 Annual Water Quality Report and shows the number of wells and intakes rated as high (H), medium (M), or low (L) for each contaminant category. The susceptibility rating does not tell you if the water source is actually contaminated; instead, the rating reflects the *potential* for contamination of source water.

As required by the federal Safe Drinking Water Act, the Consumer Confidence Report issued annually by a water utility contains information on the results of drinking water quality tests. Public water systems are required to install treatment systems if any contaminants are detected at frequencies and concentrations above allowable levels. As a result of the assessments, DEP may customize (change existing) monitoring schedules based on the susceptibility ratings. At present, the Madison Water Department is required to monitor water contaminants on an annual basis, and water quality reports, including the Susceptibility Ratings shown below, is sent to every Madison resident annually.

Susceptibility Ratings for Madison Water Department Sources (2011)

	Pathogens			Nutrients			Pesticides			Volatile Organic Compounds			Inorganics			Radio-nuclides			Radon			Disinfection Byproduct Precursors		
Sources	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L
Wells - 5		2	3	5					5	4		1	2	3		3	2		5			2	3	
GUDI - 0																								
Surface water intakes - 0																								

According to the 2011 Annual Report, all five wells are considered "highly" susceptible to nutrients and radon; four wells are highly susceptible to VOCs and three wells are highly susceptible to Inorganics. However, the Borough's finished water supply (treated) which is distributed as drinking water is of very high quality and currently meets the NJDEP standards as a public drinking water supply. The existing wells provide a reliable, high quality source of water supply to the Borough. Generally speaking, the water in Madison is non-corrosive, hard and of good quality.

WASTEWATER DISPOSAL AND TREATMENT

The Madison-Chatham Joint Meeting treatment plant serves the 24,000 residents of the Boroughs of Madison and Chatham, and a small portion of Chatham Township. All of Madison's wastewater is collected and treated by the Madison-Chatham Joint Meeting. The Madison-Chatham Joint Meeting was established as a small primary treatment plant in 1910 and has expanded and upgraded several times over the years (Major upgrades in 1929, 1969 and 1990). According to Christopher Manak, the Superintendent of the Madison-Chatham Joint Meeting, the plant is now an advanced treatment plant with a design capacity of 3.5 million gallons per day (MGD) with an average daily flow of 3.0 MGD.

The wastewater treatment plant works in multiple stages. In the first two (Primary and Secondary) stages, the solid and liquid wastes are separated, bacteria neutralize the impurities in the solids, and the waters are given initial aeration. In the tertiary treatment, the Molitar Water Pollution Control Facility utilizes a three-acre stabilization pond, where additional oxygen is introduced to purify the effluent. The stages of treatment include:

1. *Screening*. A simple process that removes large materials such as wood, rocks and other items.

2. *Pumping*. Our treatment plant is located on low ground, so much of the wastewater travels via gravity to the plant. Once in the plant and depending on the topography, most treatment plants have pumps to move the wastewater from one treatment area to another.

3. *Aerating*. Bubbling oxygen through the sewage helps release some of the dissolved gases from the water into the air. It also helps larger 'grit' such as sand, coffee grounds, etc to settle out.

4. *Sedimentation*. Sludge settles out of the wastewater and is pumped out of the sedimentation tank and then processed in a large 'digester' tank.

5. *Removing scum*. As the sludge settles to the bottom, lighter items such as grease, oils, plastics and soap float to the top. Slow-moving rakes skim the material off the surface. Thickened scum is pumped into the digesters with the sludge.

6. *Final treatment and discharge*. Finally, the wastewater is treated, often with filtration and/or chlorine to remove bacteria, odors and other items. The water is now clean and discharged into a local river.

The Joint Meeting was required by NJDEP to upgrade the plant to Level 4 effluent water quality. In 1990, the treatment plant received $16.2 million in improvements, funded by low interest loans to the Boroughs by the New Jersey Wastewater Trust Program. The new plant additions would improve the effluent by remove ammonia levels from 30 milligrams per liter to less than 2 milligrams per liter and by decholorinating the effluent to less than 0.1 milligram per liter of chlorine. The expanded facility removes 955 of the conventional impurities in the water prior to discharging the clear effluent (treated wastewater) into the Passaic River. The new sludge handling facilities thicken the activated sludge prior to conveyance to the digesters and dewater the digested sludge prior to disposal in the landfill.

In addition to treating the wastewater, the Joint Meeting sewage plant also processes the residual solid-waste material. These solids are placed in a 'digester' or large holding tank for many days. This tank acts like a stomach and using bacteria digests the solid material in a process known as anaerobic digestion. Digesting the material reduces the volume and odor and produces Methane Gas. The sewage treatment plant uses 'duel fuel' diesel engines, which run on both natural gas and methane gas that is recaptured in the plant's digester. The finished solid material is then sent to a landfill.

On May 17, 2010, the Boroughs commemorated the 100th anniversary of the joint sewage treatment plant and broke ground on a $3 million improvement project to restore and upgrade the system, funded in part by federal stimulus money. The upgrades enabled the facility to produce a portion of its own energy in the form of methane gas. The first phase of the project involved filling in one of the three “digesters” that had been built at the time of plant’s construction and ceased operations nearly 25 years ago. The other two digesters are to be overhauled to increase energy efficiency and produce more methane for the plant to use as a power source.

SURFACE WATER

Present-day Madison has very little visible surface water (See Map 7). There are five ponds: Long Pond and Round Pond are located in the Drew University Arboretum, and unnamed ponds are located on Dellwood Parkway West, on Ridgedale Avenue across from Madison High School and between Brittin Street and Grove Street. These ponds are probably glacial in origin since they have no inlets or outlets.

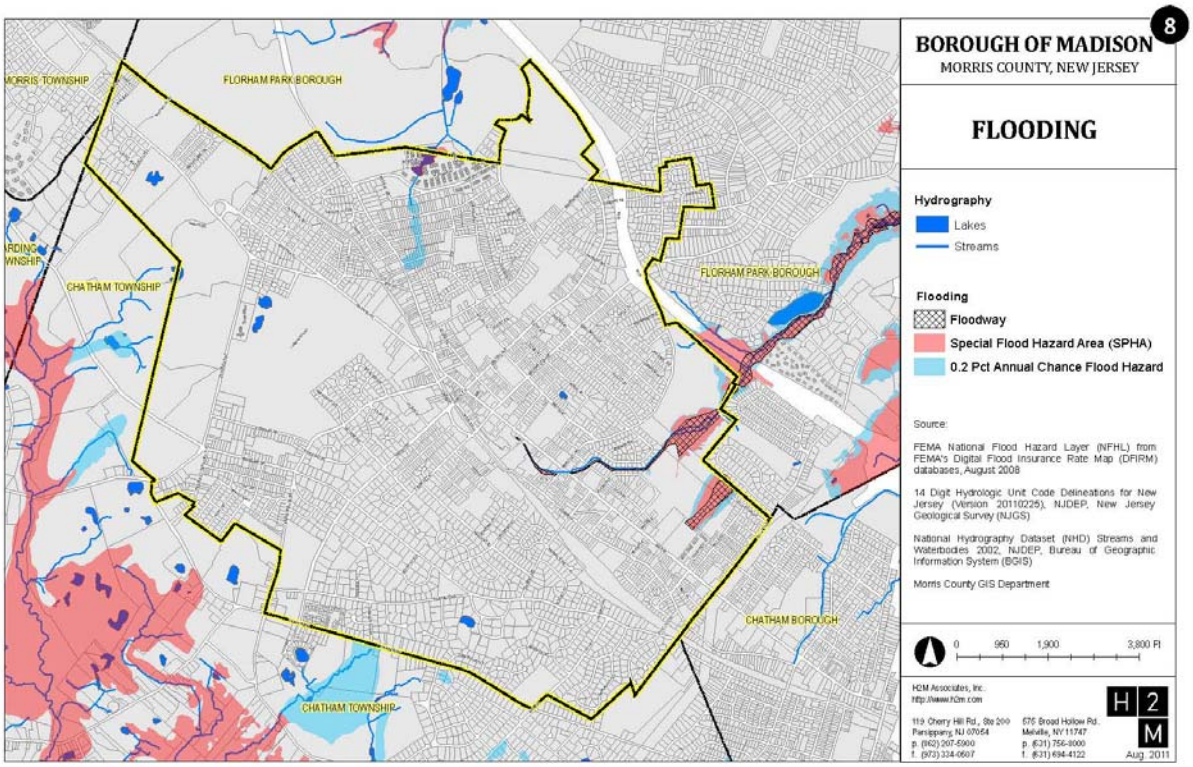
There are two streams still visible within the Borough, into which empty many storm sewers and drainage ditches.

- Spring Garden Brook and its tributaries are considered Freshwater Category 2, Non-Trout producing, or FW2-NT.

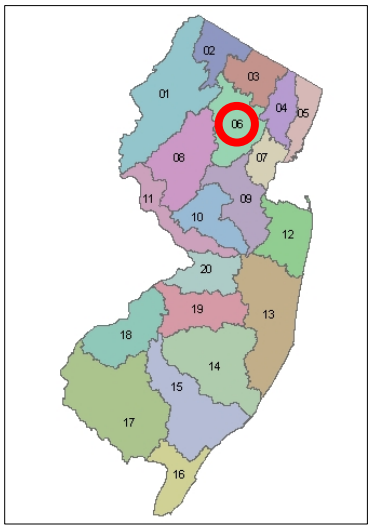
- Black Brook (the segment within the Great Swamp National Wildlife Refuge) is also a Freshwater Category 2 Non-Trout producing stream, but is also a Category 1 waterway: FW2-NT(C1). A C1 waterway is "A waterbody that is attaining all designated uses and no uses are threatened."

Black brook flows north from Anthony Drive, through the Black Meadows until it reaches the Whippany River. Spring Garden Brook flows east along Main Street and through the cemetery. During heavy storms it collects a large amount of runoff and is prone to flooding. Areas experiencing flood potential in and around Madison, as verified by FEMA's National Flood Hazard Area data, are shown on the Flooding Map (Map 8). Near Rosedale Avenue, the stream turns toward the northeast and flows through Memorial Park and the Brooklake Country Club golf course until it reaches the Passaic River near Brooklake Road in Florham Park. One tributary of Spring Garden Brook appears in front of the library, another originates west of Rosedale in the Knollwood section and flows eastward through a culvert into Memorial Park. There the tributary becomes an open stream and joins Spring Garden Brook.

On New Jersey's 2006 Integrated List of Waters, the Black Brook Great Swamp NWF (National Wildlife Refuge segment) received "non-attainment" status for several pollutant categories. The 303(d) List of Impaired Waters indicated the Black Brook Great Swamp NWF had a "medium" ranking for Arsenic and a "high" ranking for Phosphorous. On New Jersey's 2006-2008 two-year TMDL schedule, Phosphorous is an assessment parameter.

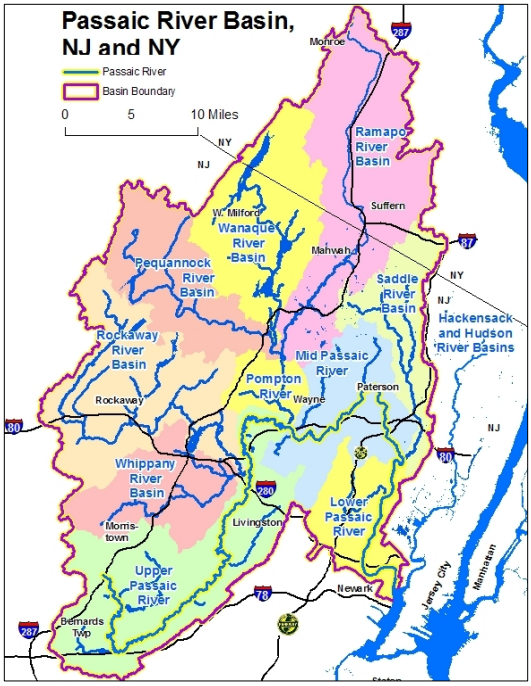


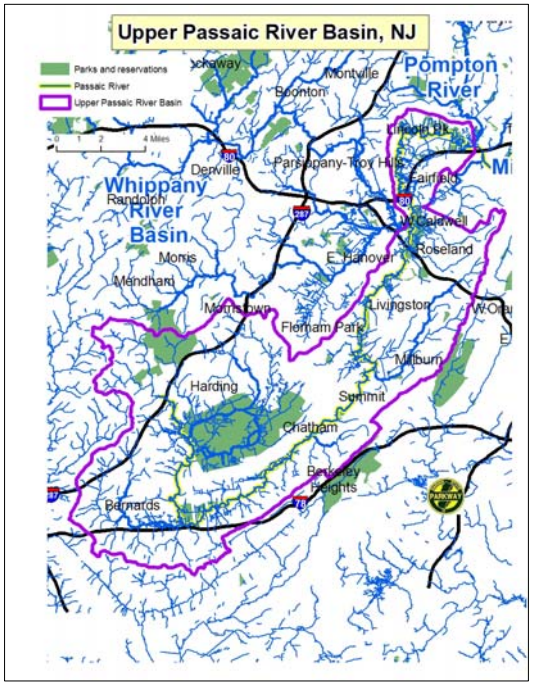
WATERSHEDS & SUB-WATERSHEDS



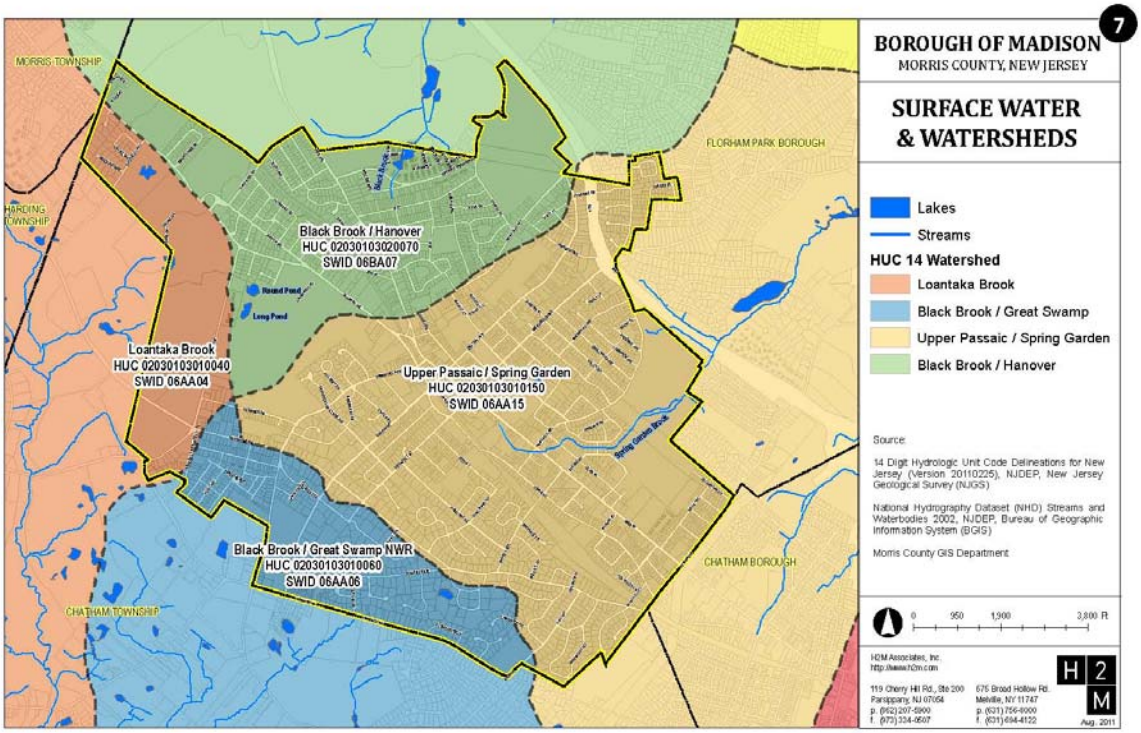
All of Madison is within the Upper Passaic Watershed Management Area (Watershed Management Area Number 6 as designated by the NJDEP). A watershed encompasses all the land that drains to a particular waterbody, and is a natural boundary. The Upper Passaic Watershed Management Area is one of 20 watershed management areas in New Jersey.

The Upper Passaic Watershed Management Area, also known as WMA6, includes the Rockaway, Whippany and upper Passaic Rivers above the confluence with the Pompton River. WMA6 is approximately 416 square miles and is about 30 miles long and 20 miles wide at the widest points. Madison is located in both Whippany and the Upper Passaic River Watersheds.





Within Madison there are four subwatersheds. The runoff and drainage characteristics are significantly different for each of the four areas. The area boundaries or "divides" are shown in Map 7. The subwatersheds include the Whippany Black Brook Subwatershed, which is part of the Whippany Watershed; the Loantaka Brook (Great Swamp) Subwatershed, which is part of the Upper Passaic Watershed; the Black Brook (Great Swamp) Subwatershed, which is part of the



Upper Passaic Watershed; and the Spring Garden Brook Subwatershed, which is part of the Upper Passaic Watershed.

The Loantaka Brook Subwatershed to the southwest includes 0.5 square miles in Madison and the Great Swamp Black Brook sub-watershed to the southeast includes 0.6 square miles in Madison. Both the Loantaka Brook and Black Brook (Great Swamp) enter and flow westward through the Great Swamp National Wildlife Refuge to reach the Upper Passaic River north of the Millington Gorge. The Spring Garden Brook subwatershed area encompasses a 2.2 square mile-area in the central and eastern part of Madison. This sub-watershed contains the greatest amount of impervious surface in the borough and produces the most runoff. This subwatershed drains into the Upper Passaic River near Brooklake Road in Florham Park. One square mile in the northern part of the Borough drains into small streams that flow through the Black Meadows to the Whippany River near Route 10 in East Hanover.

WATERSHED MANAGEMENT TO PROTECT SURFACE WATER AND GROUNDWATER

Groundwater and surface water can be affected by both point and non-point sources of pollution. Point sources have been designated in the Clean Water Act as pollution that can be clearly identified as a discharge form a pipe, ditch or other well-defined sources. Non-point source pollution means any pollution that does not originate from a point source.

In the past, the focus had been on the effects of point sources on both ground and surface waters. Many of the point sources have been identified and permitted through New Jersey's Pollution Discharge Elimination System (NJPDES) permit process. The NJPDES permit process sets limits on what the point sources can discharge and how much. To meet the strict discharge limits of the early 1990's, point source polluters were required to upgrade their treatment processes to include state of the art treatment technologies. This had a positive effect on surface waters statewide. However, additional point source issues as well as non-point source issues still needed to be addressed. NJDEP manages point and non-point source pollutions through a process known as Watershed Management.

Watershed management is a process of protecting the lakes, streams, and wetlands in a watershed from point and nonpoint source pollution. Watershed management consists of many diverse activities including controlling point and nonpoint source pollution, monitoring water quality, adopting ordinances and policies, educating stakeholders, and controlling growth and development in a watershed. This approach enables watershed communities to holistically address water pollution and supply issues so that comprehensive strategies can be implemented by government, the private sector and citizens. Through the creation of a comprehensive *Watershed Management Plan*, communities and citizens within the watershed develop goals, principles and implementing strategies to protect and enhance the ecological condition of a watershed. A Plan will holistically encompass topics as diverse as-- water quality, water quantity, stormwater management, wastewater management and disposal, stream buffers and stabilization, open space planning, and education. A plan should include action steps to prevent, reduce, or minimize activities within a watershed that may negatively impact water quality.

Stormwater runoff pollution is a concern in watershed management because it acts as a source of contamination to both surface and ground water. This source of pollution must be evaluated and addressed if we are to achieve regional water quality goals. Both the EPA and NJDEP have stressed the importance of controlling non-point source pollution. EPA expects municipalities to adopt narrative effluent limitations that require dischargers to use best management practices (BMPs). The EPA is also looking for municipalities to adopt certain minimum control measures. These measures include public education and outreach on storm water impacts, public involvement and participation, detection and elimination of illicit storm water discharges, regulation of storm water flows from construction sites of one acre or more, continued management of real estate development or redevelopment after the construction phase and pollution prevention for municipal operations.

A manual entitled "A Cleaner Whippany River Watershed," May 2000, has been development which could serve as a general guide to the local official in selecting BMP's that could best address non-point source pollutants of concern within their watershed. This manual may also serve as a technical resource to the watershed management plan where BMP's are suggested.

NON-POINT POLLUTION

Non-point source water pollution is contamination that occurs when rainwater or snowmelt washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants such as nutrients, pesticides and fecal matter. Some of the polluted runoff may infiltrate into the soil and contaminate groundwater. The remaining runoff deposits soil and pollutants into rivers, lakes, wetlands, and coastal waters. Non-point source pollution may originate from numerous small sources that are widespread, dispersed and hard to pinpoint, control or prevent. Non-point source pollution comes from a wide variety of sources and includes a diverse set of pollutants. Sources of non-point pollution include:

- Malfunctioning septic systems
- Soil erosion from construction sites or farms
- Discharges of sewage and garbage from boats
- Cleaners, paint and antifouling compounds used on boats
- Hazardous household wastes improperly stored or discarded
- Acid rain and atmospheric deposition
- Pollution from road deicing activities
- Disposal of wastes in catch basins or storm drains
- Leaking sewer lines
- Pesticides and fertilizers misused on lawns and gardens
- Motor oil and grease dripping from cars and trucks
- Animal waste from wildlife, pets and livestock
- Litter carelessly tossed aside

Non-point source discharges to surface waters may contribute to a rather complex network of biological, chemical and physical interactions. These discharges may contain biodegradable organic material that could deplete the dissolved oxygen in surface water. Dissolved oxygen is an important water quality parameter and its abundance enriches and usually coincides with the

diversity in an aquatic ecosystem. Aquatic microbial ecosystem will utilize these organic compounds as an energy source and during this process will consume dissolved oxygen. Ammonia and nitrogen containing organic compounds also have a similar effect on surface waters. The microbes present in a stream will utilize these nitrogen-containing compounds as an energy source, using oxygen in the process. Biodegradable organic and nitrogenous compounds present in water (surface water, wastewater or stormwater) are measured as biochemical oxygen demand (BOD) and sediment oxygen demand (SOD).

Nitrogen and phosphorus may also stimulate algae growth. This may lead to a condition commonly known as eutrophication, which could increase the rate of sedimentation in a surface water system thereby affecting drainage and geomorphology. Excessive algae growth will also affect daily dissolved oxygen variability, through photosynthesis and plant respiration, causing dissolved oxygen to increase during daytime and decrease at night.

Toxic compounds (i.e. heavy metals, pesticides, carcinogens, mutagens, teratogens), pathogenic microbes, acids, bases, petroleum compounds, salts and sediments may also be present in non-point sources which could impact on the receiving waters use and ecosystem. Receiving water temperature may also be affected by these sources.

Stormwater runoff from residential areas has been found to contain contaminants such as nitrogen, phosphorous, fecal coliform, petroleum hydrocarbons, salts, metals and pesticides. These contaminants enter into and affect both surface water and groundwater. Most of these contaminants originate from the overuse and improper application of fertilizers and pesticides on residential lawns, improperly operated and maintained septic systems, and improper practices dealing with the disposal of waste.

BEST MANAGEMENT PRACTICE (BMP) SELECTION

The selection and implementation of a best management practice (BMP), whether structural or non-structural, to address a watershed concern should meet the goals and objectives of the watershed management plan. The process of BMP screening and selection generally consists of the following four steps:

(1) Determine existing conditions: Analyze existing watershed and water resource data and collect data to fill gaps in existing knowledge.

(2) Quantify pollution sources and effects: Utilize assessment tools and models to determine source flows and contaminant loads, extent of impacts and level of control needed.

(3) Assess alternatives: Determine the optimum mix of prevention and treatment practices to address the problems of concern.

(4) Develop and implement the recommended action: Define the selected system of prevention and treatment practices to address the pollution problems of concern and developing a plan for implementing those practices

Below are examples of Non-structural and Structural BMPs.

Non-Structural BMPs

1) Planning and Land Use
    a. Comprehensive Master Plan
    b. Open Space Plan
    c. Zoning Plans
    d. Riparian Corridor Protection
    e. Environmental Resource Inventory
    f. Site plan/subdivision – Site plan approval
    g. Open space preservation
    h. Development and Redevelopment

2) Source Controls
    a. Minimum disturbance (soil loss; sequence of construction/phase development)
    b. Alternative landscaping
    c. Fertilizer management for urban/suburban landscaping
    d. Pesticide management for urban/suburban areas (IPM)
    e. Roadway de-icing/salt reduction
    f. Street sweeping (wet and vac)
    g. Stormwater facility maintenance
    h. Pet waste maintenance
    i. Geese/wildlife control
    j. Septic system maintenance
    k. Eliminate illegal connections to storm drain / sanitary sewerage systems
    l. Management of yard waste

Structural BMP's

1) Detention Facilities
    a. Extended Detention Dry Pond
    b. Wet Pond
    c. Extended Detention Wet Pond
    d. Constructed Wetlands

2) Infiltration Facilities
    a. Dry Wells for residential areas
    b. Infiltration trench
    c. Pervious parking areas

3) Vegetative Practices
    a. Vegetative filter strips
    b. Grass swales
    c. Riparian Forest Buffers with native vegetation species
    d. Reforestation
    e. Alternative landscaping – turf conversion

4) Filtration practices
    a. Sand filters
    b. Bioretention

5) Catch basins with water quality treatment
    a. Water Quality inlet
    b. Stormseptor
    c. Storm-treat
    d. Oil/grease separator

The following is a list of items to consider when selecting the appropriate structural BMP:

- Groundwater Quality
- Groundwater Quantity
- Base flow to streams
- Stream bank erosion
- Soil permeability
- Depth to groundwater
- Depth to bedrock
- Area of drainage
- Land use, density
- Area available for BMPs
- Pollutants of concern
- Areas which may be impacted
- Flooding concerns
- Pre-development/post-development
- Maintenance requirements
- Steep slopes (> 20%)
- Aquatic habitat creation
- Wildlife habitat creation
- Landscape enhancement
- Recreation benefit
- Community acceptance
- Maximum depth
- Restricted land use
- High sediment input
- Thermal impact to receiving waters

The Ten Towns Great Swamp Watershed Management Committee developed model ordinances that address stormwater management, stream buffer conservation zones, steep slope, soil erosion and sediment control, wetlands protection, tree protection and removal. Copies of the model ordinance have been filed with the Borough Engineers Office. The Borough of Madison, as of 2000, has adopted ordinances which address tree removal, soil erosion, steep slopes, stormwater management, soil removal and wetland protection. The Ten Towns Great Swamp Watershed Management Committee rated Madison's ordinance as "excellent" with respect to soil removal; "good" with respect to tree protection, steep slope and stormwater management; and "marginal" with respect to soil erosion and wetland protection.

The following watershed management organizations coordinate watershed management activities. Members typically include elected officials, residents, farmers, business owners and interested parties.

- Ten Towns Great Swamp Watershed Management Committee (dissolved 2010)
- Passaic Valley Coalition's Ground Water Protection Committee
- Whippany River Watershed Action Committee, and
- WMA 6 Policy Advisory Group

RESOURCES

- Phase 2 Stormwater Management Plan for the Borough of Madison, May 2005.
- Elson T. Killam Associates, Inc., 1988, Water Quality Improvement Report, Borough of Madison, County of Morris, New Jersey.
- Killam Associates, 1993, Basis of Design Report - VOC Removal Facility for Wells A, B, and E, Borough of Madison, County of Morris, New Jersey.
- Killam Associates, 1998, Water Improvements Phase II Program, Basis of Design Report, Borough of Madison, County of Morris, New Jersey.
- Killam Associates, 1999, Treatability Study and Basis of Design Report for Wells C & D, Borough of Madison, County of Morris, New Jersey.
- Meisler, Harold, 1976, Computer Simulation Model of the Pleistocene Valley Fill Aquifer in Southwestern Essex and Southeastern Morris Counties, New Jersey, U.S. Geological Survey Water Resources Investigations.
- Passaic River Coalition, 1993, Groundwater in the Passaic River Basin, Passaic River Coalition, Basking Ridge, New Jersey.
- New Jersey Department of Environmental Protection, 1988, The Clean Water Book, NJDEP, Trenton, New Jersey.
- New Jersey Department of Environmental Protection, 1995, Whippany River Characterization Report, NJDEP, Trenton, New Jersey.
- New Jersey Department of Environmental Protection, 1998, Watershed Characterization and Assessment of the Upper Passaic, Whippany and Rockaway Watersheds, Watershed Management Area 6, NJDEP, Trenton, New Jersey.
- New Jersey Department of Environmental Protection, 2000, A Cleaner Whippany River Watershed, Nonpoint Source Pollution Control Guidance Manual for Municipal Officials, Engineers and Departments of Public Works, NJDEP, Trenton, New Jersey.
- Tucker, Robert K., 1981, Groundwater Quality in New Jersey, An Investigation of Toxic Contaminants, NJDEP, Trenton, New Jersey.

VI. AIR QUALITY

Why, in a suburban town like Madison, should people be concerned with air pollution? The answer is simple: because the impacts occur in real time. Pollutants that are released into the air can have an immediate impact on people, whereas pollutants released into water or soils may not impact people for days, weeks, months or even years.

Air is composed on roughly 78.1% nitrogen, 20.9% oxygen, 0.9% argon and 0.1% of other components. Any substance that is found in the air that is not part of its natural composition or any substance whose concentration is higher than the concentration found in the air's natural composition is considered an "air pollutant." Clean air is found in few, if any places on earth.

Air pollutants may be released in the form of either gases (most of which are colorless), or particulates (i.e., dust particles), or they can be formed in the atmosphere via chemical reactions (e.g., smog). In general, air pollution is a concern because it can degrade health, harm the environment, and cause property damage. Air pollution scientists and engineers evaluate air pollutants in terms of whether they exhibit nuisance impacts, e.g., objectionable odors or discoloration of buildings or statues, impacts on plants or animals, or short term or long term impacts on human health. In general, human health impacts can include chemical sensitization, short term respiratory, dermal or digestive symptoms, long term exposure-type diseases or teratogenic (malformation) or mutagenic (genetic) effects. Exposure type diseases can include respiratory diseases such as emphysema, or different types of cancers. Most diseases are only contracted when there is a continual, long term exposure to higher concentrations of industrial type chemicals.

AIR QUALITY HISTORY

The presence of man-made air pollution in America is a condition that has existed for hundreds of years. The Los Angeles area smog is not a new phenomenon but was actually witnessed by the Chumash Indians hundreds of years ago as the result of their fires and the uniqueness of the Southern California topography. With the dawn of the industrial revolution in the late 18th and early 19th centuries came the beginnings of our current air quality problems. As we manufacture and consume more goods and travel more, the amount of pollutants that we dump into our air also increases. Air pollution impacts can also be exacerbated by certain meteorological conditions, such as a temperature inversion. Thermal inversions, which usually occur in valleys, are situations in which cooler air remains trapped and stagnant beneath a layer of warmer air, thus reducing the effective volume of air in which pollutants can be diluted.

The seriousness of the air pollution issue became evident through a series of incidents in the last century. In 1948 in Donora, Pennsylvania a thermal inversion caused 6,000 of the town's population (i.e., 43%) to become ill and 20 people died due to exposure to sulfur dioxide and particulate matter. In 1952 in London the British Isles were covered by fog and a temperature inversion from December 5 through the 9th. This accounted for between 3,000 and 4,000 excess deaths, attributable to respiratory tract irritation. Then, in 1984, in an air pollution accident at the Union Carbide chemical plant in Bhopal, India thirty tons of the poisonous gas methylisocyanate

escaped through a broken valve. Although there were no adverse meteorological conditions at the time, the resulting air pollution injured about 20,000 people and caused more than 2,000 fatalities!

The first air pollution regulations in the state, which required certain manufacturing and power generation facilities to register equipment that emitted air pollutants, were initiated in 1968. Then, in 1970, with the inception of the United States Environmental Protection Agency (USEPA), the federal Clean Air Act (CAA) was passed. This act was greatly expanded and clarified in 1977, and substantially expanded in 1990 with the adoption of the detailed, voluminous Clean Air Act Amendments (CAAA). To conform to the requirements of the CAA and CAAA, every state in the union has been required to develop a "State Implementation Plan (SIP), which is actually a detailed program outlining how a state will come into compliance with all the USEPA air pollution criteria. Since 1968, the New Jersey Department of Environmental Protection (NJDEP) has greatly expanded the state's air pollution permitting, emission control, emissions estimation and emission proving requirements. In most instances they have executed the requirements of the CAA, but in many cases the NJDEP has developed more stringent requirements than the USEPA. Since 2001 through 2010 the NJDEP has continued to expand enforcement of these acts through stricter regulation.

Most regulations focus on continuous, routine emissions from facilities. However, as a result of the 1984 Bhopal disaster, the NJDEP developed regulations called Toxic Catastrophe Prevention Act (TCPA) to govern accidental releases. With adoption of the CAAA in 1990, accidental release permitting requirements were greatly expanded under the CAAA's Air Toxics, Title III Section 112r. Section 112r requires certain facilities to develop risk management plans and to predict the potential impact and risk of catastrophic chemical releases, irrespective of the miniscule probability of every occurring.

AIR POLLUTANT SPECIES

Since there are numerous different types of air pollutants, there are many different methods to identify and categorize these pollutants. One method is to divide pollutants according to the following categories.

- Criteria Pollutants
- Hazardous Air Pollutants
- Greenhouse Gases

Criteria pollutants were the original chemical species focus of the CAA. The USEPA developed ground level ambient (outdoor) air quality limits for these criteria pollutants and named these limits National Ambient Air Quality Standards (NAAQS). The list of criteria pollutants includes the following chemical species: ozone (0_3), carbon monoxide (CO), sulfur dioxide (SO_2) and PM_{10} (i.e., microscopic dust defined as particulate matter less than 10 microns in size). New Jersey also has limits on total suspended particulates (TSP). Areas in which air quality concentrations are below the NAAQS limits are called "attainment areas", whereas areas where the ambient air levels exceed the NAAQS are called "non-attainment areas". Because ozone is formed in the atmosphere via the chemical reaction of nitrous oxides (NO_x), and volatile organic compounds (VOCs –

previously referred to as hydrocarbons) in sunlight, CAA regulations include requirements to control NO_x and VOC emissions.

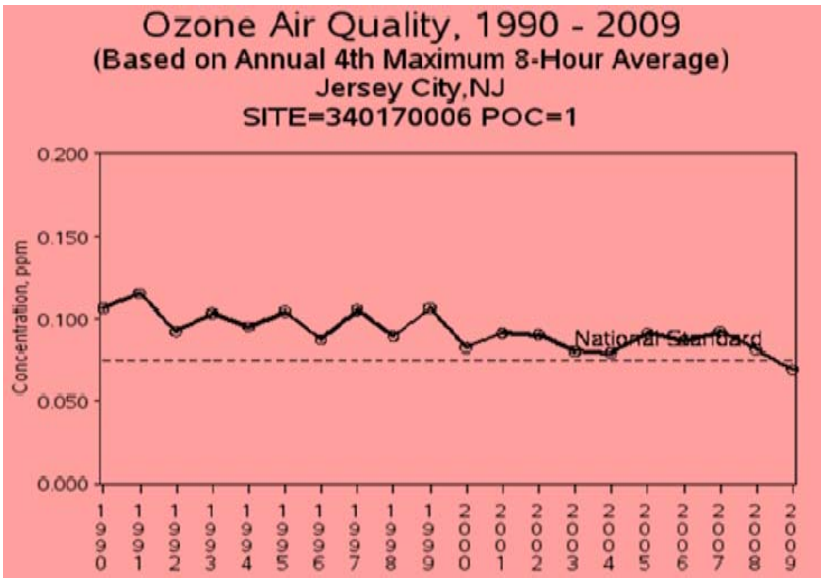
The major sources of NO_x, VOCs and CO emissions are combustion devices, i.e., power plant boilers, manufacturing facility process heaters, home and office heating systems and vehicles. Coal and oil fired power plants emit significantly greater quantities of pollutants than natural gas fired power plants. VOCs are also emitted from solvent and oil storage tanks, automobile painting operations, manufacturing processes, dry cleaners, restaurants, etc. Other sources of VOC emissions include everyday products such as gasoline, cleaning solvents, paints and consumer products.

- *Ozone*

Ozone is needed in the stratosphere (i.e., the second of the five layers covering our planet) to shield the earth from potentially harmful ultraviolet radiation from the sun. At ground level (in the troposphere) where humans breath, ozone is a respiratory impactor. Ozone has also been shown to cause degradation of foliage. All of New Jersey has been designated as a "severe non attainment area" for ozone, with the second worst air quality in the country following Los Angeles. As such, the SIP contains numerous programs and regulations to control and reduce VOC and NO_x emissions. There are numerous requirements in State for controlling these emissions. For example, there are requirements for industrial heaters and power plant boilers to install special combustion burners, and for vehicles to remain tuned up and to limit emissions (i.e., the controversial new enhanced automobile inspection and maintenance program).

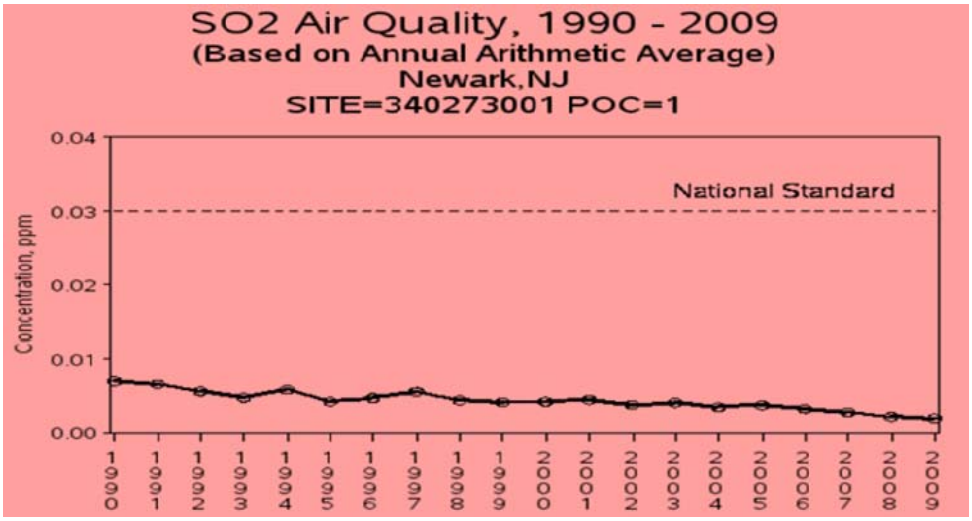
One problem with achieving the NAAQS levels for ozone, however, is that a significant portion of the ozone-causing NO_x and VOC emissions that affect New Jersey and other Eastern states air quality comes from long range atmospheric transport of pollutants emitted predominantly from power plants in West Pennsylvania, West Virginia and Ohio. Since ozone is a regional problem, under the 1990 Clean Air Act Amendments the USEPA identified the "Ozone Transport Region (OTR)" and established the "Ozone Transport Commission (OTC)" to evaluate and combat ozone on a regional basis. The OTC is comprised of all the New England and Mid-Atlantic States, Maryland, Pennsylvania and northern Virginia. New Jersey is currently part of a multi-state lawsuit with several other OTC members against the USEPA to force the heavy coal-burning states to better control the emissions from their power plants.

A 2010 review of the American Lung Association data shows that all of Morris County had an Ozone grade of F with 52 Orange and 4 Red Ozone days. A chart from Jersey City (below), located in Hudson County, shows that concentration in parts per million of ozone dipped below the national standard in 2009 for that location. At present, Hudson, Essex and parts of Bergen County are being considered for removal from the Non-Attainment List in regards to Ozone.



Sulfer Dioxide

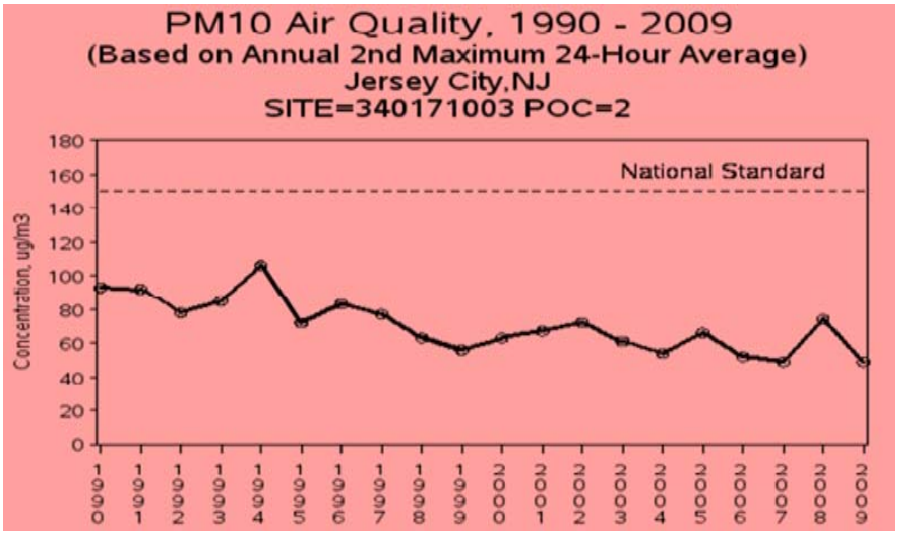
Sulfur dioxide is produced mainly as the product of burning of sulfur-containing solid or liquid fuels such as coal, fuel oil (for manufacturing, power generation and home heating) and diesel fuel. Sulfur is also emitted from municipal sewer plants since it is dispelled from the human anatomy. Sulfur dioxide in the air eventually reacts to form sulfuric acid, which is the main contributor to acid rain. (NO_x is also an acid rain contributor, but to a lesser extent). Acid rain has caused many lakes in America to become acidic and die and many forests to defoliate. The preponderance of acid rain impacts may be widespread, but are more visible in those areas where there are coal fired power plants that burn higher sulfur coals. Acid rain is considered a significant problem in the northern Adirondack Mountains in New York State, and the Great Smoky Mountains in the Virginias. The acid rain problem actually became exacerbated in the 1970's when the CAA required coal fired power plants to control their particulate (dust) emissions. It turns out that these particulates were alkaline, and would have neutralized much of the sulfur dioxide emitted, so reducing particulate emissions worsened the acid rain problem. While there is no station close to Madison that measures SO2, readings taken in Newark show levels below the National Standard.



Particulate Emissions

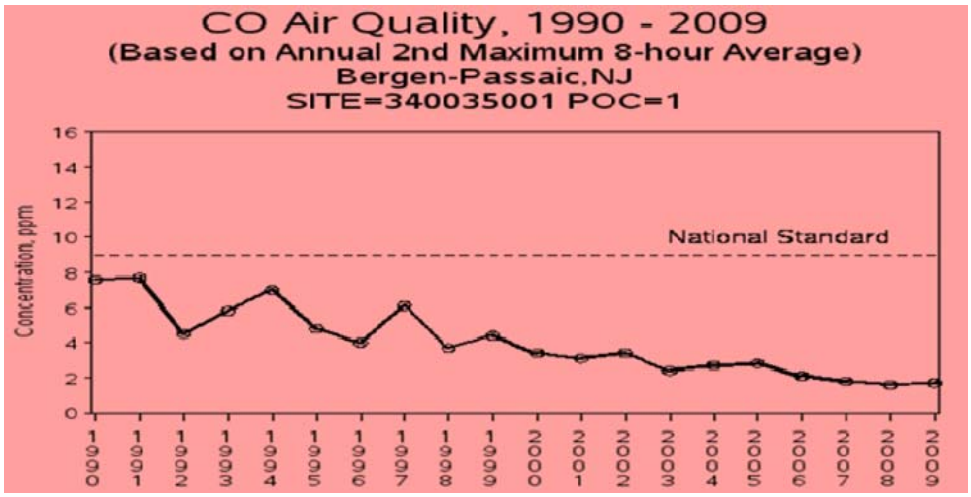
For a long time, particulate emissions have been under scrutiny for their part in impacting public health. Particulate emissions may be solid matter (dust) or liquid droplets suspended in the air. These particles float in the air and settle very slowly, with the smallest particles remaining suspended indefinitely. The degree of health damage that particulate matter does depends upon the type of particles inhaled, the number of particles inhaled, the size of the inhaled particles, and the general health of the person who has inhaled them. In general, sustained exposure to particulates can cause respiratory ailments and worsen the effects of cardiovascular disease. The smaller the particles the deeper into the lungs they penetrate. Recent studies have also started to link particulates to cancer. In California, particulates have been labeled as an "air toxic". In addition, particulates can affect visibility (of great concern in state and National forests and parks) and precipitation patterns.

Primary sources of particulates include diesel engines, power plants (especially ones that burn coal and heavy fuel oils), wood stoves, construction activities, windblown dust sources, manufacturing plants, etc. The nearest station that has up to date reporting of Particulate Emissions is Jersey City. Their chart shows them well below the National Standard. The American Lung Association gives Morris County a "B" for Particle Pollution with only two (2) "Orange Particle Days."



Carbon Monoxide

Carbon monoxide (CO) is an odorless gas produced by incomplete burning of fossil fuels, wood or other carbon-containing materials. Sources include utility, industrial and residential boilers, motor vehicles and kerosene or wood-burning stoves. Short term exposure to CO results in fatigue, and can also worsen existing heart and lung disease. Parts of New Jersey have been designated non-attainment areas for CO. However, state ambient air monitoring stations have demonstrated a decrease in CO concentrations over the years and the state is currently petitioning the USEPA to re-designate the non-attainment portions of Bergen, Essex, Hudson and Union Counties as attainment areas.



Greenhouse Gases

Some scientists warn that the buildup in the atmosphere of certain gases that tend to trap in heat towards the earth's surface will result in global warming, with subsequent polar ice cap melting and coastal flooding. Termed the "greenhouse effect", the prime culprit "greenhouse gases" (GHGs) include carbon dioxide (CO_2), methane (CH_4), and NO_x. Others propose that the increased atmospheric load of air pollutants will actually prevent some of the sun's rays from reaching the earth, thereby reducing the earth's temperature and causing a mini ice age. In any event, any climate change brought on by air pollution could drastically affect all life on earth.

CO_2 is a difficult pollutant to control since it is the primary product of fossil fuel combustion. NO_x is also a product of fossil fuel-fired operations, but it is produced at much lower levels, equal to only a small fraction of the quantity of CO_2 produced. To appreciably reduce $C0_2$ emissions in light of population increases would require a significant revamping of the U.S. energy policy, changes in air quality regulations and a reevaluation of fuel burning technologies. Fuel conservation programs and technologies, and alternative fuels programs are the main approaches for reducing CO_2.

Methane is a product of biological activities and it is also released in small quantities from fossil fuel combustion. Landfills (garbage dumps) sheep flatulation and termite mounds are significant sources of worldwide methane production. During December, 1997, officials from 160 countries met in Kyoto, Japan and developed a legally-binding Protocol under which industrialized countries will reduce their collective emissions from a group of six greenhouse gases by an average of 5.2% by 2012 relative to the year 1990 emissions. The United States requirement is to reduce the GHGs by 7%. The U.S. originally signed the Kyoto Protocol. However, nations are not subject to the commitments of the protocol until they have ratified it and it enters into force. In Senate Resolution 98, the U.S. Senate took the firm position that it would not ratify the Protocol until developing countries (such as China, India and Brazil) demonstrate "meaningful participation" in the program. The feeling was that limited controls on GHG production in these countries would negate any benefits achieved by GHG reductions in developed countries. Other issues that were not fully resolved were whether emissions trading and credits for carbon sequestration by forests,

soils and agricultural practices could be counted towards a country's emission reduction requirements. It is anticipated that the control of GHGs in America will be a contentious global issue for decades to come.

Hazardous Air Pollutants

As a result of the CAA of 1977, the USEPA started to crack down on certain hazardous air pollutants. The initial list of hazardous air pollutants was small, with only eight substances. Included in this list were lead, emitted primarily from automobile exhaust pipes, vinyl chloride, a component of PVS production, and benzene, a ubiquitous VOC emitted from gasoline storage tanks, automobiles, fuel tank spill remediation's and manufacturing plants. Emission control requirements were pretty strict for these compounds. Then, in the CAAA of 1990 the list of HAPs were expanded so that there are now 187 individual compounds or groups on the list. Under the CAAA requirements manufacturing plants are initially required to install air pollution control devices that employ maximum achievable control technology (MACT) equipment). Eight years after installing MACT equipment, manufacturers must still review their emissions relative to "residual risk" to the population to determine whether additional controls are required.

EMISSIONS QUANTIFICATION & CONTROL

For New Jersey to demonstrate progress towards achieving NAAQS levels and compliance with the SIP programs, larger manufacturing facilities must provide the state with an annual inventory of actual emissions called an "Emission Statement". These emission levels are compiled, and compared to the allowable potential emissions so that the state is able to modify existing programs or develop new emission reduction programs, if warranted.

In most air pollution regulations emission limits are stated and it's up to a facility to decide on the proper air pollution control technology and equipment to achieve those limits. In some regulations, however, certain numeric control or removal efficiency criteria are stipulated, depending upon the technology chosen.

In New Jersey, potential emission levels are compared with certain criteria to determine whether a state-of-the-art (SOTA) technology review is required. Typically, sources with the potential to exceed the SOTA thresholds are required to install air pollution control equipment. However, the NJDEP's SOTA equipment requirements are not truly as rigorous as the dictionary definition of state-of-the-art.

In addition to the state's SOTA equipment requirements, an emission source could also be subject to a number of other USEPA control technology requirements under various regulations that include the New Source Performance Standards (NSPSs), MACT (defined previously for HAPs), or Federal New Source Review (NSR) or Prevention of Significant Deterioration (PSD).

AIR POLLUTION IN SUBURBIA

Air quality considerations are often dismissed as being of minimal concern in suburban communities since the people aren't subject to a continual barrage of chemicals as are people living alongside or close to industrial areas. However, in our older, more industrialized states like New Jersey it must be remembered that in the suburban and rural areas there are still sources of industrial air pollution since small manufacturing and assembly plants are scattered throughout neighborhoods, having been sited there before many towns and townships had zoning laws. Other ubiquitous air emission generating sources often overlooked because of their perceived non-impact include auto body painting and repair shops, dry cleaners, etc. Emissions from these smaller facilities have come under greater scrutiny by the NJDEP in the past decade and they are a non-trivial local source of air pollution. Most neighborhood dry cleaning establishments these days are pickup/drop-off locations for larger cleaners, who use newer cleaning equipment that contain very good air pollution control equipment.

Transport of air pollutants generated in other areas i.e., both short range (a few miles) and long range (50 miles or more) impacts on the air we breathe. As stated previously, the whole State of New Jersey is designated as a non-attainment area for ozone so we are all breathing sub-standard air.

As a result of the Clean Air Act Amendments of 1990, the use of air pollution-causing consumer products will come under greater scrutiny in areas where the air quality does not improve. In the past 10 years there has been a significant push to regulate the production of air pollution-causing consumer products. The two initial types of these sources that were regulated were aerosol spray cans and paints. Under the 1988 Montreal Protocol, many nations around the world agreed to replace ubiquitous ozone-depleting chlorofluorocarbons (CFCs) by 2000 with low and non ozone-depleting chemicals. There was direct evidence that CFCs were responsible for the increasing size of the "ozone hole" in the stratosphere and a subsequent increase in skin cancers caused by UV absorption. CFCs were used throughout the world as the main propellant in consumer aerosol sprays (e.g., in hair sprays and deodorants) and as industrial solvents. Regarding paints, over the past 15 years the USEPA has developed paint specification requirements that limit the amount of VOCs in certain types of paints and coatings. This has resulted in the increased development and usage of non-VOC and water-based coatings. In areas with poor air quality like Los Angeles and New Jersey, a manufacturer's paint may have a different formula than the paint they sell in North Dakota.

If the air quality in New Jersey does not demonstrate improvement over the next decade, there could be added pressure to reduce the quantity of VOCs emitted from consumer products. Such draconian measures have already been considered in Los Angeles, e.g., restricting the use of charcoal in barbeques, outlawing old, polluting lawn mowers, etc.

FUTURE SOURCES OF AIR POLLUTION

Regarding nuisance emissions such as ones that cause objectionable odors, municipal Madison, the wastewater treatment plant is about 1 mile east of the eastern border of Madison. Local Chatham residents rarely issue complaints of odors and since winds blow very infrequently

towards the west, Madison residents are rarely, if ever, impacted by potential odors. In 2010, the Madison – Chatham wastewater treatment plant started an upgrade to the methane recovery tanks to capture more methane to burn off to power the facility.

Another source of potentially objectionable odors is composting operations. The only operations of such a type in the immediate area are the leaf and mulch recycling operations at the Borough maintenance garage on John Street. Occasionally, a hard, fruity odor can be smelled in town, usually under the proper atmospheric conditions either at night or in the early morning, and along the direction of the wind. This occurs due to the biological "fermenting" of the leaves and mulch, but it is not a health hazard. Leaves are no longer composted at this site. (2010)

Another considerable group of sources of air pollution that continue to receive greater state and federal attention are mobile sources i.e., automobiles, trucks, buses, boats, trains, aircraft and construction equipment. Automobiles release much lower levels of air emissions today than in years past due to better engine designs and tougher emissions testing requirements (i.e., at the state-approved inspection stations). However, the significant growth in the usage of sport utility vehicles (SUVs) has limited both emission reductions and subsequent improvements in ambient (outdoor) air quality. This is because the USEPA gave in to pressure from the automobile industry and initially categorized SUVs as trucks, which have less restrictive tailpipe requirements than automobiles. Originally this wasn't an issue but since up to 30% of new vehicles sold are now SUVs, this now has a significant impact on our air quality. The USEPA, however, has decided to re-designate SUVs and will begin to require tougher tailpipe standards.

In terms of local impacts on air quality from automobiles, traffic congestion is an important factor. Prior to the opening of Route 24 in November, 1992 there was extensive traffic along the major arteries in Madison. The Route 24 opening initially displaced the traffic congestion from Main Street to the highway, but over the past several years the increased development in the general region has caused a return of much of the Main Street congestion. In addition, the traffic along much of Route 24 has become increasingly congested over the years.

Major developments that come on line have the potential to exacerbate traffic congestion in and around Madison and degrade air quality. One of the larger projects in recent years was the development of two new townhouse complexes, providing a combined 560 units, located on Passaic Avenue in Florham Park, across from the Joint Meeting of Chatham and Madison. The development of the 466-acre Exxon property on Park Avenue, of which 8.8 acres sit in Madison, may pose traffic concerns. In September 2008, the Jets Football team moved into their newly built practice facility that was built on part of the former Exxon property. Although daily traffic has not increased noticeably, the team will periodically hold public rallies, which require police traffic control, detours and emergency notification alerting Madison residents to avoid the area unless going to the event. Ground breaking on the 466-acre property for a new national headquarters of BASF began in June 2010. The facility, which will accommodate 1,100 personnel, will be an economic generator for the region, but may pose traffic concerns if not properly planned.

ACCIDENTAL RELEASE

Industrial facilities, mainly chemical and pharmaceutical plants, usually take special care when dealing with toxic and hazardous air pollutants. However, even though extreme cautions are taken and the probability of an accidental release is infinitesimally small, it can still happen. The real concern is that a major release can impact people as far as 25 miles away. People may remember the noxious odor that engulfed the Borough in 1984, which was the result of a release from the Exxon Bayway Refinery in Linden, N.J. 25 miles away!

The worst accidental release in world history was the 1984 Union Carbide release in Bhopal, India in which a combination of equipment failures resulted in a release of tons of the deadly gas methylisocyanate, causing 2,000 fatalities and 20,000 injuries. In New Jersey within the past ten years an explosion at the Napp Chemical plant in Paterson in 1998 resulted in 4 fatalities among plant workers and an April 1998 release at the Morton Chemical plant in Paterson resulted in a 2 alarm fire and the release of chemicals into the community.

A few historical catastrophic releases in New Jersey have included the 1980 Chemical Control fire in Elizabeth, which spurred on the passage of the USEPA Superfund program, the Monsanto explosion in Kearney in 1972, which left the plant looking like it had been hit by mortar fire, and the 1971 Exxon H-Oil Explosion at the Bayway Refinery in Linden, which caused a 600 ton reactor to take off like a Saturn V rocket and land ½ mile away (amazingly, there were no fatalities).

For the most part, there are a minimal number of appreciably-sized manufacturing plants within a five mile radius of Madison. The few pharmaceutical operations in the area, i.e., the Novartis facilities in Summit and East Hanover, are research facilities which used smaller quantities of dangerous chemicals and take extreme precautions to eliminate all chemical releases.

In 1987 the USEPA instituted the "Right to Know" law, which requires facilities that handle hazardous chemicals to register and report the quantities of these chemicals to the local fire departments and emergency planning councils. A review of the Madison Fire Department's files showed the only registered industrial chemicals to be a storage tank of sulfuric acid at Verizon on Park Avenue, some landscaper insecticides, some perchloroethane at local cleaners, small quantities of printing chemicals at Madison Printing on Main Street, small quantities of solvents at auto repair shops, and small quantities of solvents and metals at the Heller and Higgs companies off of Sampson Avenue. There are 33 listed polluters in Morris County. Two of them, National Manufacturing Co., Inc. and ISP Chemicals, Inc. Sutton Laboratories are located in Chatham. At this time, there have been no reported major accidental releases from either of these sites.

If a chemical release or spill were to happen within the boundaries on the Borough, the Madison Fire Department's procedure is to place an immediate call to the Whippany Hazmat Team, which is the regional first responder for both the Borough and the State Police.

While Madison does not have large quantities of hazardous materials within its borders it is to be noted that there are 40 superfund sites in Morris County, the closest to us being Saint Elizabeth College Landfill in Convent Station.

INDOOR AIR QUALITY

Most people are concerned with the impacts of outdoor air pollution on their health. However, an outbreak of Legionnaires' disease at an American Legion convention at the Ritz Carlton Hotel in Philadelphia in 1976 helped focus attention on the problems associated with indoor air pollution.

Since outdoor air enters buildings, a lot of the outdoor pollutants, both man-made and natural (e.g., pollen), get transported indoors. In addition, emissions can be generated from indoor activities and sources, e.g., renovations (dust), new carpets de-volatilizing chemicals, consumer products such as paints and polyurethane coatings, cigarette smoking, etc. In addition, molds and mildew can grow in areas subject to dampness, e.g., basements, ceilings from leaky roofs, etc. The term "sick building syndrome" was coined in response to humans showing health symptoms as a result of exposure to indoor air pollutants.

In the 1970s, as a result of the energy crises, energy efficiency was introduced to the American way of life. One of the prime areas where this was practiced was in thermal retention in buildings. Thermal retention is achieved through minimization of infiltration of outdoor air into buildings and use of larger quantities of attic and wall insulation. Unfortunately, thermal infiltration minimization also had a negative side effect, namely, of reducing the amount of outdoor air exchanges and dilution of interior generated air pollution. Subsequently, new homes today are often installed with air-to-air heat exchangers which transfer about 80% of the thermal heat value of air that is intentionally exhausted to reduce the concentration buildup of air pollutants.

Three key indoor air species that have shown to have an impact on human health and which have been evaluated extensively in New Jersey over the past 20 years are asbestos lead from paint, and radon. Asbestos is a natural fiber that was used extensively in the 20th century up until the 1970's to insulate boilers and water pipes. It is also used in the manufacture of automobile and truck brake pads. In time, the asbestos used for building insulation can start to soften and crack, reverting to a form called "friable". Friable asbestos can become airborne and be breathed in. Once inhaled, the long pointed asbestos fibers can be retained in the lungs causing inflexibility of the lungs and possibly leading to respiratory diseases. In extreme cases asbestos can also be an initiation site for cancer.

Health effects caused by asbestos were clearly demonstrated in workers who worked in industries that made or extensively used products made from asbestos. However, there was an alarmist reaction to the potential health impacts from asbestos in homes starting in the 1980's. As a result, an asbestos removal industry grew in the 1980's. Unfortunately, much of the asbestos risk concerns were blown out of proportion, the removal industry was fraught with incompetence and the whole asbestos issue came to be looked up as a scam. In most cases, unless there is a considerable amount of friable asbestos being generated and entrained into the air, asbestos is not a considerable indoor air issue. Madison has removed most of the asbestos from the Hartley Dodge Memorial building during an extensive two year renovation that was largely completed in December 2010.

Regarding lead, through much of the 20th century lead was used as an octane booster in gasoline. Once health effects of lead were demonstrated the USEPA banned lead from gasoline. In recent years, a concern has started to grow, that household particulates containing lead from old lead paint residual dust gets re-entrained into indoor air and breathed in. There is still a debate as to the degree of health risk this dust actually poses.

In the 1970's the term, "radon" became a household word in New Jersey. Radon is the only naturally occurring radioactive element which is a gas. Technically, the term "radon" can refer to any of a number of radioactive isotopes having atomic number 86, but the predominant isotope of concern inside homes is radon-222. Radon-222 is directly created by the decay of radium-226, and has a half life of 3.82 days. The four "daughter" products which immediately follow radon-222 in the decay chain are polonium-218, lead-214, bismuth-214 and polonium-214. These elements have such short half-lives that they exist only in the presence of radon. These daughter products are ultra-fine solids which tend to adhere to other solids including dust particles in the air and solid surfaces in a room. They adhere to lung tissue when inhaled and bombard the tissue with alpha particles, thus creating the health risk associated with radon. Radon is suspected of being a potential contributor to the formation of lung cancer.

Radon accounts for approximately 54 percent of normal everyday background radioactivity. High concentrations are associated with a geologic formation covering a good portion of Northern New Jersey called the "Reading Prong". Houses built on the Reading Prong may have radon naturally seeping through openings in foundations such as floating slabs or sumps. If it is determined through testing that the level of radon is above a certain level, i.e., 4 pico curies per liter, the homeowner should consider a remedy to the problem such as sealing up the openings and/or venting the radon gas.

In conclusion, if there is suspicion of an indoor air problem due to health effect symptoms, a homeowner should contact the Borough's Health Department and consider hiring an indoor air quality consultant or industrial hygienist, although this is not an inexpensive endeavor.

NOISE POLLUTION

Often included in companion with air pollution studies, an often overlooked aspect of environmental resources is noise pollution. Every government-funded transportation construction project must do a noise pollution investigation to determine whether the project will cause noise impacts.

Common sources of high levels of noise include aircraft industrial equipment, construction equipment and vehicles. Regarding loud noise generated by construction equipment, idling diesel trucks, etc., this is best handled on a personal basis by contacting the Madison Police Department and Borough Health officer with a complaint.

With the continual growth of corporate headquarters and office buildings in the region, the number of take-offs and landings have continually increased at Morristown Airport. Since a number of the flight paths are directly over Madison, the number of noisy low altitude aircraft has increased markedly prompting establishment of QUEST, a non-profit group with a mission to reduce aircraft

noise in Madison, particularly from Morristown Airport. In 2004, Quest working with the Morris County Freeholders and representatives of Morristown Municipal Airport produced a new map for helicopter traffic avoiding noise sensitive areas in Madison. In 2006, this working group adjusted the airplane landing approach to 3.5 degrees from 3.0. This reduced noise over Madison by keeping the planes higher in their approach pattern. Airport noise complaints are handled by calling Morristown Airport Operations Noise Abatement Office at 973-538-3366.

CONCLUSION

The degree of air pollution is directly related to the amount of industrial activities in the area, the population, the amount of traffic congestion and the amount of pollution that blows in from other regions. As population increases, improved technologies will have to more than make up for the increase in air pollution in order to improve our air quality and meet the Federal Clean Air Act requirements. If we are unsuccessful in curbing our development and improving our air quality, then we will be forced to comply with draconian restrictions such as limiting charcoal use in barbeques and using old lawn mowers. Over the years since 2000 the air quality for most pollutants has gotten better with stricter Federal and State regulation, with the notable exception being Ozone that comes in from other areas of the country.

To receive air quality alerts or check the air quality in Madison, follow this link: http://www.stateoftheair.org/2011/states/new-jersey/morris-34027.html

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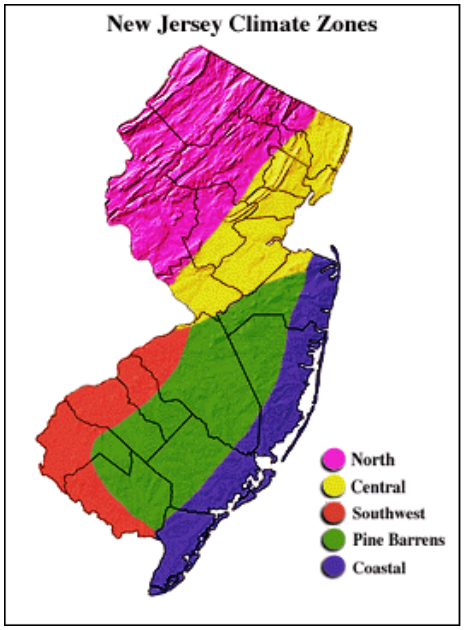
VII. CLIMATE

There are great differences in the productivity and habitability of different parts of the land surface of the U.S. These differences are largely the result of the interactions of several weather factors, including prevailing wind speeds and directions, temperature, and precipitation, with the geology or physiography of the earth. Long term conditions of these weather factors are called *climate*. When describing climate, meteorologists prefer to use scientific averages of 30 years or more. Averages based on a shorter term could be significantly different.

New Jersey enjoys what is termed a "humid, hot-summer continental climate". It is a beneficial and agreeable climate for human habitation because there is considerable variation in weather without the hardships caused by prolonged extremes. There is growing evidence that the climate of the United States has been relatively stable for the last four centuries. As for the projected future, there are conflicting theories that either global warming, caused by the "greenhouse effect" from mankind's industrialization, will gradually increase temperatures a few degrees, which can cause significant climate shifts or that we are slowly but naturally proceeding towards the next ice age tens of thousands of years off in the future.

New Jersey's climate is defined by its median position between the equator and the North Pole, its proximity to the sea and the passage of atmospheric weather systems across its surface. New Jersey is crossed by both tropical and polar air masses whose boundaries oscillate northward and southward, often tracking the jet stream, in the global procession of storm patterns. Subsequently, prevailing winds come out of the southwest in the warmer months and out of the northwest in the colder months. Tropical systems bring warm, wet weather with primarily south-westerly winds from the Gulf of Mexico up along the coast. Polar air masses are typically cold and dry, with prevailing winds from the northwest. They move across the Great Lakes and down the valley of the St. Lawrence River, often extending well into the northern part of New Jersey.



TEMPERATURE

In Northern New Jersey's continental climate, average monthly temperature varies by almost 45° Fahrenheit between the coldest month (January: 28°F) and the hottest month (July: 73°F). Table VII-1A shows mean, maximum and minimum monthly temperatures based upon the period from 1895 to 2000. Table VII–1B shows mean temperatures for 2001 to 2009. The combined chart for the two tables shows a slight rise in overall temperature in the last decade. Charts 1-4 break the span of 1931 – 2009 by decade into yearly quarters to more clearly reflect monthly temperature trends over time.

Table VII-1A:
Average Monthly Temperatures in Northern New Jersey from 1895 to 2000

	Mean	Normal	Maximum	Year	Minimum	Year
January	28.4	28.0	38.1	1950	18.4	1977
February	29.4	30.5	37.3	1998	16.9	1934
March	38.3	39.1	48.5	1945	29.6	1916
April	48.8	49.1	55.1	1941	43.7	1907
May	59.4	59.5	65.5	1991	51.9	1967
June	68.1	68.1	73.1	1943	62.7	1903
July	73.0	73.2	78.6	1955	69.5	2000
August	71.0	71.3	75.7	1955	65.7	1927
September	63.7	63.7	70.3	1961	58.5	1917
October	53.1	52.3	58.8	1949	46.1	1925
November	42.5	43.0	48.5	1931	36.6	1901
December	32.2	33.1	39.2	1923	23.0	1917
Totals	50.7	50.9				

Table VII-1B:
Average Monthly Temperatures in Northern New Jersey from 2001-2009

	Mean 2001 – 2009	Mean 1895 – 2000	
	Source Canoe Brook Station	Source Table VII-1	Change
January	28.5	28.4	+ 0.1
February	33.4	29.4	+ 4
March	40.2	38.3	+ 1.9
April	52	48.8	+ 3.2
May	61.3	59.4	+ 1.9
June	70.6	68.1	+ 2.5
July	75.4	73	+ 2.4
August	75.7	71	+ 4.7
September	66.4	63.7	+ 2.7
October	53.1	53.1	0
November	46.3	42.5	+ 3.8
December	34.3	32.2	+ 2.1

Chart of Data Tables Above

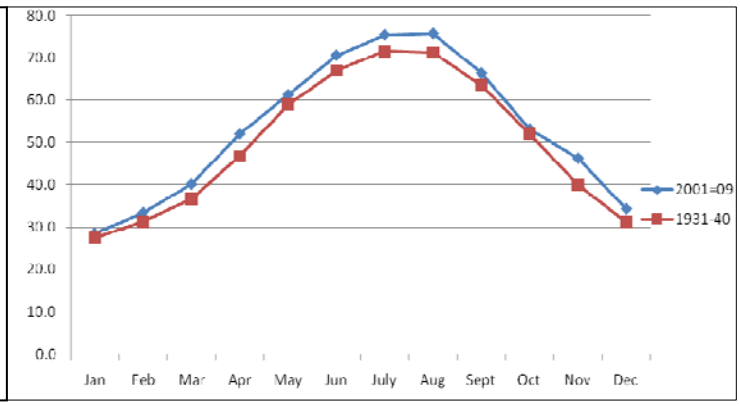


Chart 1: Mean Temperatures 1931 – 2009, January – March
Source: Canoe Brook Station

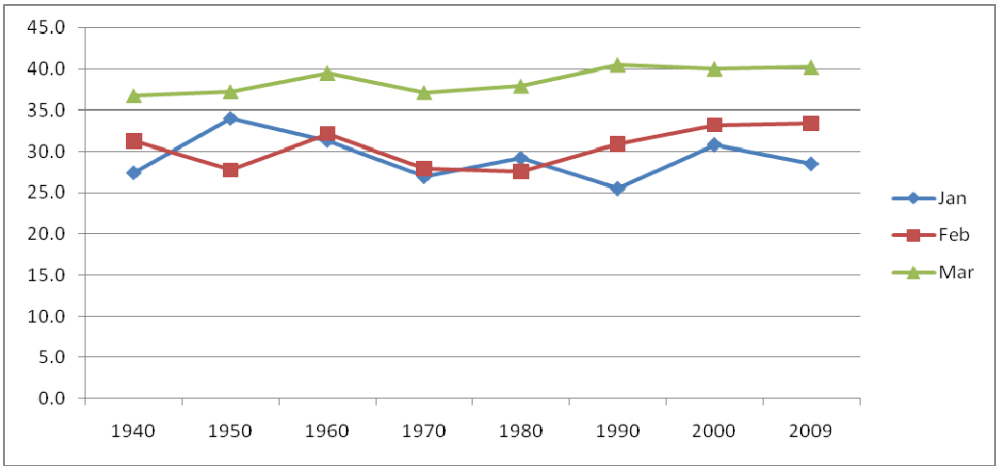


Chart 2: Mean Temperatures 1931 – 2009, April – June
Source: Canoe Brook Station

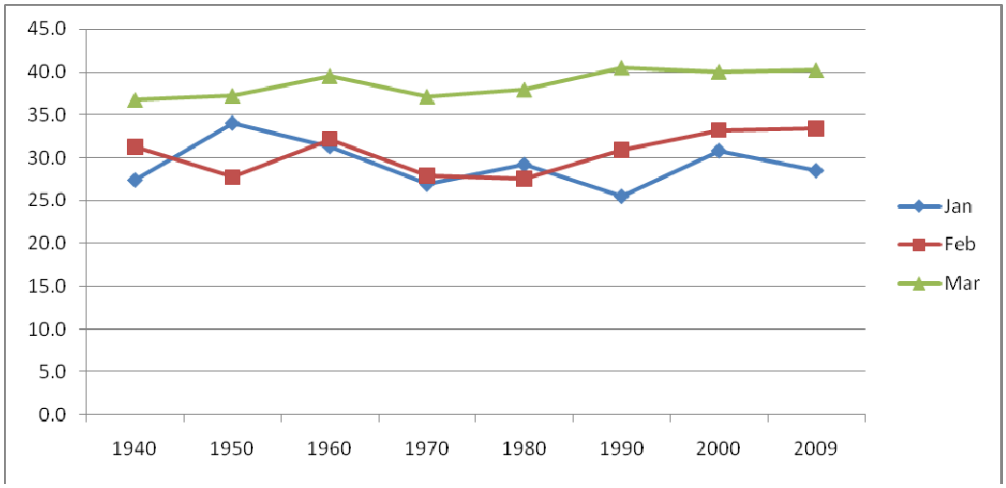


Chart 3: Mean Temperatures 1931 – 2009, July - September
Source: Canoe Brook Station

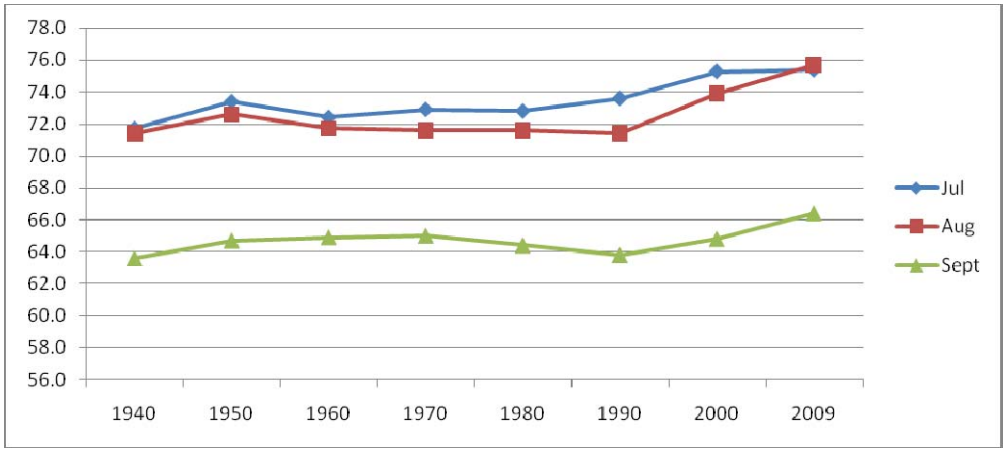
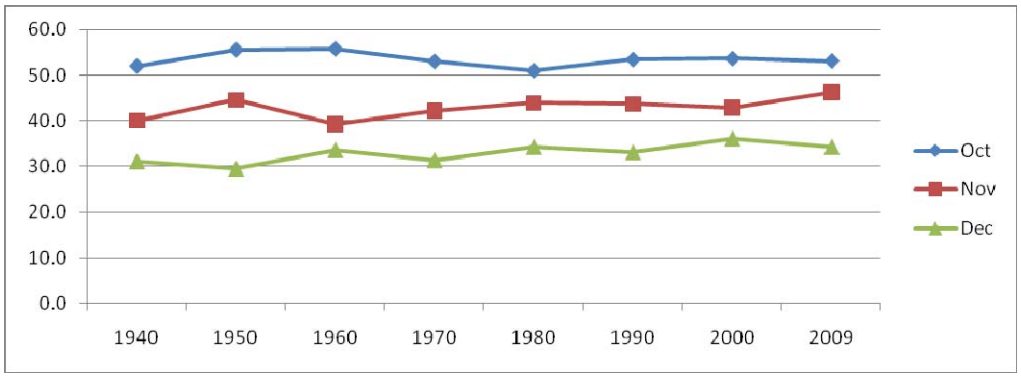


Chart 4: Mean Temperatures 1931 -2009, October – December
Source: Canoe Brook Station



The frost line in Madison varies from about 20 to 24 inches, depending upon such factors as exposure to the wind, vegetative cover, topography and elevation. For engineering and building purposes the Borough's Engineering Department has assumed a conservative, uniform frost line value of 36 inches. The dates of first and last frost vary from April 21 to May 10th and from October 3 to October 31, respectively, as shown in Table VII-2. The average annual number of frost free days in this area is about 168 days/year (Madison Environmental Commission – 1982).

Table VII-2
Freeze Data: Average Monthly Degree Days

	Last Spring Frost	First Fall Frost	Numbers of Days Between Dates	Reference
				Canoe Brook Station Elevation 173 feet
1976	5/9	10/19	163	
1977	5/9	10/18	162	
1978	5/4	10/9	158	
1979	4/21	10/27	189	
1980	4/23	10/10	170	
Average			168	
				Morristown Airport Elevation 613 feet
2006	4/24	10/15	174	
2007	4/11	10/30	202	
2008	4/31	10/19	172	
2009	4/17	10/12	178	
2010	4/28	10/30	185	
Average			182	

A "heating degree day" is the number of degrees that the average daily temperature falls below 65° on that day. Heating degree days are used during the heating season for space heating calculations. Table VII-3A shows average monthly degree days over a 30 year period. The average for the period was 5,595.

Table VII-3A
Heating Degree Days

	1971-2000	2001-2009	Difference
Jan	1133	1098	-35
Feb	962	924	-38
Mar	783	752	-31
Apr	456	374	-82
May	180	140	-40
June	25	4	-21
July	2	0	-2
Aug	4	0	-4
Sept	71	42	-29
Oct	376	358	-18
Nov	636	554	-82
Dec	976	922	-54
Mean	5595	5227	-368

Source: Canoe Brook Station

A "cooling degree day" is the number of degrees that the average daily temperature falls above 65^0 on that day. Cooling degree days are used in warmer seasons to calculate air conditioning requirements, and are shown in Table VII-3B.

Table VII-3B
Cooling Degree Days

	1971-2000	2001-2009	Difference
Jan	0	0	0
Feb	0	0	0
Mar	0	0	0
Apr	0	0	0
May	27	33	6
June	146	168	22
July	281	292	11
Aug	232	296	64
Sept	64	90	26
Oct	7	0	7
Nov	0	0	0
Dec	0	0	0
Mean	757	934	177

Source: Canoe Brook Station

PRECIPITATION

The meteorological factor which often historically receives the great attention in local planning is precipitation. Rain and snow replenish Madison's valuable drinking water aquifer, affect steam flows, and impact on structural engineering requirements, flood predictions, wastewater treatment plant discharge runoff control measures and snow plowing requirements. Since 1895, Northern New Jersey's precipitation has varied between 30 and 64 inches annually, well above the national average of 20 inches. Morris County's annual average precipitation ranges from about 46 to 49 inches. Table VII–4 shows the mean, minimum and maximum monthly precipitation levels from 1895 through 2000.

Table VII–4
Average Monthly Precipitation in Northern New Jersey from 1895 - 2000

	Mean	Normal	Mean 2001 To 2010	Max.	Year	Min.	Year
Jan	3.42	4.02	2.90	10.51	1979	0.62	1981
Feb	3.07	2.97	2.52	6.34	1896	0.94	1901
Mar	3.89	4.11	4.25	8.44	1983	0.72	1910
Apr	3.89	4.24	3.85	10.37	1983	0.86	1963
May	3.92	4.72	3.49	9.99	1984	0.01	1903
June	3.92	4.31	4.43	10.87	1972	0.24	1949
July	4.68	4.72	4.25	12.15	1897	1.03	1999
Aug	4.47	4.36	3.76	14.36	1955	0.64	1964
Sept	4.05	4.68	4.02	12.04	1999	0.32	1914
Oct	3.60	3.79	5.19	9.34	1903	0.15	1924
Nov	3.56	4.09	3.97	9.70	1972	0.56	1917
Dec	3.57	3.79	4.02	8.93	1973	0.37	1955
Totals	46.05	49.79	48.18				

Source for Mean 2001-2010: climate.rutgers.edu

Precipitation in the area is fairly well distributed throughout the year. Monthly precipitation levels typically vary from about 3 to 5 inches of rain – equivalent. However, some months can be almost devoid of precipitation, whereas in other months precipitation can exceed six inches. Typically the heaviest rains occur during summer thunderstorms or during tropical storms or hurricanes in the early fall. Short term droughts are a part of life in New Jersey, and seemed more plentiful in the 1990s than any other time in the past 50 years. Oftentimes just a short term phase in the frequency distribution of precipitation over time, droughts typically are dealt with in town via water rationing. The last water rationing Madison imposed was in July to early August, 1999. Whereas other nearby towns have much more frequent water rationing requirements, e.g., Florham Park, Madison is fortunate in that we do not have to impose such restrictions due to our careful control of our valuable water supply. Madison has started a five year water plan that includes repairing leaking water mains and installing of new water meters throughout the town. An Ordinance was adopted January 24, 2011 revising water rates to fund those projects.

OTHER FORMS OF PRECIPITATION

Regarding other forms of precipitation, hailstorms occur very infrequently in Madison and usually only last for short durations. Snowfall varies widely from year to year, with the extremes ranging from a low of 5 inches or less to as much as 60 inches. The average annual snowfall recorded in Morris Plains from 1948 through 1990 was 32.4 inches. Maximum monthly amounts for December through March were in the 25 to 31 inches range. Snowfall rates measured at Newark Airport for the decade ending 1980 were 23.1 inches, ending 1990 were 30.05 inches, decade ending 2000 were 13.8 inches and the decade ending 2010 were 31.5 inches. The average snowfall over the past 40 years was 24.6 inches.

Madison's topography is such that only a few low-lying areas are susceptible to extensive flooding. The potential exists, however, for very heavy rainfall from tropical storms, local thunderstorms and significant snow events. A list of some significant rain and snow events from the past includes the following:

- Aug. 5, 1843: 15 inches of rain
- Sept. 21-23, 1882: 11 to 18 inches of rain (Hurricane)
- Aug., 1902: Rains caused flash flood in Madison
- Oct. 8-9, 1903: 10-plus inches of rain (tropical storm)
- Nov. 6-7, 1953: 20 to 30 inches of snow
- March 16-19, 1956: 30 to 40 inches snow
- Aug. 26-27, 1971: 9.8 inches of rain
- April 6, 1982: 12 inches of snow
- Jan. 1, 1996: 24 to 30 inches of snow
- Sept. 16, 1999: Hurricane Floyd
- Dec. 26, 2010: 14 – 20 inches of snow
- August 2011: Hurricane Irene

A scan of recordable events listed at NOAA's website for Morris County shows that while drought, rain, and temperature extremes have remained constant between the prior decade and this decade, events of flooding, hail storms, strong wind events and snow storms has greatly increased.

NOAA Recordable Events for Morris County	1991 -2000	2001– 2010 * * As of 10/31/10	Change
Drought	17	20	+3
Precipitation	20	20	--
Temperature Extremes	41	40	-1
Flood	29	52	+23
Hail	7	17	+10
Snow	59	110	+51
Strong Wind	0	45	+45

WIND

To assist pilots and for air pollution modeling predictions, precise, local meteorological

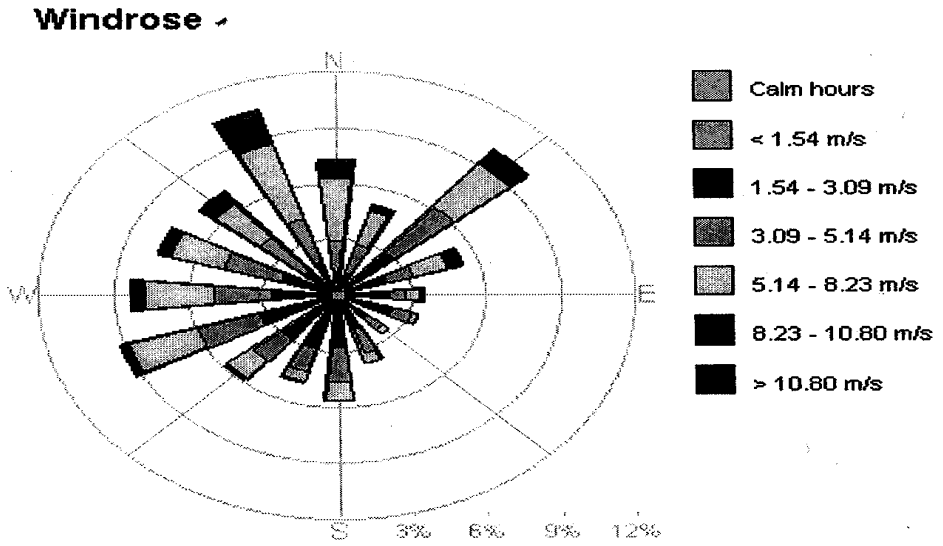


Figure VII – 2:
Newark Meteorological Data
WindRose, 1998

Figure VII-2A
Newark Meteorological Data (WindRose, 1998)

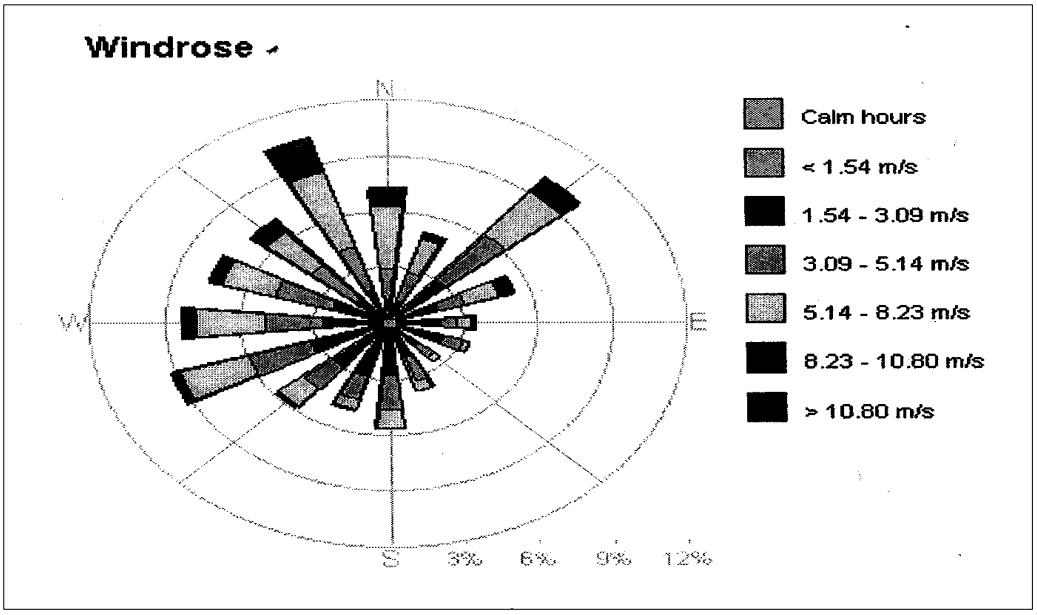
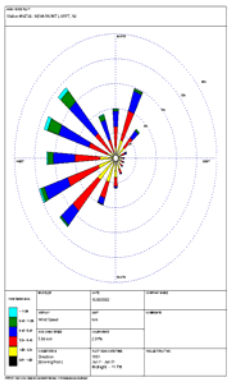


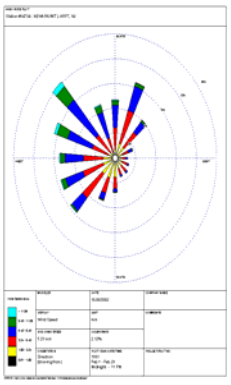
Figure VII-2B is a series of average monthly windrose graphs from January to December. These give a clearer picture of the wind patterns and how they change over the year.

Figure VII-2B:
Newark Meteorological Data (Windrose, 2002)

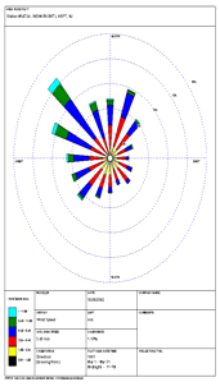
January



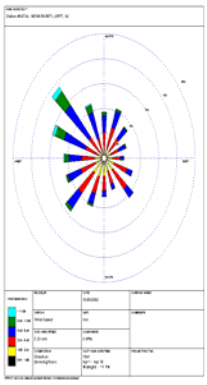
February



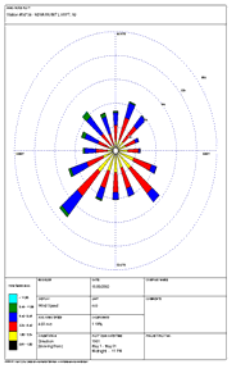
March



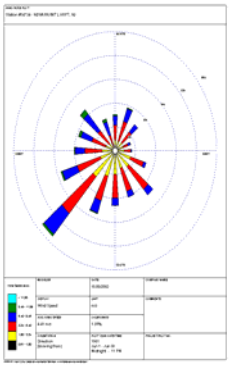
April



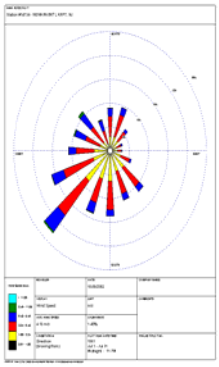
May



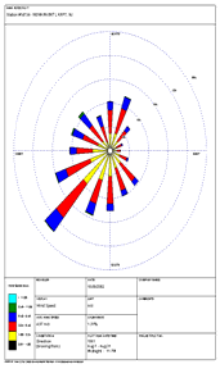
June



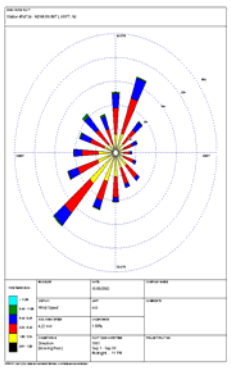
July



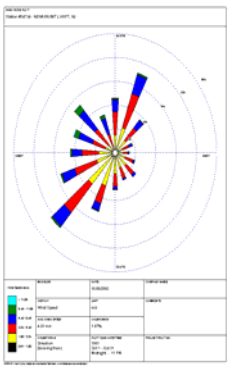
August



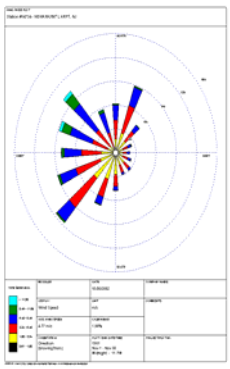
September



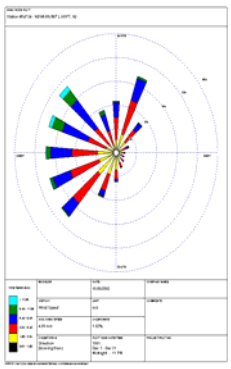
October



November



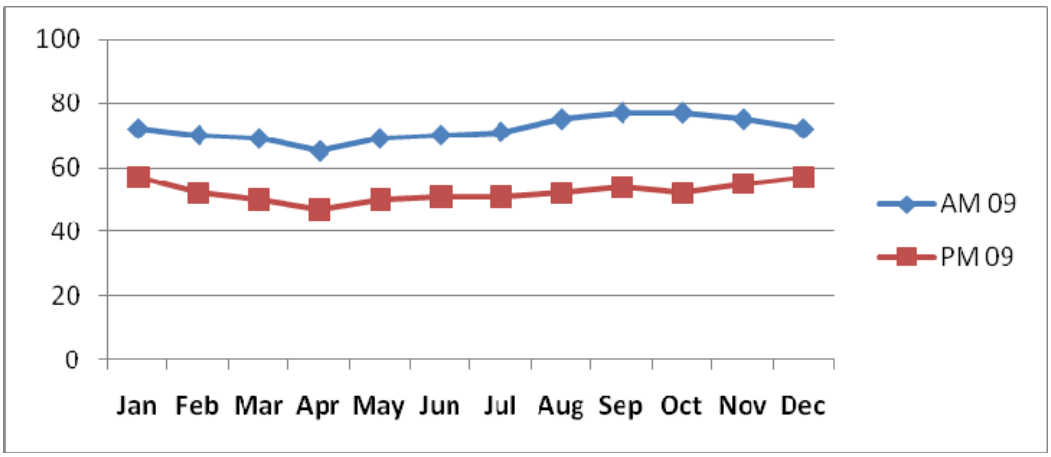
December



RELATIVE HUMIDITY

Humidity affects the level of comfort of humans and the operating ability of some types of equipment. Thus, it is an important consideration in heating, cooling and air conditioning. The U.S. Weather Service at Newark Airport is the closest official recording station of relative humidity, which relates actual water vapor present to that which could be present at "saturated conditions". Average readings over a fifteen year period (Figure VII-2) illustrate two patterns: (1) that within each day, humidity is higher during the early morning hours, declines into the early afternoon heat and then rises toward evening; and (2) that the months when humidity is highest are June through December. Figure VII-3 updated through 2010 shows AM &PM levels.

Figure VII-3
Relative Humidity Pattern at Newark Airport



EXTREME WEATHER CONDITIONS

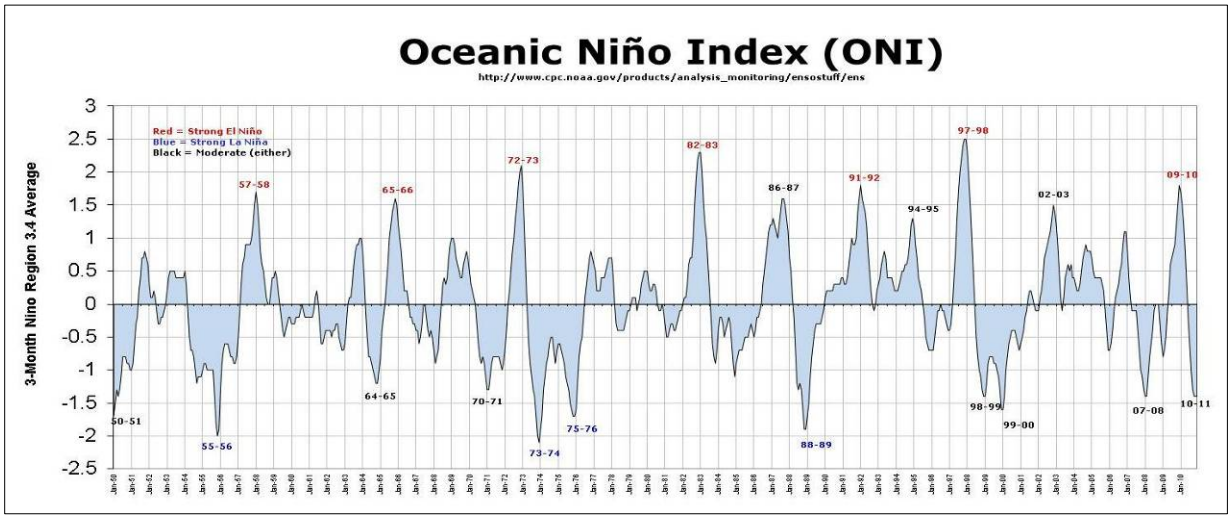
Over decades and centuries weather can demonstrate appreciable variability. Throughout the 1990s frequent short-term extreme weather conditions hit most of the continental U.S., including Madison. While certain regions in the country were suffering from drought, at the same time others were suffering from intense rains and flood. Two ocean-atmospheric system weather phenomena in the Pacific Ocean, termed "El Nino" and "La Nina" were responsible in part for global weather disruptions. Historically only discussed by climatologists, El Nino and La Nina became the frequent topic of many a news weather reporter in the late 1980s and 1990s. El Nino is the condition characterized by unusually warm ocean temperatures whereas La Nina is characterized by unusually cold ocean temperatures in the Equatorial Pacific. These variations from more temperate conditions are climate. The impacts are seen most clearly in wintertime. In the continently U.S. during El Nino years, temperatures in the winter are warmer than normal in the North Central States, and cooler than normal in the Southeast and Southwest. During a La Nina year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest. In the Northeast, El Nino and La Nina have an effect on our climate because our prevailing winds come from the Northwest and the Southwest. However, the effects are much more

subdued. The Oceanic Nino Index (ONI) has become the de-facto standard that NOAA uses to identify these events.

Rated Events

El Nino			La Nina		
Weak	Moderate	Strong	Weak	Moderate	Strong
2004	2002	2009		2007	
2006				2010	

Source: Oceanic Nino Index



Source of graph: http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ens

Over the past few decades, as usual, New Jersey received its typical share of warnings regarding potential Caribbean-bred hurricanes. However, in 1999 one of the most ferocious storms of the century, Hurricane Floyd ("Floyd"), wreaked havoc on the East Coast. Floyd hit New Jersey on September 16, and while its intensity had weakened from a category 4 to a category 2 hurricane by time it initially hit landfall in the U.S. in North Carolina, it wasn't a typical category 2 hurricane due to its massive size and the added time that it lingered in an area. Subsequently, these conditions caused widespread flooding. In all, 73 deaths were attributed to Floyd, including four (4) in New Jersey. The town of Bound Brook witnessed the rise of the Raritan River to the second story of houses near the river, a site never before seen. In Madison, the water level rose well above the 100-year flood mark, and the highest water level in Borough history since the flash flood of August 1902 was recorded. (Note) The flash flood of 1902 ripped through the Presbyterian cemetery, tossing caskets and bodies from about 50 graves). The Spring Garden Brook overflowed its banks, streets were flooded out and properties and basements that had never before experienced flooding were inundated.

Over the past decade there have been two years in which there were noteworthy snows events. In the winter of 1993-1994 there were a total of 16 snowstorms. This constant barrage of snow never allowed the underlying road ice to be cleared from the streets, resulting in dangerous

driving conditions for most of the winter. In addition, on January 1, 1996 a single snowstorm dumped approximately 2 feet or more of snow, something unseen in a generation.

Tornados are rare in New Jersey and even rarer in Morris County and Madison. This may be due to climatological elements, or it may be due to better meteorological investigations and measurements. Most tornados occurred in the warmer months, always in conjunction with thunderstorms. While no deaths occurred from these tornadoes, extensive damage to a limited number of homes frequently resulted.

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http://www.worldclimate.com/
http://www.ncsu.edu/

VIII. SOILS

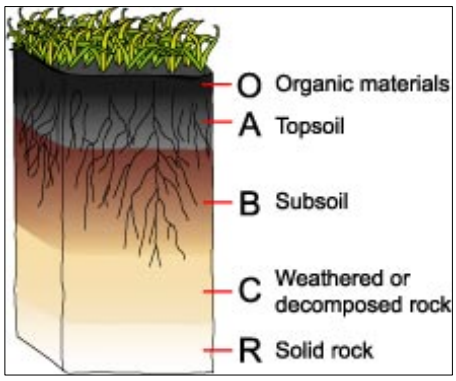
Soil is made up of several components, including rock particles, organic material, air spaces between the particles, and water. The source or parent material of soil is either weathered bedrock at the site, or as in Madison, material carried to its present location by glacial ice and running water. Decaying vegetable and animal matter, the organic component, mixes with the rock particles. Air and water fill the spaces between this combination of mineral and organic substances, and the end result is soil. The soil scientist defines soil to include all four components, in whatever combination, existing on a specific site between the vegetative cover and the material that was little altered by the soil-forming process. It takes thousands of years for soil to become fully developed.

SOIL CHARACTERISTICS

The physical characteristics of soils vary depending on the parent material in which they develop, the climate and the topography. The mineral component of soil is made up of particles of sand, silt and clay in different proportions. Sand particles are the largest, silt and clay are the finest. Soils are classified according to the size and percentage of the particles they contain. Single soil classes seldom exist alone; they are usually a mix of sand, silt and clay. Soil scientists use terms like sandy loam, silt loam or clay loam to describe the texture of a soil. Loam soils, for example, contain 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. In most soils the organic content rarely amounts to more than 5 percent. A rough estimate can be made by observing the color of the soil. Usually, the darker the soil, the higher the percentage of organics. Gardeners know that adding organic material to soil improves its texture and ability to retain and supply water and nutrients to plants.

The relative amount of water and air in a soil depends on local precipitation and on the properties of the soil itself. As water moves down through the voids between soil particles, some is absorbed by the roots of plants and trees. Some of the rest eventually reaches the water table, below which all of the voids are filled. “The depth of water table below the surface of the ground varies with time, depending on long-term precipitation levels. In general, the water table reaches a high point in the late spring. The long-term average level of this high point is called the ‘seasonal high water table’. It can be determined at any specific location by color changes in the soil. Long-term presence of water gives the soil a grayish color, whereas soil that has fairly steady exposure to air is a brownish or reddish color (Fraser and Morris, 1980).

Over a long period of time, water entering the soil shifts soil materials into layers called *soil horizons*. The coarsest particles in the topsoil are located in the A horizon. Clay particles are carried down into the subsoil (B horizon). The C horizon usually contains the parent material which has been changed very little by the soil-forming process. The sequence of natural layers in soil is called a *soil profile*. The engineer must be concerned with the deeper layers which remain after the topsoil has been removed from a construction site. The farmer and gardener are more interested in the properties of the topsoil.



The infiltration capacity of a soil refers to the ability of water to enter and be transmitted through the soil when the soil is already moist. Well drained, coarse textured soils with high infiltration capacity minimize surface water runoff. Extensive root development in the surface layer also increases infiltration; bare, compacted soil increases runoff. The potential for soil erosion grows as runoff increases. "Erosion is a constant process…Even as soil is slowly built up through erosive processes in the subsoil, the topsoil is being washed away by the same erosive processes. The topsoil is the most precious part of the soil and any disturbance only accelerates the erosion" (Morris County Soil Conservation District, Environmental Newsletter 81-5). Topsoil is generated naturally at a rate of approximately one inch every 500 years. Unfortunately New Jersey's rate of cropland erosion is the highest of all 11 northeastern states. Almost 5.5 million tons is lost annually, enough to blanket the entire city of Trenton with a layer 7.1 inches deep (Swackhammer, 1981). Some of this soil is permanently lost when it is washed into streams and rivers and eventually the ocean. The remainder is re-deposited elsewhere, leaving the area from which the soil eroded less productive and more prone to further erosion.

Analysis of Morris County soils is found in the *Soil Survey of Morris County, New Jersey* (1976, revised 1999), completed by the U.S. Department of Agriculture's Soil Conservation Service (SCS). "The soil survey is a collection of aerial photographs…on which the distribution and kinds of soils are indicated. Detailed descriptions of each soil series found in the area are given as well as interpretations about the potential use of each soil for farming, roads, dwellings, recreation, septic systems, engineering uses, and other uses. Engineering properties such as depth to bedrock, seasonal high water table, percolation rate, drainage potential, shrink-swell potential, etc. are also included. Limitations for soil uses are expressed as slight, moderate and sever" (Howell and Eby, 1981). Slight means that soil properties are generally favorable for the intended use; moderate means that some soil properties are unfavorable but can be overcome by careful planning design and management at somewhat great costs; severe means that soil properties are so unfavorable and so difficult to correct or overcome as to require exceptional, complex or costly measures. "The *Soil Survey* provides a detailed overview for use in general planning. Planning the actual location of a dwelling, a road, a septic system, etc. requires an onsite investigation to clarify exactly what is there…When looking at a site plan application, the reviewer uses the soil survey to determine the kinds of soil related limitations to be anticipated on a site, to plan needed onsite investigations, and to estimate the adequacy of the site plan to provide corrective measures" (Howell and Eby, 1981).

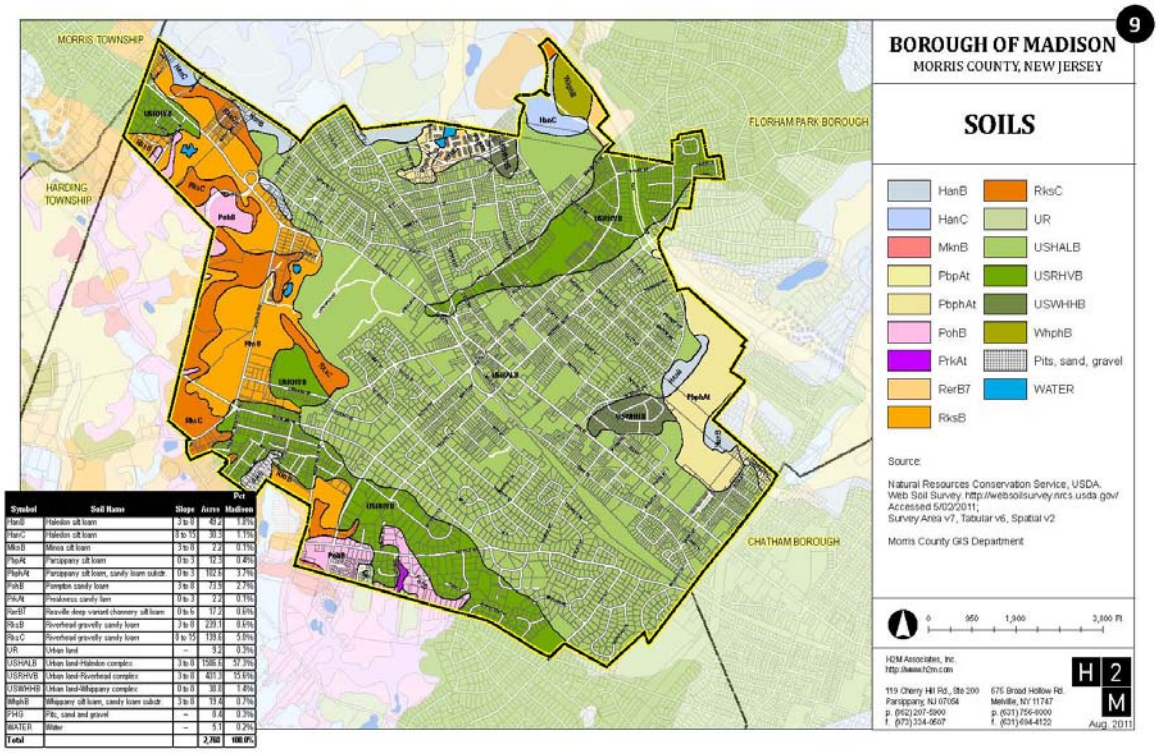
The most updated soil information available for Morris County at the time of the 2011 ERI Update was retrieved through the "Web Soil Survey (WSS)" online application, which is produced by the National Cooperative Soil Survey and operated by the USDA Natural Resources Conservation Service (NRCS). NJDEP no longer produces soil GIS data, but relies on the USDA's resources. (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.)

MADISON'S SOILS

The General Soil Map from the *Soil Survey* shows that Madison soils fall into two different soil associations: the Haledon-Urban land–Boonton association; and the Riverhead-Urban land-Pompton association. A soil association is a landscape with a distinctive pattern of soils, consisting of one or more major soils and several minor soils, and is named for its major soil.

The Haledon-Urban land – Boonton association are soils formed in young glacial till, and are characterized as "deep, well drained to somewhat poorly drained, gently sloping and strongly sloping silt loams, gravelly loams, and extremely stony loams that overlie basalt or shale; on uplands" (*Soil Survey*). More than two-thirds of Madison on the north side is mapped as Haledon-Urban land – Boonton association. The Riverhead-Urban land-Pompton association are soils formed in organic deposits, glacial lake sediment, or glacial outwash, This association is "deep, well drained to somewhat poorly drained, nearly level to strongly sloping gravelly sandy loams and sandy loams that overlie stratified outwash sand and gravel; on outwash plains and terraces" (*Soil Survey*). In Madison, the Riverhead-Urban land – Pompton association soils are located in a strip one-half mile wide in the southern part of the Borough extending in a northwest to southeast direction.

The soil associations may be further reduced into soil series and mapping units. These are shown in detail on Map 9, and also on Sheet 35 of the *Soil Survey*. Map 9 uses the SSURGO (Soil Survey Geographic Data Base) symbols. The comparison of the SSURGO and *Soil Survey* symbols is summarized in Appendix A of the *Soil Survey*. In Madison, the most common soils in the Haledon-Urban land – Boonton association are Urban land – Haledon complex and Urban land – Riverhead complex. The most common soils found in the Riverhead-Urban land-Pompton association are the Riverhead gravelly sandy loams, the Pompton sandy loam, and the Urban land-Riverhead complex. The following is a description of each soil series per the *Soil Survey*.



Symbol	Soil Name	Slope	Acres	Pct Madison
HanB	Haledon silt loam	3 to 8	49.2	1.8%
HanC	Haledon silt loam	8 to 15	30.3	1.1%
MknB	Mineo silt loam	3 to 8	2.0	0.1%
PbpAt	Parsippany silt loam	0 to 3	12.3	0.4%
PbphAt	Parsippany silt loam, sandy loam subsoil	0 to 3	102.6	3.7%
PohB	Pompton sandy loam	3 to 8	73.5	2.7%
PrkAt	Preakness sandy loam	0 to 3	2.2	0.1%
RerB7	Reaville deep variant channery silt loam	0 to 6	17.2	0.6%
RksB	Riverhead gravelly sandy loam	3 to 8	239.1	8.6%
RksC	Riverhead gravelly sandy loam	8 to 15	139.6	5.0%
UR	Urban land	–	9.2	0.3%
USHALB	Urban land-Haledon complex	3 to 8	1586.6	57.3%
USRHVB	Urban land-Riverhead complex	3 to 8	431.3	15.6%
USWHHB	Urban land-Whippany complex	0 to 8	38.8	1.4%
WhphB	Whippany silt loam, sandy loam subsoil	3 to 8	19.4	0.7%
PHG	Pits, sand and gravel	–	8.4	0.3%
WATER	Water	–	5.1	0.2%
Total			2,768	100.0%

Urban land is soil that has been re-worked and the original soil profile cannot be adequately described. These occur in all areas that have already been developed and are not suited for other purposes.

Urban land – Haledon complex – "This complex consists of poorly drained and well-drained soils that have a high proportion of silt and fine sand…The soil material is more or less gravelly and cobbly glacial deposits of material derived mainly from red and brown shale and sandstone, traprock, and granitic gneiss…The complex is about 40 percent cut and fill land and a nearly equal percentage of Haledon soils. About 20 percent is Boonton, Holyoke, and other soils." The Haledon soils have a dark-brown silt loam surface layer. In the subsoil, there is a brown, mottled silt loam, followed by a dark-brown, firm very fine sandy loam.

Urban land – Riverhead complex – "This complex consists of well-drained, nearly level to strongly sloping sandy and gravelly soils. It is mainly on undulating outwash terraces…The underlying material is loose, unweathered, stratified and sorted sand and gravel outwash, mostly of granitics material that contains some shale, sandstone, quartzite, and conglomerate. Coarse fragments are mainly gravel and a few cobbles, but in places there are stones and boulders…This complex is about 55 percent soils that have been disturbed by man to the extent that the original profile no longer remains and 35 percent Riverhead soils. Making up the remaining percentage are areas of Otisville and Pompton soils." A description of the Riverhead soils is provided below.

Riverhead gravelly sandy loam – "The Riverhead series consist of well-drained, nearly level to strongly sloping gravelly soils… The soils formed in sandy and gravelly outwash derived mainly from granitic material that contains small amount of shale, sandstone, quartzite, and conglomerate… This soil is on wide terraces in valleys and on knolls on broad, low outwash plains…" The Riverhead soils have a very dark grayish-brown gravelly sandy loam surface layer. Below the topsoil is a dark-brown gravelly sandy loam, a yellowish-brown gravelly sandy loam, and a yellow to pale brown gravelly loamy sand and loamy sand. The RmB and RmC have a yellowish-red subsoil.

Pompton sand loam – "The Pompton series consists of deep, nearly level to gently sloping, somewhat poorly drained soils…They formed in sandy and gravelly glacial outwash derived mainly from red and brown shale and traprock and a small amount of other kinds of material, such as quartzite, sandstone, and conglomerate. The soils are underlain by stratified, water-sorted sand and gravel." The Pompton soils surface layer is a very dark grayish-brown sandy loam. The upper part of the subsoil is a yellowish-brown sandy loam and gravelly sandy loam. Below this is a yellowish-brown and light olive-brown, loose gravelly loamy sand.

Listing of Soils in Madison

Symbol	Soil Name	Slope	Acres	Pct Madison
HanB	Haledon silt loam	3 to 8	49.2	1.8%
HanC	Haledon silt loam	8 to 15	30.3	1.1%
MknB	Minoa silt loam	3 to 8	2.2	0.1%
PbpAt	Parsippany silt loam	0 to 3	12.3	0.4%
PbphAt	Parsippany silt loam, sandy loam substr.	0 to 3	102.6	3.7%
PohB	Pompton sandy loam	3 to 8	73.9	2.7%
PrkAt	Preakness sandy lam	0 to 3	2.2	0.1%
RerB7	Reaville deep variant channery silt loam	0 to 6	17.2	0.6%
RksB	Riverhead gravelly sandy loam	3 to 8	239.1	8.6%
RksC	Riverhead gravelly sandy loam	8 to 15	139.6	5.0%
UR	Urban land	--	9.2	0.3%
USHALB	Urban land-Haledon complex	3 to 8	1586.6	57.3%
USRHVB	Urban land-Riverhead complex	3 to 8	431.3	15.6%
USWHHB	Urban land-Whippany complex	0 to 8	38.8	1.4%
WhphB	Whippany silt loam, sandy loam substr.	3 to 8	19.4	0.7%
PHG	Pits, sand and gravel	--	8.4	0.3%
WATER	Water	--	5.1	0.2%
Total			2,768	100.0%

MADISON SOILS IN CRITICAL AREAS

Under Section 208 of the Clean Water Act passed by Congress in 1977, each state was required to develop area-wide land use plans to control non-point sources of pollution such as erosion and stormwater runoff. As a result, the *Water Quality Management Plan* (1979) was prepared under the auspices of the Department of Environmental Protection, and approved by the Governor. It states that "in 208 planning, *critical areas* are sensitive natural lands and waters which when altered would lead to the degradation of water quality."

The Water Quality Management Plan includes prime aquifer recharge soils such as Riverhead and Urban land-Riverhead, frequently flooded soils such as Parsippany, and water retention soils such as Pompton and Urban land-Whippany. A SCS soil scientist recommended that the Pompton soils be considered prime aquifer recharge soils instead of water retention soils because they are as permeable as the Riverhead soil in the substratum.

Clearly one of the important soils in Madison is the Riverhead that covers most of Giralda Farms, the land at the southwest corner of Loantaka Way and Woodland Road, the Madison golf course, the land between Garfield Avenue and Shunpike, and the land between Ridgedale and Central Avenues over to Greenwood Avenue at the Florham Park line. The main properties of this soil that affect its use are rapid permeability rates in the substratum, steep slopes, and a moderately high erosion potential. It should be emphasized that Riverhead soils are prime aquifer recharge soils. According to the N.J. Department of Agriculture soil scientist Mr. Shinder, "the hazard of groundwater pollution is severe because of subsurface layers of sand and gravel which

are minimally effective in absorbing (retaining) major contaminants generally associated with urban development."

Another recommendation made by Shinder was for Urban-Haledon soils to be considered as potential aquifer recharge soils. As he explained, "these areas are called potential for two reasons: one, they are already built up and only a fraction is available for recharge; and two, the soil has a dense, restrictive layer of material below the surface which impedes the downward movement of water. As a result any aquifer recharge devices, such as retention ponds, infiltration trenches or dry wells would have to be constructed below this restrictive layer. In addition, the areas designated as Urban-Haledon have a seasonal high water table which, during wet periods, minimizes their suitability for potential aquifer recharge."

There are three maps included in this ERI that show important soil characteristics. The Groundwater Recharge Areas Map (See Map 10) shows the wide variation in groundwater recharge rates throughout the Borough. As mentioned above, the Giralda Farms area has comparatively high groundwater recharge rates of 19 to 23 inches per year. Ground-water recharge (GWR) is defined as the water that infiltrates the ground and reaches the water table regardless of the underlying geology. It supports aquifer recharge, stream baseflow and wetlands. The Hydric Soils Map (See Map 11) illustrates how hydric soils are very limited within the Borough. As defined by the NRCS, a hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Soils that developed under sufficiently wet conditions can support the growth and regeneration of hydrophytic vegetation. Hydric soils maintain important functions in the environment as they have water holding capacity and also store more organic carbon. Finally, soils of Prime Agricultural Importance are shown in Map 12. The northwesterly portion of the Borough has soil areas considered "prime farmland" and of "statewide importance."

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- Swackhamer, Phyllis, "New Jersey Food System. A Harvest of Doubt for the Garden State," Rodale Press, Emmaus, Pa. 1981.
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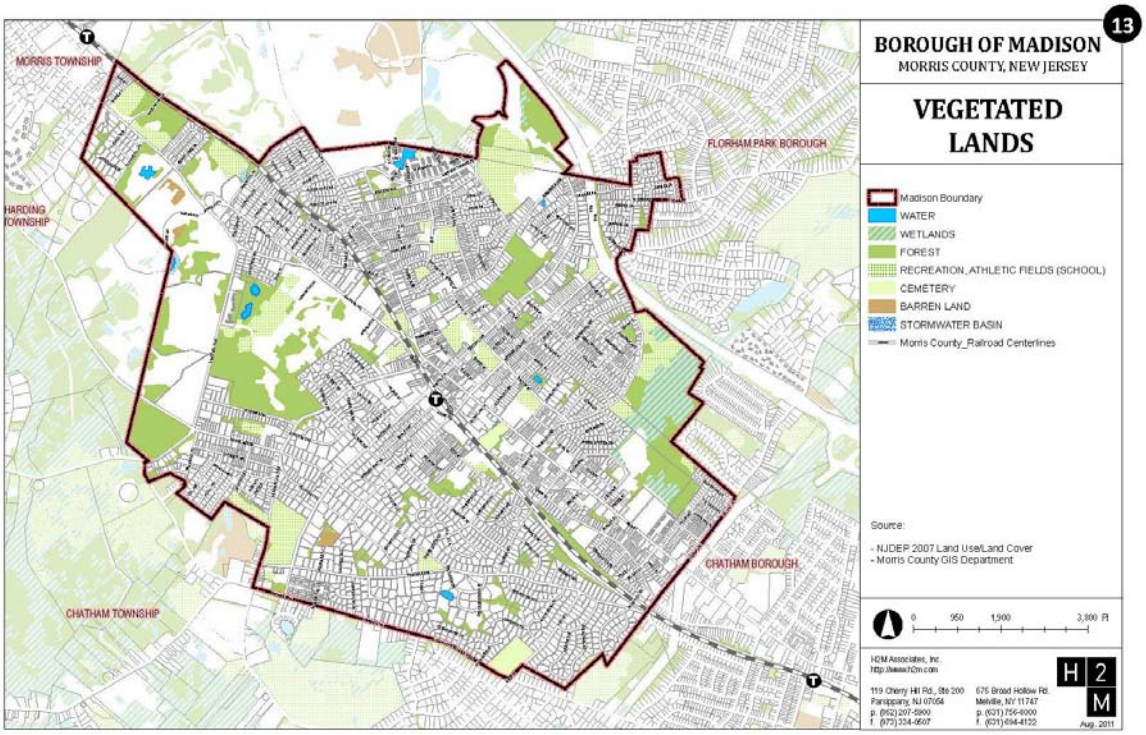
IX. VEGETATION

VALUE AND TYPE OF VEGETATION IN MADISON

Vegetation beautifies the community of Madison, anchors critical food webs that support biodiversity, and shelters songbirds and other wildlife. Aesthetic, recreational, and even psychological benefits of nature contribute to the Borough's quality of life and property values. Vegetation also provides invaluable ecosystem services: minimizing flooding, controlling soil erosion, filtering water pollutants, recharging the groundwater that we drink, moderating extreme summer and winter temperatures, providing buffers against noise and visual pollution, storing greenhouse gases, and removing both particulate and gaseous air pollutants.

Viewed from above, the ecosystems of Madison are elucidated by Map 3 (Land Use/Land Cover), Map 13 (Vegetated Lands), Map 16 (Open Space) and Map 18 (Impervious Cover). A close look reveals a variety of ecosystems which vary in their pollution-cleansing capacity, wildlife value, and biodiversity. Madison is lush with greenery, with a modest proportion of commercial development, primarily along Main Street, and almost no industrial land. Residential lands predominate, including extensive lawns and ornamental plantings. Open space includes recreational fields, a golf course, school campuses, a small cemetery, parks, and other patches of woods. The Borough has no agricultural lands. Old canopy trees can be found on residential, park, and conservation land; however, no old-growth, unlogged forests occur in the Borough. Mature, second-growth forest is present in several locations, described below, mostly in poor condition ecologically.



Wetlands, which take the form here of wooded swamps rather than open marshes, are present toward the eastern end of Madison, in the 49 Acres open space tract, and in small pockets along intermittent streams. At least one vernal pool is present, in the Hepburn Woods section of the Drew University Forest Preserve. Vernal pools are wetlands that hold water only in the spring and support a distinctive group of amphibians and invertebrates. Ice-block depressions, locally known as punch-bowls or dells, punctuate the area. These small valleys do not hold water with the exception of two ponds in the Zuck Arboretum of the Drew University Forest Preserve that were lined with clay to retain water by previous landowners decades ago.

HISTORY OF MADISON'S ECOSYSTEMS

Before settlement by European-Americans, eastern North America was blanketed by forest, unbroken by open fields. Madison is situated within North America's Eastern Deciduous Forest formation, which extends from northern New England to southern Florida and westward to the prairies. Madison's pre-settlement ecosystems included oak-chestnut forest, albeit without chestnut trees lost to an invasive fungal disease decades ago, and maple-beech forest in rich soils. Forests were dominated by several species of oaks (chiefly red, black, white), American beech, sugar maple, tulip-tree, American chestnut, black birch, cherry, hickory, sassafras, and others. Wetter areas along Spring Garden Brook and other streams were dominated by red maple with pin oak, American elm, ash, swamp white oak, and sweet gum trees. These forests supported multiple layers of trees, shrubs, tree seedlings, ferns, wildflowers, with scattered patches of moss and woodland grasses. Standing dead trees and rotting logs provided valuable wildlife habitat.

The landforms, soils, and ecosystems of Madison were shaped by geological history (Chapter IV; Map 5). Madison lies within the geological region known as the Piedmont physiographic province, which is flanked by ancient Precambrian bedrock of the Highlands province to the northwest and by the younger sandy Inner and Outer Coastal Plains provinces to the southeast. Each of these regions is underlain by a distinct type of bedrock. Piedmont bedrock in is comprised of red sandstone and shale dating to the Cretaceous Period (65-135 million years ago) when dinosaurs and early mammals roamed together.

Even more influential for northern New Jersey ecosystems were multiple episodes of glaciations over the past two million years. The most recent glacial advance, which melted back from our region around 11,000 years ago, left behind a mosaic of soils and landforms atop bedrock. Map 5 (Surface Geology) shows that approximately 40% of Madison lies on deposits known as till, material laid down directly by glaciers, including a sizable area of terminal moraine, where the most recent glacial advance reached its southern terminus.

A smaller area formed at the bottom of ancient lakes, including the massive Glacial Lake Passaic; these clay-rich, poorly-drained lake deposits gave rise to wetlands in Madison as in the nearby wetland complex of the Great Swamp. Other lands were shaped by moving water as it flowed from the melting glacier, building glacial deltas similar to today's river deltas.

VEGETATION: ISSUES AND THREATS

Deforestation

New Jersey was almost completely deforested in the 1800's for farmland, timber, and fuel in the late 1700's through the mid-1800's. Few trees escaped the settler's axe, and ancient old-growth forests are extremely rare. The moist climate and young, fertile soils of northern New Jersey are favorable and supported the return of forest trees after logging. Studies show, however, that many wildflowers fail to return and that forest composition is altered by forest clearance. The second-growth (i.e. post-logging) forests of northern New Jersey carry this historical legacy and tend to be depauperate in their diversity, even as they mature. Deforestation is again transforming the New Jersey landscape, this time driven primarily by suburban development since the 1950's. However, Madison has moved in recent decades moved to protect open space and to control impervious cover. Expanded construction footprints on residential lots have fallen under increased scrutiny. The 25-acre Loantaka Moraine open space was protected with Green Acres funding in 1994, and more recently two new parks, Gibbons Pines and Livesey Park, were established. In 2009 the Borough acquired and protected as 49 acres of open space, the Madison Recreational and Conservation Complex.

Invasive Plants

Unfortunately, Madison's forests are desperately degraded beneath the canopy with virtually no young trees to replace the current generation. Two major forces behind this devastation are overabundant deer and burgeoning loads of invasive plants.

Like other forests throughout of eastern and Midwestern North America, Madison's natural areas are threatened by the spread of non-native trees, shrubs, vines, and weeds. Not every introduced plant turns into an aggressive invader, but many reproduce and spread. Invaders have completely displaced ground layers of vegetation, eliminated tree reproduction, and transformed wildlife habitat throughout the Borough. Among Madison's most problematic invaders, Japanese barberry transforms soil nitrogen to a form unavailable to woodland wildflowers; garlic mustard inhibits beneficial fungi required for establishment of tree seedlings; Norway maple suppresses diversity of shrubs and wildflowers; bittersweet and wisteria literally strangle trees and so convert forests to tangles of shrubs and vines. Scientists consider such biological invasions by plants, animals, and microbes to rank among the top threats to biodiversity worldwide. The consequences cascade throughout the food web with damage to beneficial insects and both migratory and nesting birds.
Only by tackling these problematic plants can Madison hope to preserve its forest ecosystems and their beneficial services. Land managers across the state and the nation are fighting to control invasive plants. In Madison, such projects are underway in Central Green and the Drew University Forest Preserve at this time. Several states and many towns restrict the sale and planting of damaging invasive plant species.

Federal agencies and regional organizations provide detailed, up-to-date listings of invasive plants, including those of our area. New invasive plants emerge continuously; for example, the notorious southern vines kudzu and mile-a-minute plant have appeared only recently in New Jersey. Thus current reports and websites should be consulted before plantings are made:

the National Park Service's "Weeds Gone Wild" database (http://www.nps.gov/plants/alien), the US Fish and Wildlife Service/National Park Service joint publication "Plant Invaders of the Mid-Atlantic Natural Areas" (available on line at http://www.nps.gov/plants/alien/pubs/midatlantic/), and the Mid-Atlantic Invasive Plant Council's database (http://www.invasive.org/maweeds.cfm) and information from the New Jersey Invasive Species Strike Team (http://www.njisst.org/).

Invasive Plants Currently Problematic in Madison

Trees:
- Norway maple (*Acer platanoides**)
- Sycamore-leaved maple (*Acer pseudoplatanoides*)
- Tree of heaven (*Ailanthus altissima*)
- Princess tree (*Paulownia tomentosa*)
- Black locust (*Robinia pseudoacacia*)
- Callery pear (*Pyrus calleryana**)

Shrubs:
- Japanese barberry (*Berberis thunbergii**)
- Burning bush (*Euonymous alata*)
- Privet (*Ligastrum vulgare*)
- Honeysuckle – shrubs (*Lonicera maackii, L. tartarica*, most others)

Vines:
- Japanese honeysuckle (*Lonicera japonica*)
- Oriental bittersweet (*Celastrus orbiculatus*)
- Wineberry (*Rubus phoenicalasius*)
- Wisteria, Japanese and Chinese (*Wisteria sinensis, Wisteria floribunda*)
- Multiflora rose (*Rosa multiflora*)

Herbaceous Plants:
- Purple loosestrife (*Lythrum salicaria*)
- Lesser celandine (*Ranunculus ficaria*)
- Garlic mustard (*Alliaria petiolata*)
- Japanese knotweed (*Fallopia japonica*)
- Japanese stilt grass, also called Nepalese brown top (*Microstegium vimineum*)
- Mugwort (*Artemesia vulgaris*)

* All cultivars, forms, and varieties of Norway maple, callery pear, and Japanese barberry are invasive.
Note: Consult internet sources above for updates on invasive species

- *The white-tail deer problem:*

Another serious threat to Madison's vegetation is the white-tailed deer, whose large and growing population destroys both ornamental and wild plants. Field surveys in 2011 show that deer have eliminated most wildflowers, native shrubs, and tree seedlings from wooded lands in the

Borough. Losses of ornamental plantings are substantial, and frustrated residents despair for their gardens across the state and the region. Deer are thriving not only because of a lack of predators but also because of a steady, healthy early-spring diet of grass and plantings, available long before food emerges in their natural habitat. Madison deer are known to give birth to triplets and to have two litters per season. Controlling deer damage is difficult in a populated community such as Madison. Protective deer fencing is permitting woodland recovery in small areas within Madison's Central Green and Drew Forest Preserve. Similar protection combined with restoration plantings and invasive species removals are recommended for management and protection of wooded parks.

- *Threats from insects and disease:*

Today a growing rogue's gallery of damaging insects and fungal pathogens threatens wooded areas and shade trees of the region. The invasive gypsy moth attacks oaks in particular and is deadly if outbreaks are repeated. The hemlock woody adelgid insect has nearly eliminated hemlock trees from our forests, parks, and gardens. The Asian long-horned beetle rapidly kills maples and many other deciduous hardwood trees; for example, the city of Worcester MA lost 25,000 shade trees in 2008. The emerald ash borer, an insect lethal to the widespread genus of ash trees, has reached 15 states at the time of this report including Pennsylvania and the Hudson Valley of New York State. Other problems on the horizon include sudden oak death and beech bark disease.

ECOSYSTEM TYPE 1. LAWNS, FIELDS AND GARDENS

Madison's lawns and gardens contribute greatly to the town's beauty and quality of life. An annual May Day in Madison event brings the community together to plant, mulch, and beautify public plantings throughout the Borough. These vegetated areas all help control runoff and erosion, while promoting groundwater recharge.

Most of Madison's parks feature grassy lawns, some with shade trees and ornamental plantings: Cole Park, James Park, Edwards Field, Madison Park, Niles Park, Gibbons Pines, Livesey Park. Lawns comprise portions of other parks including Memorial Park, Summerhill Park, and the Madison Recreation and Conservation Complex. Open fields also occur on private property, not only in residential areas but also within the Giralda Farms office park, the Madison Golf Course, and campuses of public and private schools and universities. Athletic fields are depicted on Map 16 (Open Space).

Lawns and fields must be carefully managed if threats to water and air quality are to be minimized. Alternative low-maintenance ground covers are worth encouraging where possible, for the sake of environmental quality (Bormann et al. 1995: "Redesigning the American Lawn").

1) Lawns are treated, often excessively and unnecessarily, with chemical pesticides, particularly herbicides (which target weeds) but also fungicides and insecticides. Accurate information about pesticide toxicity is not widely available.

2) Fertilizers also move through the ecosystem and pollute waterways. They contaminate groundwater and promote explosive algal growth and a concomitant deletion of dissolved oxygen, to the detriment of aquatic animal life, and can contaminate groundwater. More fertilizer and pesticide pollution is produced per acre by lawns than by farmlands. To protect water quality, New Jersey passed in 2011 a law to regulate fertilizer application for these reasons. Information is provided at http://www.nj.gov/dep/healthylawnshealthywater.

3) Lawn mowing and leaf-blowing cause air pollution. The relatively inefficient engines of lawn machinery emit more greenhouse gases, acid rain precursors, and respiratory hazards than most vehicles today. Mechanized leaf blowers produce particularly high levels of noise pollution. Some communities have adopted regulations setting pollution standards on lawn machinery.

Ornamental garden plantings are highly beneficial to Madison's environment. They can pose a surprising environmental concern when dominated by non-native plants. Some egregious invasive plants including barberry and purple loosestrife are still sold and commonly planted. Many benign shrubs and vines emerge as invaders after a lag period of good behavior. It is difficult to predict which will turn malignant. Even those non-native plants that are not invasive provide at best an ecological dead zone. A move toward native plants would help fight the spread of invasive plants into natural areas and would help to restore elements of the lost forest ecosystem that once covered Madison (Recommended source: "Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens" by D.W.Tallamy).

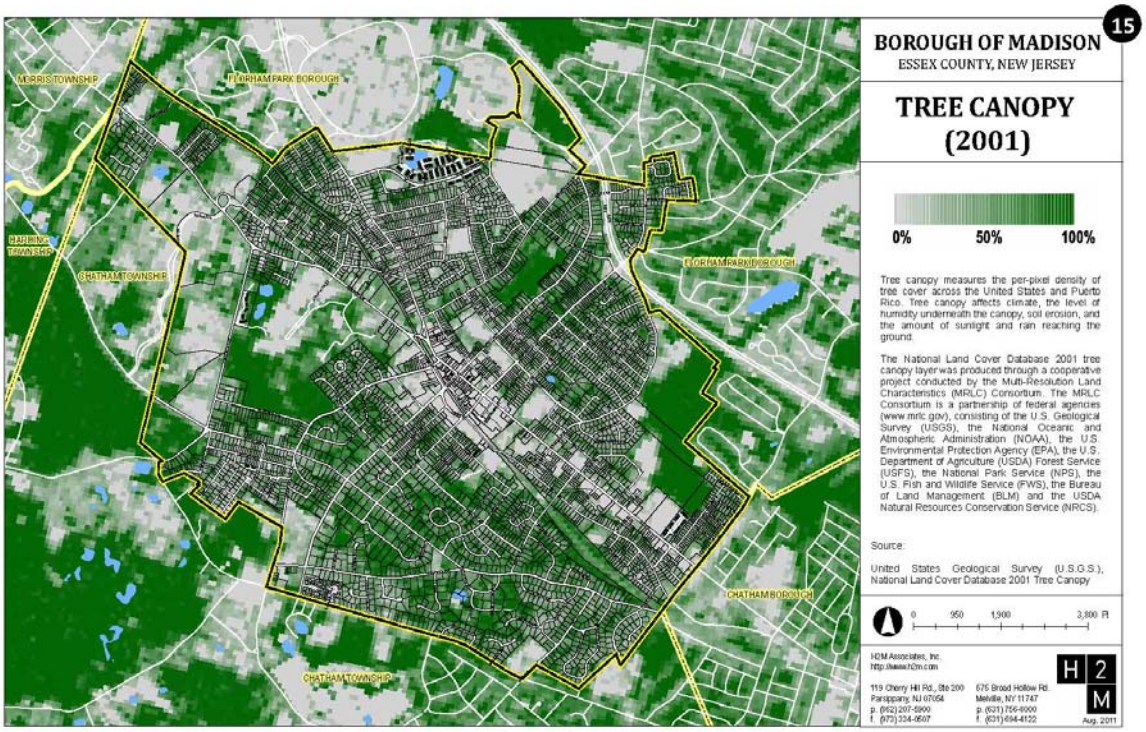
By emulating the region's natural areas, gardeners can promote butterflies, birds, and other desirable native wildlife. A demonstration area of native plantings in lieu of lawn is found on the Drew University campus, where students each spring convert a section of sod to a diverse ecosystem of native ferns, shrubs, and wildflowers. Information about native plant sources and benefits is available from the New Jersey Native Plant Society of New Jersey (http://www.npsnj.org/).

ECOSYSTEM TYPE 2: MADISON'S SHADE TREE POPULATION

Madison's shade tree population adorns Borough streets, public buildings, parks, campuses, and private property (See Map 15: Tree Canopy). It includes intentional plantings, "volunteer" trees that reproduce on their own, and old trees persisting from before land development. Together these trees form a living matrix of greenery throughout the Borough. However, even in grassy suburbia, street trees face stresses from road salt, weed killers, competing lawn grasses, and drought exacerbated by warmer microclimate of open sites. Unnecessary losses also result from digging in the root zone for construction, utility work, and landscaping. Citizens should be made aware that sensitive roots extends out from the trunk to (and beyond) the extent of the tree's branches and crown – the so-called drip zone.

A population of 6775 trees representing 112 different species provides shade on public lands and street rights-of-way of Madison. Thousands more grow on private property but have not been inventoried. This summary focuses on the shade trees of public lands and of the street rights-of-way throughout the Borough. In these locations, Madison's active Shade Tree

Management Board and its affiliated fund-raising group, the Friends of Madison Shade Trees, maintain a tree database and have planted approximately 105 trees per year for the past decade (source: Peggy Garman, Madison Shade Tree Management Board).



The composition of the shade tree population is a mixture of native trees (52% of individual trees) and trees introduced from other lands or from other parts of North America (48%). A large subset of non-native trees are invasive species that spread into natural areas (28% of all trees; see table), mostly Norway maple (675 trees), widely planted before its threat was recognized, and Callery pear (383 trees). As noted above, the national trend toward using native species is recommended for Madison, because of damage when exotic plants spreading into natural areas and because even non-invasive species from elsewhere cannot enhance ecosystem functioning and biodiversity as native trees do.

Borough Shade Tree Population, July 2011	No. Species*	% of Species	No. Trees**	% of Trees
Native species	29	26%	3526	52%
Invasive species	13	11.5%	1883	28%
Other non-native species (not invasive)	70	62.5%	1442	20%
Total	112		6751	

** Cultivars and varieties within a species were combined for this tabulation*
*** Total excludes 170 trees identified only to genus for this tabulation*

Forest diversity

Another important goal is a diversified population of shade trees. Madison's shade tree population is rich in diversity, with 112 species along streets and on public lands. Many streets are, however, planted with a single species, mostly as a legacy from times before the risks became apparent. Such risks are well demonstrated in the case of Dutch elm disease. Many eastern and Midwestern towns lost entire shade tree populations to this disease because only elms had been planted. Moreover, Dutch elm disease spread rapidly through roots of adjacent trees. The landscape was stripped of its shade trees, and costs of massive tree removals drained local budgets, leaving few funds for replanting.

Pathogens and insect pests of trees

A key environmental concern is how to deal with insect pests and pathogens that attack trees. School grounds are managed, by New Jersey law, to minimize use of chemical pesticides, following the practice known as Integrated Pest Management (IPM). IPM deploys knowledge of pests and their life cycle, knowledge that permits more targeted control efforts and that prevents ineffective treatments. For private and other public lands, IPM and its components are well worth implementing. Pesticides vary widely in their toxicity and effectiveness, but many damage human health, water quality, and natural ecosystems. For example, elsewhere in the New York region, heavy spraying with malathion to battle the west Nile virus polluted Long Island sound and killed off seafood populations. With some pests, trees withstand defoliation without pesticides and resprout a new crop of leaves during the same season. In other cases, pest attack will be lethal and pesticide use cannot help. The nonprofit organization Beyond Pesticides provides helpful information about pesticide choices and risks (http://www.beyondpesticides.org).

Choosing shade tree species:

Decisions about which trees to plant in the Borough, on public and private lands, should take into account the benefits of native species (see table); the problem of invasive species (detailed above), insect enemies, and diseases. Ecological conditions should be matched carefully with the requirements of particular tree species, explained in the US Forest Service's report, "Silvics of Trees of North America," at http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm. Another key consideration is global warming which is changing the geographic ranges where individual species can thrive. In its Climate Change Atlas, the U.S. Forest Service has mapped projections of where our native trees will be thriving in the future under several greenhouse-gas scenarios (http://www.nrs.fs.fed.us/atlas/). To minimize losses, common sense suggests that trees at the southern edge of their range should be avoided, while trees with drought- and heat-tolerance should be favored.

Native Trees for Planting in Northern New Jersey

Note: common names and genus names are often shared by unrelated trees from distant origins. Only the specified species are recommended native choices.	
Trees: Common Name (synonyms in parentheses)	Scientific Name
ash, black[1,3]	*Fraxinus nigra*
ash, green[1]	*Fraxinus pennsylvanica*
ash, white[1]	*Fraxinus americana*
aspen, bigtooth	*Populus grandidentata*
aspen, quaking	*Populus tremuloides*
basswood, American	*Tila americana*
beech, American	*Fagus grandifolia*
birch, black (sweet birch)	*Betula lenta*
birch, grey	*Betula populifolia*
birch, river	*Betula nigra*
birch, yellow	*Betula lutea*
black walnut	*Juglans nigra*
box elder	*Acer negundo*
butternut	*Juglans cinerea*
cedar, Atlantic white	*Chaemcyparis thyoides*
cedar, eastern red	*Juniperus virginiana*
cherry, black	*Prunus serotina*
cherry, pin	*Prunus pensylvanica*
chestnut, American [1]	*Castanea dentata*
dogwood, flowering [2]	*Cornus florida*
elm, American [1]	*Ulmus americana*
elm, slippery (red elm) [1]	*Ulmus rubra*
gum, black (sour gum, tupelo)	*Nyssa sylvatica*
hackberry, northern	*Celtis occidentalis*
hemlock, eastern[1]	*Tsuga canadensis*
hickory, bitternut	*Carya cordiformis*
hickory, mockernut	*Carya tomentosa*
hickory, pignut	*Carya glabra*
hickory, shagbark	*Carya ovata*
hornbeam (blue beech) [2]	*Carpinus caroliniensis*
ironwood (hop hornbeam) [2]	*Ostrya virginiana*
maple, red	*Acer rubrum*
maple, silver	*Acer saccharinum*
maple, sugar	*Acer saccharum*
mountain ash, American	*Sorbus americana*
mulberry, red	*Morus rubra*

oak, black	*Quercus velutina*
oak, chestnut	*Quercus montana*
oak, chinquapin [2]	*Quercus muelenbergii*
oak, northern red	*Quercus rubra*
oak, scarlet	*Quercus coccinea*
oak, southern red [4]	*Quercus falcata*
oak, swamp white [3]	*Quercus biflora*
oak, white	*Quercus alba*
oak, willow[4]	*Quercus phellos*
persimmon, common	*Diosporys virginiana*
pine, eastern white	*Pinus strobus*
pine, pitch	*Pinus rigida*
pine, shortleaf[4]	*Pinus echinata*
pine, Virginia[4]	*Pinus virginiana*
redbud, eastern	*Cercis canadensis*
sassafras	*Sassafras albidum*
serviceberry (shadblow, juneberry) [2]	*Amelanchier spp.*
sweetgum	*Liquidambar styriciflua*
sycamore, American (buttonwood)	*Platanus occidentalis*
tuliptree (yellow poplar)	*Liriodendron tulipifera*
willow, black [3]	*Salix nigra*

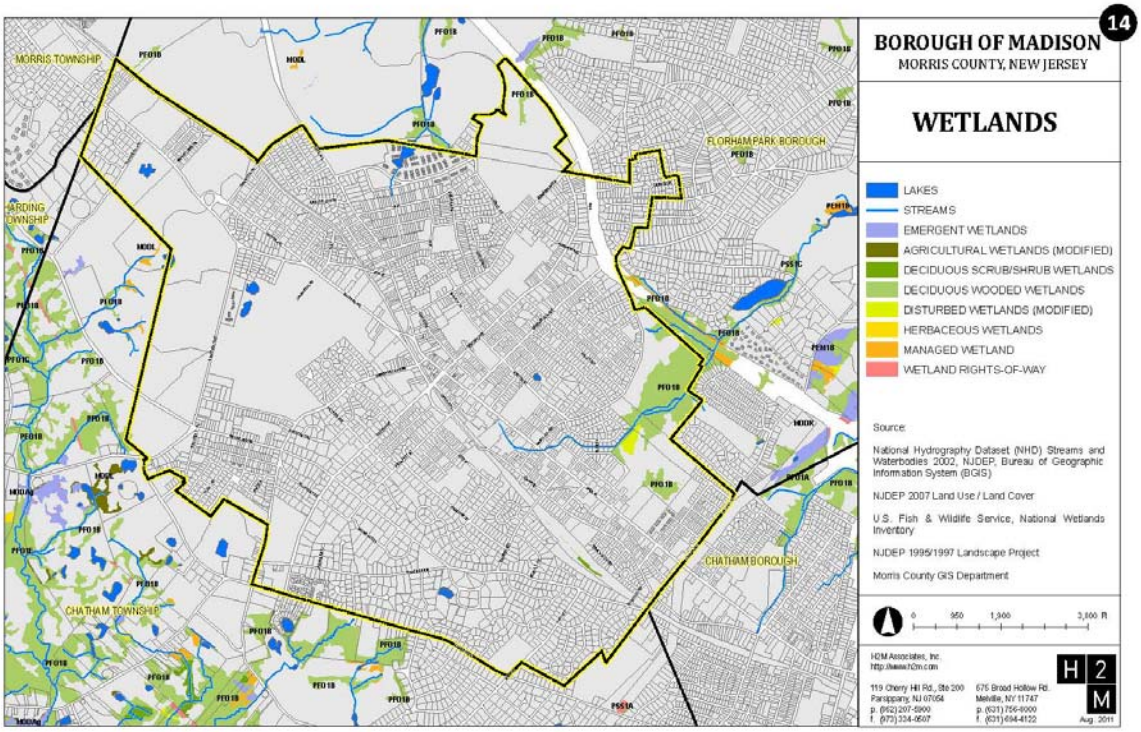
1 = Susceptible to deadly insects or pathogens
2 = Small tree
3 = Wet sites only
4 =Native to areas somewhat south of Madison

ECOSYSTEM TYPE 3. NATURAL VEGETATION: FORESTS AND WETLANDS

In addition to lawns, fields, gardens, and shade trees, Madison has several small but important remnants of natural vegetation in the form of forests, including wetland swamps. Within a suburban matrix of managed lands, forests are reservoirs of biodiversity that improve environmental quality. Below, several parks and other forested lands are described with emphasis on ecological conditions and environmental problems. (Chapter on Open Space provides a more complete list of parks and open space). These forests all exhibit overall decline in ecological integrity and diversity.

Memorial Park, Madison Wetlands, and Delbarton Area: In addition to athletic fields, the town pool, a playground and picnic grounds, Memorial Park includes forests, which continue into the adjacent Madison Wetlands conservation area and the Delbarton Area (see Map 16: /Open Space). These woods are wetland swamps (see Map 14: Wetlands), forming a floodplain for Spring Garden Brook. Tree roots and litter effectively bind the soil against erosion and filter out pollutants washed from the streets in the central and northeastern sections of Madison. When stormwater recedes, it gradually drains back into the channel of Spring Garden Brook. This

wooded floodplain is invaluable for controlling flooding here and also downstream in the flood-prone Passaic River. Red maple, the tree of the Great Swamp, is most abundant, with other trees of wetlands (elm, swamp white oak, silver maple, ash, pin oak, box elder, and some sycamore) and uplands (shag-bark hickory, white oak, beech, black cherry, back walnut, tulip-tree, black birch, shag-bark hickory, sour gum) growing on lower and higher ground, respectively.



Beneath the canopy, much has been lost. An impressive list of native wildflowers was recorded in 1982 by botanist Florence Zuck, who observed spring beauty, trout lily, wild geranium, blue lobelia, star-flowered false solomon's seal, dog-violet, blue flag iris, wood anemone, pink lady slipper orchids, Canada mayflower, partridge berry, spotted wintergreen, and eight species of asters. By 2011 these plants had all but disappeared. Also lost or declining since that time are native shrubs: arrow-wood, black haw, shrub dogwoods, maple-leaf viburnum, blueberry, male-berry. Here and elsewhere, a decline has occurred for spicebush, once ubiquitous throughout the region's forests. The list of native species thriving today in the forest understory is small: wetland taxa such as skunk cabbage and lizard's tale (Saururus cernuus) as well as widely scattered, Virginia creeper, jack-in-the-pulpit, wild grapevine, poison ivy, blackberry, stinging nettle.

As native vegetation disappeared beneath the canopy, invasive plants moved in. Most conspicuous in early spring is the invasive lesser celandine (Ranunculus ficaria), whose lovely yellow flowers resemble those of the native marsh marigold but with a Eurasian origin and with tenacious roots that spread aggressively. Other invaders include shrubs (barberry, burning bush, shrub honeysuckles) , vines (Japanese honeysuckle, multiflora rose, wineberry), and herbaceous plants (Japanese knotweed along roadsides and stream beds, mugwort in open areas, garlic mustard everywhere). Alongside these invasive "weeds in the woods," lawn weeds thrive along trails and in openings. Amongst the trees, the invasive Norway maple tree has a growing

presence, encroaching from the east; other invasive trees are black locust and tree-of-heaven. As elsewhere Memorial Park is witnessing the combined effects overly successful deer and explosive plant invasions.

Central Green a park whose protection owes thanks to efforts of neighborhood residents, follows a stream and serves to store runoff from adjacent streets and properties. Predominating is a swamp floodplain community of native elm, silver maple, red maple, pin oak, swamp white oak, and box elder. Alongside these wetlands, upland zones support native sassafras, red oaks, white oaks, and cherry trees. Some trees are quite large in both wet and upland areas. Madison's Parks Advisory Committee is working to control an alarming infestation of invasive Japanese knotweed. Other invaders include barberry, garlic mustard, stilt grass, English ivy, bittersweet, wisteria, and multiflora rose. Under the leadership of Cathy Coultas, teams of volunteers have battled invasive plants over a period of years, with support from SLAP (Sheriff's Labor Assistance Program), and with grants for native plants from the Madison Garden Club. Native plants now present in the understory include Christmas fern, New York fern, spice bush, red bud, juneberry (Amelanchier), native viburnum shrubs, violets, and Virginia creeper. . Knotweed, extremely difficult to eradicate, is still present, and herbivory by deer is high.

Summerhill Park encompasses lands of great interest historically, the site of greenhouses from the days when Madison earned its nickname "The Rose City." Old greenhouse foundations remain for exploring, overrun by a tangle of native and invasive trees, shrubs, and vines. Open mowed fields mark old homesites while woods have closed in across much of the land. Little remains of the early-successional brambles (blackberry, cat brier) and field weeds such as ragweed, Queen Anne's lace, pokeweed, and goldenrod that were still abundant in 1980. A legacy of ornamental trees and shrubs includes planted conifers (Norway, Colorado blue, and white spruce; white, scots, and Austrian black pine; cypress; douglas fir) and hardwoods (horse chestnut, white mulberry, black locust, Norway maple [in modest numbers]). Most distinctive among Madison's parks is a large population, including seedlings, of the invasive sycamore maple (Acer psuedoplatanoides). Ornamental shrubs include non-invasive lilac, spirea, siebold viburnum, and spirea shrubs as well as invasive barberry and burning bush. Worrisome infestations have begun for Norway maple, knotweed, oriental bittersweet, and wisteria. English ivy, a known threat to tree survival, is beginning to climb from old foundations into canopy trees. As elsewhere, native wildflowers, ferns, and shrubs are sparse. Majestic native trees remain from before the demise of the rose-growing industry, representing most notably white ash, silver maple, and black walnut. This park with its historic importance also has value for public education about the environment.

Parkside Park is a small wooded tract enhancing a residential neighborhood. Conditions are seasonally moist in some areas, with soils showing some evidence of flooding and with conspicuous presence of wetland trees: red maple, American elm, box elder, and ash. Other native trees such as black walnut are more mesic in habitat. The major threat is the invasive Norway maple tree, the most abundant tree species present. Below the canopy, invasive multiflora rose vines are abundant, alongside interspersed patches of invasive Japanese honeysuckle vines and of non-native (but non-invasive) periwinkle. Other conspicuous invasive plants include garlic mustard and wineberry. Trees are not reproducing in the shade of Norway maple, and few native species appear: poison ivy, pin cherry, jumpseed, and white snakeroot.

Belleau Woods is a small wooded park in a neighborhood of relatively high residential density. Like Central Green, this park surrounds a creek and includes wetland areas dominated by floodplain trees such as red maple, elm, box elder, swamp white oak, black ash, and pin oak. Drier upland areas around the park's boundary support black walnut, black locust, cherry, and the beginning of a Norway maple invasion. Alongside native poison ivy and Virginia creeper vines, the invasive Japanese honeysuckle vine forms extensive patches, and the difficult Japanese knotwood is beginning to spread. Other invaders include multiflora rose, garlic mustard, privet, wineberry, and mugwort. A few native plants are present and available to seed a recovery if protected from deer: Virginia creeper, wild grape, jewel weed, dogbane.

Library Woodlands is a small, stream-side conservation area located between the Madison Public Library and Pomeroy Road, a gem of natural forest that is home to some of the largest white oaks and red oaks in Madison. The canopy layer of the Library Woodlands is a mixture of native deciduous trees, with American beech perhaps most abundant amongst the taller trees. Other mature trees include black birch, hickory, red maple, and the invasive Norway maple. Beneath this diverse canopy, a well-developed subcanopy of young Norway maples suggests that this invasive tree species will dominate the next generation; a few native beech and black cherry saplings are also present. The forest floor is mostly bare, punctuated with patchy undergrowth: large, expanding patches of pachysandra, a garden escapee; smaller mats of the invasive lesser celandine and invasive garlic mustard; and a new colony of Japanese barberry; and everyone's favorite native plant, poison ivy.

Drew University Forest Preserve, including Hepburn Woods and Zuck Arboretum: The campus of Drew University includes both ornamental vegetation and natural woodlands. The Drew University Forest Preserve (45 acres) is the largest expanse of woodland in Madison, officially established in 1956 in response to a joint proposal of the Garden Club of Madison and the Drew Botany Department (now Biology Department).

The importance of this forested open space cannot be overstated. The Drew campus is a major area for groundwater recharge, and the natural vegetated cover helps purify and restore the Buried Valley Aquifer from which the Borough obtains its water supply. These lands include the best example in Madison of the region's natural forests. Birds, beneficial insects, and small mammals find food and shelter in this natural acreage which is less fragmented geographically than other Borough woodlands. The Forest Preserve serves as an outdoor laboratory and research site for Drew University students and faculty as well as scientists from elsewhere. Open to the public, the Drew Forest adds to the beauty of Madison and inspires artists, musicians, writers, photographers, and nature lovers from across the community.

Most if not all of the Drew Forest was cleared for pasture, but oak trees (black, white, red, and pin) returned between 1835 and 1910, and the forest began filling with shade-tolerant beeches and sugar maples by 1890 (Webb et al. 2000). Other native trees today include tuliptree, white ash, black birch, red maple, silver maple, black cherry, black walnut, butternut, and elm.

The Drew Forest Preserve is hosting a major ecological restoration effort to bring back an example of the natural forest ecosystem for educational, research, and ecological purposes. Similar projects are underway across northern New Jersey at, for example, New Jersey Audubon's

Scherman-Hoffman sanctuary, New Jersey Land Conservancy's South Branch preserve, and Great Swamp Watershed Association's Conservation Management Area.

The Drew Forest has been transformed by the same conversion from native to invasive plants plaguing other open space lands throughout the region. Shrubs and wildflowers typical of the mixed oak forest type were once prevalent; many have disappeared since 1988 (maple-leaf viburnum, white heart-leaved aster, common blue heart-leaved aster, clasping aster, witch hazel, hairy solomon's seal, twisted stalk) or declined dramatically (spicebush, may apple, beech drops, winterberry holly). No sign remains of ferns and wildflowers planted by the Madison Garden Club around 1980. An absence of beech regeneration belies claims that deer avoid this tree. Most recently, between 2008 and 2011, all tree reproduction has failed – even that of the invasive Norway maple - except where protected from deer. Remaining vegetation beneath the canopy is sparse and entirely dominated by invasive shrubs (privet, winged burning bush, Japanese barberry), vines (bittersweet, wisteria, multiflora rose, Japanese honeysuckle, wineberry), and herbaceous plants (garlic mustard, Japanese stilt grass). Invasive bittersweet and wisteria vines have strangled many acres of trees. Norway maple's suppression of biodiversity was first documented in the Drew Forest, where a program of research has monitored this biological invasion since 1988.

Within the Drew Forest Preserve, two sections have been designated for ecological restoration, both named for prominent Madison environmentalists in honor of their support for conservation and preservation.

The *Florence and Robert Zuck Arboretum*, within the Drew Forest, was officially established in 1980 in honor of the eminent retired botany professors Zuck. The 15-acre Zuck Arboretum includes two ponds and former garden plantings of the adjacent Dodge estate, from which the University purchased the land. Vegetation is a mixture of native and ornamental plants, both non-invasive (pachysandra, periwinkle, rhododendron, and forsythia), and invasive (see above). Large trees are present, including both native oaks and ornamental conifers. A "subcanopy" layer and the undergrowth are dominated by young maples poised to take over the forest canopy in the next generation. Unlike many arboreta, the Zuck Arboretum is devoted to natural vegetation rather than ornamental plantings. Fallen logs, standing dead trees, and natural processes are valued and retained. In 1999 a self-guiding nature trail was established. Since 2000, invasive species removals have targeted Japanese barberry and garlic mustard with some success. However, past efforts to reintroduce native plants were unsuccessful. In spring 2011, a 10' fence was constructed to exclude deer from the Zuck Arboretum, in hopes of restoring the ecosystem. Native plantings resumed in 2011 with the planting of 450 native ferns (marsh, ostrich, cinnamon, and royal) at the ponds' waterline.

The *Hepburn Woods Restoration Area*, a separate 15-acre section of the Drew Forest, was designated in 2011, named for environmentalist and Madison civic leader Chris Hepburn whose generosity supported protective deer fencing not only for the Zuck Arboretum but also for the most degraded portions of the Drew Forest where large infestations of two tree-strangling vines, oriental bittersweet and wisteria, have suppressed forest development. Hepburn Woods encompasses these areas plus a research area where the invasive Norway maple is being studied,

including a 1997 experiment in which trees and saplings were removed from a one-hectare area in 1997 but retained in an adjacent control area.

A major forest restoration project began in 2008 in Hepburn Woods, in partnership with the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife program and with New Jersey Audubon's Private Lands Stewardship Program. The restored forest and the project will represent a model for similar efforts that could be brought to other parks in Madison and elsewhere. The three components of this effort were:

(1) Control of invasive plant species, with focus on ecosystem-dominating species: oriental bittersweet, wisteria, and Norway maple. Other invaders targeted include garlic mustard, barberry, stilt grass, and privet.

(2) Construction of 10' fence for protection from deer, around both the Hepburn Woods and Zuck Arboretum, in spring 2011.

(3) Planting of native plants made available through the Fish and Wildlife Service, most provided by the New Jersey penitentiary work program. In spring 2011, 1300 small seedlings were planted including four species of native shrubs (high-bush cranberry, sweet pepper bush, elderberry, and witch hazel) and 17 species of native trees (river birch, American beech, black cherry, flowering dogwood, hackberry, shagbark hickory, shellbark hickory, northern red oak, pin oak, scarlet oak, white oak, persimmon, tuliptree, white pine, sourgum (tupelo), sweet gum, and American sycamore). Additional restoration plantings are planned.

Madison Recreation and Conservation Complex: Madison's newest open space project is a 49-acre tract acquired for athletic and passive recreation, located near Madison High School at the border with Florham Park. This open space acquisition was funded for two purposes: recreation and open space conservation. Land cover is a mixture of existing athletic fields, grass-covered areas mowed until recently, young woodlands, and mature forest. Wetlands are present on site (see Map, "Wetlands"). The grassy fields are ecologically disturbed with few native species and are the best sites for athletic fields and related facilities including parking lots. A double row of stately pin oak trees adorns the property's roadway and is being protected as the property is developed.

A sizable wooded tract of mature forest (northeast of the roadway that bisects the property) has high ecological value, as indicated by old, large (up to 3' diameter) canopy trees, high tree diversity, and wetland conditions across approximately 35% of mature forest zone. These features suit the forest well for passive recreation: walking, biking, nature study, environmental education. This zone is inappropriate for recreational development. Native trees present include wetland species (red maple, green ash, white ash, elm, pin oak) and typical trees of natural upland forests (white oak, black oak, beech, black birch, sugar maple, flowering dogwood, black cherry, and at least two species of hickory). Heavy deer influence is revealed by browse damage to shrubs and seedlings and by a paucity of native plants below the canopy. Invasive plants overrun the ground layers except in deepest shade, with ubiquitous carpets of Japanese stilt grass in particular and with barberry proliferating at forest edges, poised to spread

further into the forest and damage the soil. Other invasive plants include garlic mustard and multiflora rose, with a small presence of Norway maple.

Younger woodlands are scattered across the complex: grading into a swamp of dense, small red maples at the southern corner of the tract; forming a buffer zone for the neighboring Cheshire Home facility (small cherry and ash saplings with scattered large ash trees); and abutting existing athletic fields (with black cherry, black birch, ash, pin oak, and sassafras trees). These open, fragmented woods hold a heavy burden of invasive species. Here as throughout the parks and open spaces of Madison there are steps to be taken to protect vegetation for its biodiversity value and for its capacity to cleanse and beautify the environment. Thus while the conservation mission of this project is implemented, ecological restoration efforts would be fruitful.

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X. WILDLIFE

Wild animals in Madison today are limited to those native species which have been able to adjust to a people-oriented environment. The people of Madison also have learned to adjust and appreciate most of our animal neighbors. The animals tend to be furtive creatures, many of them nocturnal in habit. Their safe-distance instinct seems to have lessened as they become used to co-habitating with the residents of Madison. Dogs and cats still bring keep most of the wild animals away from their living spaces.

Madison is a developed town with little unmanaged land. Therefore, wildlife is restricted to the several preserved woodlands located in the Borough. The Drew University forest preserve and the Arboretum provide habitats, territory, and food in the form of nuts, fruits, succulent roots, tender twigs, inner bark of trees, and leaves. Within the Zuck Arboretum are two manmade ponds that date back over 40 years. These have some amphibious wildlife within and are also used as a water source for the animals living within Drew University's borders. Many animals supplement this food with herbaceous vegetable matter gleaned from nearby gardens and lawns, to the annoyance of some homeowners and the pleasure of others. Raccoons, woodchucks, opossums and rabbits are the chief foragers in this respect. Unguarded garbage receptacles are also attractive to animals looking for food. Moles are sometimes destructive to lawns as they burrow beneath the turf in search of insect larvae, grubs & worms, but they also help in keeping destructive insect populations in check.

Memorial Park and adjacent wetlands, though which Spring Garden Brook flows, offer different wildlife habitats. The muskrat constructs its home on the banks of the brook. Frogs, turtles, salamanders and newts live close to the water and on the wet floodplain forest floor. The location of Memorial Park on the northeastern border of the Borough and contiguous to another large tract of woodland provides a wider range of territory for wildlife. Deer are frequently seen here and in the surrounding areas foraging. Their population continues to increase in Madison. Inasmuch as most of the species of native animal seen anywhere in Madison are also found in Memorial Park, the accompanying list of wildlife in the park is fairly representative of the native animals in the Borough.

In 2009, 49 acres of open space were added to the inventory of Madison's open space. This land is adjacent to over 400 acres, formerly occupied by the Exxon Corporation in a complex with 600,000 sq. ft of office space. The land is partially wooded with some meadows. There is clear evidence of wildlife habitats here all similar to the other open spaces within the Borough's borders.

The white tailed deer herd in Madison has exploded over the last decade. There are no natural predators to the deer herd and still some open space for them to propagate and stay out of site when the deer require isolation. In 2003, the Borough of Madison decided not to cull the herd since it would present a dangerous situation to residents; shooting would be taking place around inhabited areas. As a result, the deer herd is estimated to be over 200 and growing, based on a NJDEP study conducted in 2002.

In 2008, in an effort to reduce the deer herd prevalent on their property, the Giralda farms group of corporations managed by Reckson Corporation initiated a program to reduce reproduction through birth control.The following statement from the DEP explains the details of the program:

> "An experimental program using GonaCon™ at Giralda Farms in Madison (Morris County) was instituted in 2005. Thirty-two percent of the females treated once with GonaCon™ became pregnant. GonaCon™ has limitations including the need to capture and hand-inject each animal, and granulomas formed at the injection site. At this time, chemical fertility control is still very labor intensive and not practical for large, free-ranging deer populations."

Insects have a profound influence in the environment. On the beneficial side, they are pollinators of many of the plants man is dependent on for food and enhancement of his surroundings. They are important in the food chain, being a source of food for many birds and animals. In form, many of them are diverse and beautiful. However, in the course of their own life cycles, some are extremely destructive. Examples include the gypsy moth, seventeen-year locust, canker-worm – all serious defoliators; and several species of scale which attack ornamental trees and shrubs. Avoidance of spray programs for the elimination of these insects allows natural controls to operate.

The following list of animals was compiled by Dr. Rosemary Hein, formerly Professor of Biology at Upsala College, for a Natural History Manual of Memorial Park which the Advisory Committee prepared for the Madison Public Schools:

AMPHIBIANS AND REPTILES IN MEMORIAL PARK

(N) – indicates nocturnal

Class Amphibia

Northern Dusty Salamander	Desognathus fuscus fuscus
Red-backed Salamander	Plethodon cinereus cinerues
Red-spotted Newt	Diemictylus viridescens
Wood Frog	Rana Sylvatica
Green Frog	Rana Clamitans Melanota
Bullfrog	Rana castesbeiana
Leopard Frog	Rana pipiens pipiens
Northern Cricket Frog	Acris Crepitans crepitans
Spring Peeper	Hyla crucifer
American Toad	Bufo americanus

Class Reptilia

Common Snapping turtle	Chelydra serpentina
Eastern Box Turtle	Terrapene Carolina Carolina
Eastern Painted Turtle	Chrysemys picta Picta
Northern Water Snake	Natrix sipedon Sipedon
Northern brown Snake	Storeria dekayi dekayi
Eastern Gater Snake	Thamnophis sirtalis Sirtalis
Eastern Ribbon Snake	Thamnophis Sauritus Sauritus
Ring Neck Snake	Diadophis Punctatus
Black rat snake	Elaphe obsolete Obsolete
Milk Snake	Lampropeltis Doliata

MAMMALS IN MEMORIAL PARK

Order Marsupialia

Virginia Opossum	DidelphisVirginiana (N)
Red Fox	Vulpes vulpes
Gray Fox	Urocyon cinereoargenteus

Order Insectivora

Short-tailed Shrew	Blarina brevicauda

Order Chiroptera

Little Brown Bat	Myotis lucifugus
Silver-haired Bat	Lasionycterus Noctivagans (N)
Eastern Pipistrel Bat	Pipistrellus Subflavus (N)
Red Bat	Lasiurus borealis (N)
Hoary Bat	Lasiurus cinerus N

Order Lagomorpha

Eastern Cotton-tail Rabbit	Sylvilagus floridanus

Order Rodenta

Woodchuck	Mormota monax
Eastern Chipmunk	Tamias striatus
Eastern Gray Squirrel	Sciurus Carolinensis
Deer Mouse	Peromyscus Maniculatus (N)
Flying Squirrel	*Glaucomy sabrinus*
Skunk	*Mephitis nigra*

BIRDS

The distribution of birds in an area depends upon altitude and the availability of food, water, and vegetation including trees, thickets, marshes and open fields which provide cover for nesting and protection from predators. Madison's several woodlands, many large shade trees, landscape shrubbery, laws and gardens offer adequate habitats and natural food for a large variety of birds. Five natural ponds, one man-made retention basin, and two brooks within the Borough provide water for birds. Marsh land is limited in Madison and there are no large bodies of water. Therefore, waterfowl are infrequently seen except for a few wood ducks, mallards, an occasional heron, gulls, and the Canadian Geese, new inhabitants to the area starting in the 1970s.

BIRDS RECORDED FROM THE GROUNDS OF DREW UNIVERSITY

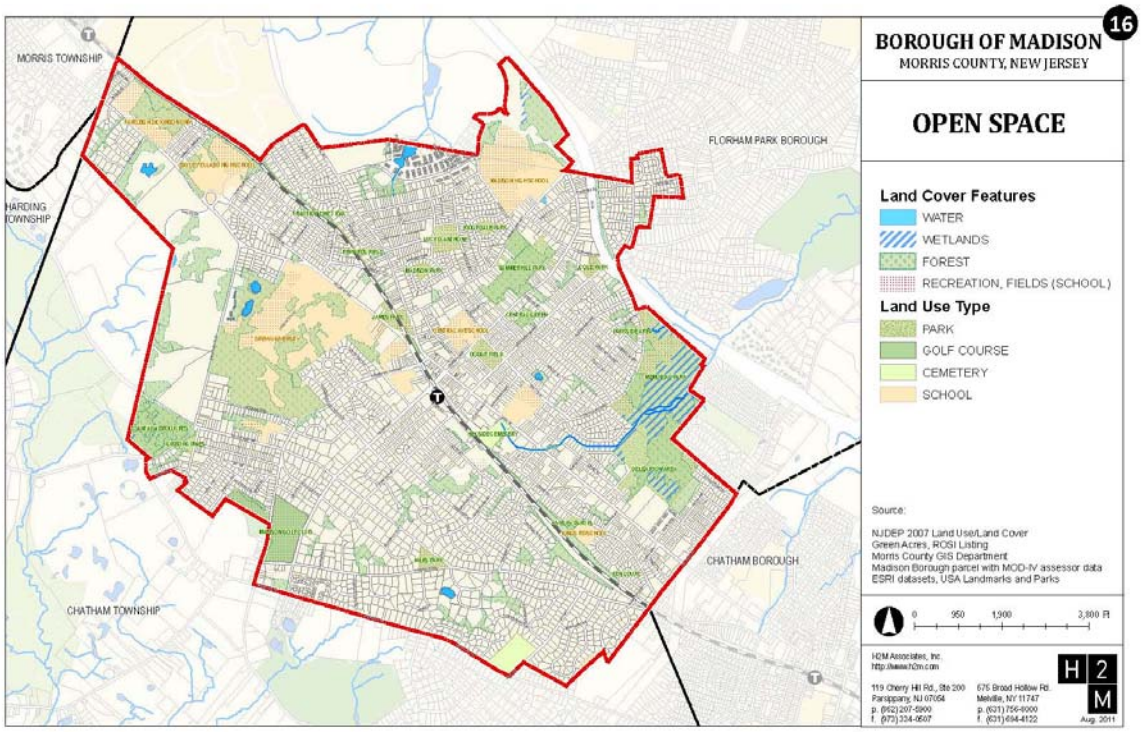
Double-crested Cormorant	Phalacrocorax olivaceus
Great Blue Heron	Ardea herodias
Green Heron	Butorides striatus
Canada Goose	Branta Canadensis
Mallard	Anas platyrhynchos
Wood Duck	Aix sponsa
Turkey Vulture	Cathartes aura
Osprey	Pandion halieaetus
Bald Eagle	Haliacetus leucocephalus
Sharp-shinned Hawk	Accipiter striatus
Cooper's Hawk	Accipiter cooperii
Red-shouldered Hawk	Buteo lineatus
Broad-winged Hawk	Buteo platvpterus
Red-tailed Hawk	Buteo jamaicensis
American Kestrel	Falco sparverius
Wild Turkey	Meleagris gallopavo
Killdeer	Meleagris gallopavo
Spotted Sandpiper	Actitis macularia
American Woodcock	Philoheia minor
Ring-billed Gull	Larus delawarensis
Herring Gull	Larus argentatus
Great Black-backed Gull	Larus marinus
Rock Pigeon	Columbia Livia
Mourning Dove	Zenaida macroura
Eastern Screech Owl	Otus asio
Great Horned Owl	Bubo virginianus
Common Nighthawk	Chordeiles minor
Chimney Swift	Chaetura pelagica
Ruby-throated Hummingbird	Archilochus colubris
Belted Kingfisher	Megaceryle alcyon
Red-bellied Woodpecker	Melanerpes carolinus
Downy Woodpecker	Picoides pubescens
Hairy Woodpecker	Picoides villosus

Norther Flicker	Colaptes auratus
Pileated Woodpecker	Dryocopus pileatus
Eastern Wood-pewee	Contopus virens
Eastern Phoebe	Sayornis phoebe
Great Crested Flycatcher	Myiarchus crinitus
Eastern Kingbird	Tyrannus tyrannus
Tree Swallow	Iridoprocne bicolor
Rough-winged Swallow	Stelgidoptervx ruficollis
Barn Swallow	Hirondo rustica
Blue Jay	Cyanocitta cristata
American Crow	Corvus brachyrhynchos
Fish Crow	Corvus ossifravus
Black-capped Cickadee	Parus Atricapillus
Tufted Titmouse	Parus bicolor
White-breasted Nuthatch	Sitta carolinensis
Brown Creeper	Certhia familiaris
Carolina Wren	Thaothorus ludovicianus
House Wren	Troglodytes aedon
Winter Wren	Troalodytes troglodytes
Golden-crowned Kinglet	Regulus strapa
Ruby-crowned Kinglet	Regulus calendula
Blue-gray Gnatcatcher	Polioptila caerulea
Veery	Catharus fuscescens
Gray-cheeked Thrush	Catharus minimus
Swainson's Thrush	Catharus ustulatus
Hermit Thrush	Catharus izuttatus
Wood Thrush	Hylocichia mustelina
American Robin	Turdus migratorius
Gray Catbird	Durnetella carolinensis
Northem Mockingbird	Mimus polyglottos
Brown Thrasher	Toxostoma rufum
American Pipit	Anthus spinoletta
Cedar Waxwing	Bombycilia cedrorum
European Starling	Sturnus vulgaris
White-eyed Vireo	Vireo griseus
Solitary Vireo	Vireo solitarius
Warbling Vireo	Vireo gilvus
Philadelphia Vireo	Vireo philadlphicus
Red-eyed Vireo	Vireo olivaceus
Blue-winged Warbler	Vermivora Dinus
Lawrence's Warbler	Virinivora chusoptera pinus
Tennessee Warbler	Vermivora peregrina
Nashville Warbler	Vermivora ruficaill
Northern Parula	Parula Americans
Yellow Warbler	Dendroica petechia
Chestnut-sided Warbler	Dendroica pensylvanic

Magnolia Warbler	Dendroica magnolia
Cape May Warbler	Dendroica tigrina
Black-throated Blue Warbler	Dendroica caeralescens
Blackbumian Warbler	Dendroica fusca
Pine Warbler	Dendroica pinus
Prairie warbler	Dendroica discolor
Palm Warbler	DeiidroicaXalm.aru
Blackpoll Warbler	Dendroica striata
Bay-breasted Warbler	Dendroica castanea
Black&White Warbler	Mniotilta varia
American Redstart	Setophaga ruticilla
Worm Eating Warbler	Helmithero vermivorous
Ovenbird	Seiurus aurocapillus
Northern Waterthrush	Seiurus noveboracensis
Connecticut Warbler	Oporornis agilis
Mourning Warbler	Oporornis philadelphia
Common Yellowthroat	Geothyypis trichas
Hooded Warbler	Wilsonia citrina
Wilson's Warbler	Wilsonia pusilla
Canada Warbler	Wilsonia Canadensis
Scarlet Tanager	Piranga olivacea
Northern Cardinal	Cardinalis cardinalis
Rose-breasted Gosbeak	Pheucticus ludovicianus
Indigo Bunting	Passerica cyanea
Rufous-sided Towhee	Pipiloerythrophthalmus
Chipping Sparrow	Spizella passerina
Field Sparrow	Spizella pusilla
Song Sparrow	Melospiza melodia
White-throated Spar.	Zonotrichia albicollis
Swamp Sparrow	Melospiza georgiana
Dark-eyed Junco	Junco heymalis
Bobolink	Dolichonyx oryzivorus
Red-winged Blackbird	Ageliaus phoeniceus
Rusty Blackbird	Euphagus carolinus
Common Grackle	Quiscalus quiscula
Brown-headed Cowbird	Molothrus ater
Orchard Oriole	Icterus spurius
Baltimore Oriole	Icterus galbula
Purple Finch	Carpodacus purpureus
House Finch	Carpodacus mexicanus
American Goldfinch	Carduelis tristis
House Sparrow	Passer domesticus

XI. OPEN SPACE

According to the State's 1968 enabling legislation, an environmental commission must maintain an index of all open areas, publicly or privately owned, in its municipality. As its first major act, the newly formed Madison Environmental Commission prepared an open space inventory in 1973. Earlier open space data was presented in the 1963 Master Plan. The Commission is charged with updated the Borough's open space data according to the best available information. Current open space areas within Madison are depicted on Map 16. The Map includes properties that are listed on the Borough's Recreation and Open Space Inventory (ROSI), which is regularly updated by the governing body in support of applications for funding open space acquisition and improvement projects. NJDEP's Green Acre's program maintains the ROSI database here: http://www.nj.gov/dep/greenacres/openspace.html



Like many New Jersey municipalities, Madison's open space has declined over the years, reflecting a trend toward urbanization. Open space declined by 10% between 1973 and 1983, and by an additional 7.5 % from 1982 to 2001. Much of this growth can be attributed to residential housing development. Map 17 shows areas of the Borough that changed in land use between 2002 and 2007. Undeveloped areas (areas that were previously forested, contained wetlands or were barren) that have since been developed, are also highlighted. Madison lost approximately 13.5 acres of forested land between 2002 and 2007, including seven (7) acres that was developed for single-family residential, nearly four (4) acres for commercial use and the remaining for other urban or transitional use.

The Association of New Jersey Environmental Commissions (ANJEC) recommends that the municipal Master Plan be the vehicle for organizing the planning process for protecting open space. In the case of Madison, where the town is very developed with limited open space, planning for open space protection and expansion should be a top priority of the master planning process. For a variety of reasons, Madison has become a desirable community to live, and builders have been willing to pay premium prices for new development opportunities.

To protect its little remaining open space, the Borough should evaluate putting protections in place that would thwart incremental reductions in open space and potential subdivisions. This can be achieved by changing zoning regulations (i.e., lot size requirements, open space requirements, etc.), acquiring additional property for open space, and instituting conservation easements. Requirements that limit "tear downs" of houses for the replacement of homes with larger footprints (which also shrink actual pervious ground cover) can also be considered. A new or updated Conservation Plan Element of the Master Plan should also be considered.

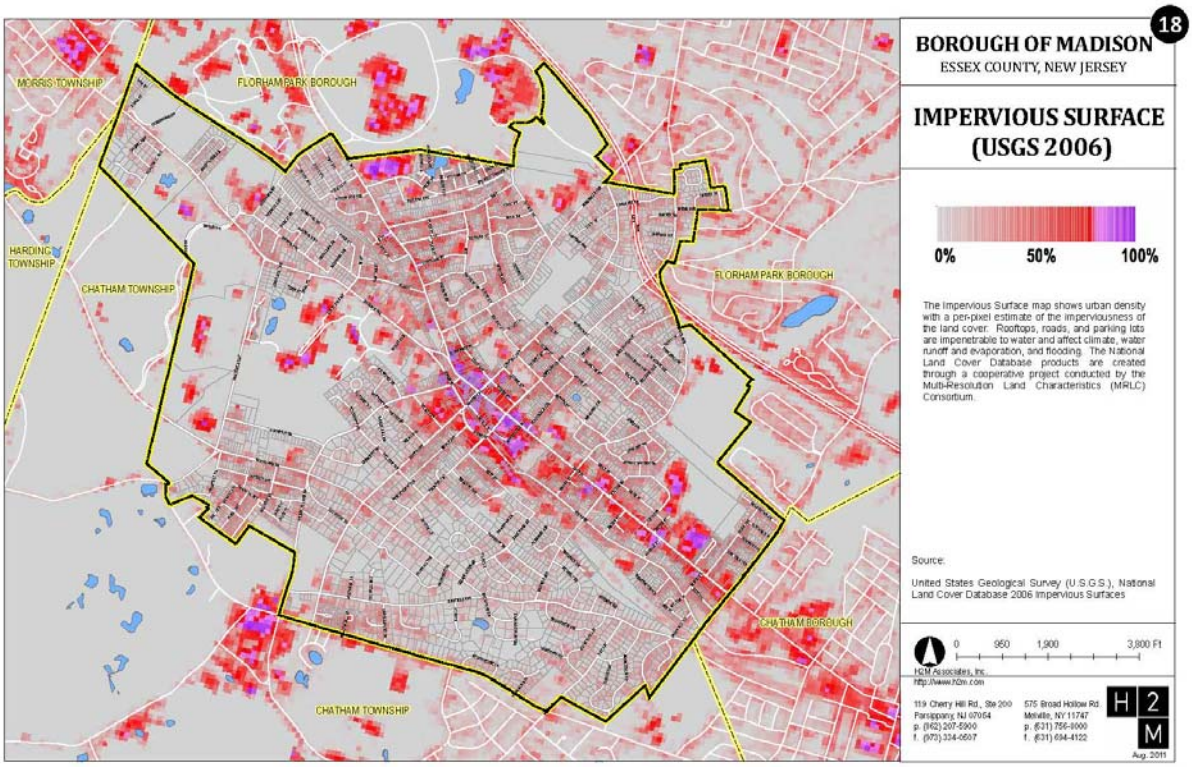
The development of privately-owned, undeveloped tracts of land is perhaps the most significant reason for reductions in Madison's open space. Troublingly, the number of new open space acquisitions, has not matched the pace of development. Below is a list of large tracts of privately owned land which have experienced development since 1982:

- 29.5 acres of the 177.5 acres in Madison at Giralda Farms. Only an additional 6 acres can be developed. Plans for one additional office building at the northwest corner of the property on Loantaka Way and Madison Avenue are currently on hold.
- At Drew University a new gym was built in the mid- 1990s and a new academic arts building is currently being constructed for occupancy in 2001.
- The 15 acre Sodano Tract between Garfield Ave and Shunpike in the area between Park Lane and Olde Green House Road. A number of single family residences were built.
- The present Madison Green Village townhouse complex between Garfield Ave. and Shunpike was completed. A total of over 32 townhouses were built in 1979 – 1982.
- The 7.31 acre tract on the north side of Madison Avenue at Loantaka Way. A total of 20 single family homes were built in 1991-1992 (2 houses were demolished).
- Brannick Drive (east of Sampson Avenue south of the railroad tracks. Seven new homes were built in 1995 on the available 9.75 acres.

The actual percent decrease in the amount of open space in Madison must also consider the relative change in size in Borough area, since through annexation, the Borough has increased in total size at various times in its history. In 1990, approximately 3.5 acres were annexed from the Chatham Borough and developed with 11 houses on the street now named "Independence Court" and with four houses on Union Hill. In 1994, 16 lots in the southwest section of the borough in the "Orchard" section of town were annexed by Madison Borough at the request of the property owners. In both cases the streets were readily accessible to Madison but were not directly accessible to Chatham Borough nor Chatham Township. In 2011, an additional 49 acres of land,

mostly open space, was annexed from Florham Park, including a portion of the former Exxon complex and a Madison High School property.

The impact of urbanization on Madison's land can be more easily understood by looking at historical changes in impervious coverage. Map 18 and Map 18B show impervious coverage from two separate data sources. Map 18 offers a per-pixel estimate of the imperviousness of the land cover in Madison, with data being provided by the USGS for the year 2006. This includes all rooftops, roads, and parking lots that are impenetrable to water, and which affect climate, water runoff and evaporation, and flooding. Map 18B shows impervious coverage as provided by NJDEP in the 2007 Land Use/Land Cover (LU/LC) dataset. An impervious surface (IS) code was assigned to each LU/LC polygon based on the percentage of impervious surface within each polygon as of 2007. The USGS estimate is perhaps more useful, since it shows imperviousness at more detailed level. As more current data becomes available, the Borough should compare how impervious coverage has increased or decreased over time.



Map 18 illustrates how the level of impervious surface is most dense along the north-south route of East Main Street, the Borough's business district. As the community has grown, the Borough's business district has expanded along the length of East Main Street to the Chatham border. This has meant the loss of some former open space areas along the corridor. Where businesses were once concentrated in a few central core blocks, with pockets of green space in between, commercial development exists today along most of East Main Street. This could illustrate a need for small pocket parks or public plazas to serve downtown patrons. At the same time, by concentrating development along the downtown "core," and creating a thriving, mixed-use center with access to transit, shopping, and housing, the Borough is ensuring a more sustainable

land use development pattern. Within the core, people can walk to their destinations without the need for a car. Concentrating development in a dense, walkable area, can also serve to preserve the feeling of "openness" within the Borough's outer residential neighborhoods.

As a developed community, few large tracts of land remain in Madison. Planners once thought of open space merely as parks and recreation areas. However, "*open space is now considered to be one means to hold together the fabric of an urbanizing environment by providing the requisite natural breaks vital to create a visual and aesthetic amenity for urban dwellers. Additionally, open space serves natural functions in providing infiltration for precipitation, cleaning the air, providing breathing space, mitigating unpleasant odors, noises, and sights*." (1) It is clear that open space has important economic functions (i.e., increased property values, resident attractors) as well as environmental benefits. In addition to protecting the few remaining large tracts of land, even the presence of small pockets of open space have enormous visual, psychological, environmental and economic impacts.

Approximately 100 acres of land in Madison is considered "recreation use," which includes areas for parks, as well as the Borough's community center, which offer's recreational opportunities. An additional 78 acres of land are set aside for school athletic fields. Combined, the Borough's parks, recreation space (including community center uses) and school athletic fields make up approximately 6.4% of Borough land area. The principal open space areas in Madison are described below:

PUBLICLY OWNED OPEN SPACE

A. *Memorial Park*: 68.70 acres purchased in 1953 by the Borough. It is located off Rosedale Avenue north of Main Street. Planning for this park is the responsibility of the Mayor's Advisory Committee for Memorial Park. 24.70 acres have been developed with a pool area, ice skating rink, two baseball diamonds, a picnic area, a shelter, and parking areas. In 1982 a soccer field was added, and in 1999 an in-line skating track was added around the perimeter of the ice skating rink. It is important to preserve the remaining acreage as undisturbed woodland.

B. *Madison's Wetlands* consists of 51.86 acres adjacent to Memorial Park. This area is described in detail in the Vegetation chapter.

C. *Summerhill (Greenacres) Park* covers 24.81 acquired by the Borough in 1972, partially through donations and partially through purchases assisted by the State under the Green Acres program. The site is about one-third mile north of Main Street between Ridgedale and Central Avenues. No plans for development of the park have been implemented by the town.

D. *James Park* contains 6.02 acres at the intersection of Park Avenue and Main Street in downtown Madison. A gift to Madison from the James family, the park provides welcome relief from the man-made environment of traffic, sidewalks, crowded storefronts and hurrying people. The memorial flowering cherry trees, dogwoods and stately shade trees furnish an appropriate setting for the memorial monuments.

E. *Belleau Park* covers 5.47 acres between Belleau and Chateau Thierry Avenues. This former farmland now being reclaimed by forest is significant in that it provides a buffer between a large townhouses development and single family residences. It was designated as proposed parkland in the 1975 master Plan and appears on the Official map of the Borough adopted in 1977.

F. *Dodge Field* consists of 4.78 acres encompassing one town block, three blocks north of Main Street. Central Avenue Elementary School faces one side of the park, and residential housing surrounds it on the other three sides. The park contains a football field, a track, a baseball diamond with bleachers, basketball courts, a tot lot and a wading pool. It is fenced on all sides and receives heavy use.

G. *Loantaka Moraine* includes approximately 25 acres south of Woodland Road at the corner of Loantaka Way. This land was acquired in 1994 by the Morris County Parks Commission using Green Acres funds and annexed to the Loantaka Brook Reservation. This tract of land is a unique natural feature located at the edge of a delta built into glacial Lake Passaic about 20,000 years ago. It is the largest remaining section of the delta which is not developed nor can be developed. It's varied topography, characterized by steep and undulating slopes covered with old field vegetation, and the long vistas over the surrounding countryside impart a wilderness feeling to these acres, even though they are only a modest walk from the center of Madison. A topographical sketch of the Loantaka Moraine is shown in Figure X! – 1.

H. *Central Green (off Serpico Way – formerly Floyd Street)* is 2.40 acres between Central and Greenwood Avenues designated as proposed parkland in the 1975 Master Plan. It contains secondary forest of maples, elms and wild black cherry. The area is surrounded mostly by residences.

I. The remaining publicly owned parks in Madison include the following neighborhood parks and open plots:

	Acres
Lucy D (Baseball Fields @East & Myrtle)	6.66
Niles Park (Woodland Road)	3.80
Cole Park (Greenwood Avenue)	3.40
Madison Park (within Wayne Blvd.)	1.93
Parkside (western side of Rosedale Ave.)	1.80
Delbarton Park (Delbarton Drive)	1.50
Ridgedale (Oxford Lane)	1.26
Edwards Field (Kinney Street Field)	0.81
Fen Court	0.25
Academy Street	~0.30

PRIVATELY OWNED OPEN SPACE

A. *Giralda Farms*, has been developed as an office park since 1987. It contains 180 acres of great natural beauty (177.5 of which are in Madison) which the various developers' Agreements with the Borough seek to maintain. Only 15% of these prime and potential prime aquifer recharge soils may be covered with impervious surfaces (buildings, parking areas, walks or roads). Natural features are to be preserved wherever possible, and buffers are to be created where necessary to soften the visual impact of the buildings. In 2000-2001 a new building with underground parking was constructed on Woodland Road and Loantaka Way. As of this ERI update, the building is as yet unoccupied. Only one additional building at the corner of Loantaka way and Madison Avenue may be built.

B. *Drew University Forest Preserve and Aboretum* contains approximately 50 acres of mature mixed-oak forest. While these forested areas are maintained for the benefit of the student community, faculty, administration, staff and their visitors, the public is welcome to enjoy them by arrangement. Specifics on the Forest Preserve and Arboretum are included in the Vegetation Section. In 2001-2002 a new Arts Center is being build approximately 100 yards from the Madison Avenue entrance of the school. This brings the total impervious coverage level for the Drew campus up to approximately 20 percent.

C. *Madison Golf Course* consists of approximately 27 acres of potential prime aquifer recharge soils in the "critical area" category. The 1975 Master Plan designated the golf course as proposed parkland to give to the Borough the opportunity to acquire it if the site were ever proposed for development.

REFERENCES

1) Nieswand, George H. and Peter J. Pizor, Current Planning Capacity: A Practical Carrying-capacity Approach to Land Use Planning, Extension Bulletin 413, Rutgers University, Prepared in cooperation with the N.J. Division of State and Regional Planning, Department of Community Affairs, June, 1977, pp. 11 – 12.

OTHER SOURCES

2) Borough of Madison Master Plan, prepared by Robert Catlin and Associates, Denville, 1975.
3) Koenig, Scott, Town of Madison Park Proposal for Greenacres, Cornell University student report in Landscape Architecture, December 1981.
4) Kaiser, Kim Ball, *Using the Master Plan to Save Open Space*, ANJEC Quarterly Report, Summer, 2001

XII. HOUSEHOLD RECYCLING

As defined by Wikipedia (2/26/11), recycling means: "processing used materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production".

More technically, the process of recycling creates an "operational loop" that reclaims materials from *used* products and incorporates them into *new* products. The first step includes *collecting* materials, which are handled by curbside programs, drop-off centers, buy-back centers and deposit/refund programs, and processing of materials at a materials recovery facility in which the marketable commodities are prepared for sale. The second step is *manufacturing*, in which new items are composed partially or totally of recycled materials. The final step in the recycling loop consists of organizations and consumers *purchasing* recycled products, which creates the demand to fuel the recycling loop.

Source separation, or separating recyclable waste from the solid waste stream, has in fact reduced solid waste tonnage in every community. It promotes clean, marketable materials and reduces waste disposal costs to the recycling households or communities.

The tag-line for recycling is "Reduce, Reuse, Recycle" which broadens the meaning of recycling to include source reduction, reducing the quantity and toxicity of solid waste, and reusing materials.

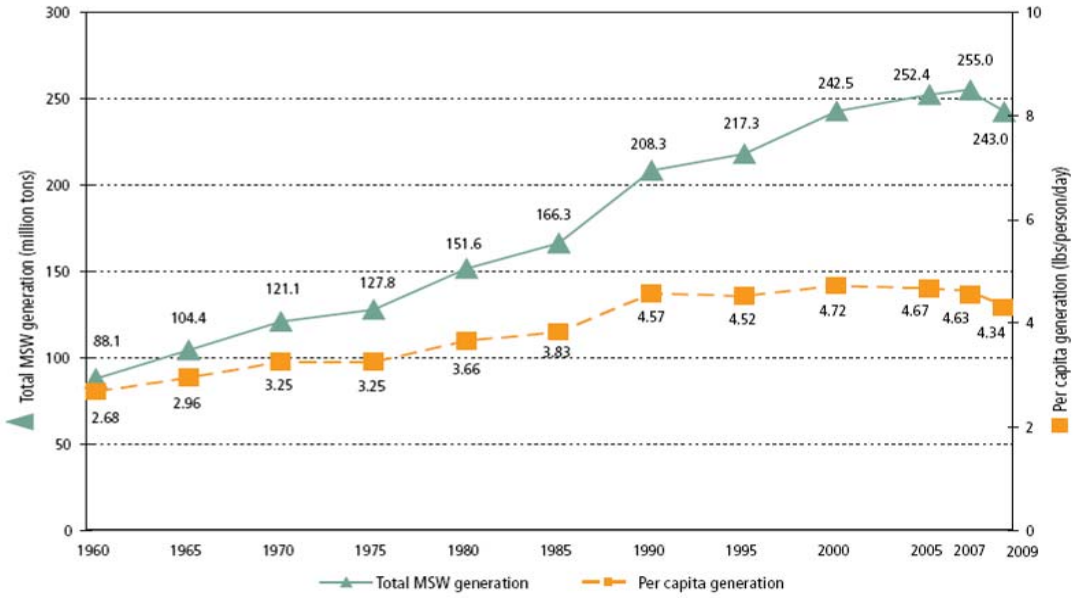
RECYCLING SUCCESS AND SOLID WASTE REDUCTION IN THE US AND NJ

As per the EPA, "In 2009, Americans generated about 243 million tons of trash and recycled and composted 82 million tons of this material, equivalent to a 33.8 percent recycling rate."[1] This recycling rate of 33.8% is up over 5% from Madison's last recycling ERI report of 2004, which reported a national rate of 28%.

[1] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf

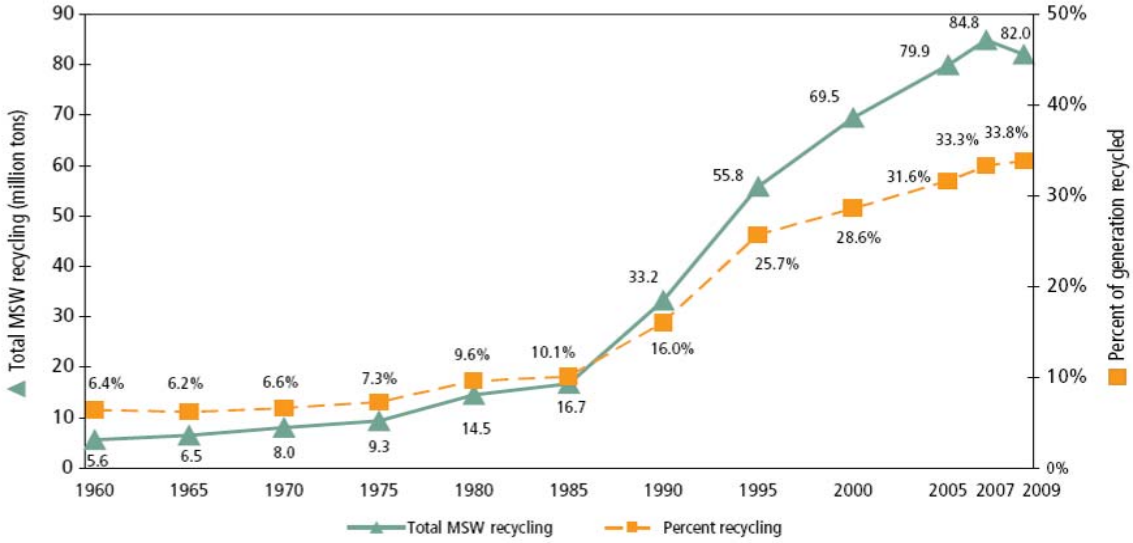
The following chart (from the same EPA report) shows total municipal solid waste generation, and the per capita rate, from 1960 – 2009. It is important to note the steady reduction of per capita municipal solid waste (MSW) from 4.72 pounds/person/day in 2000 to 4.34 in 2009. This is the only significant MSW reduction trend in the chart's 60 year history. In fact, Madison's municipal solid waste reduced significantly from 5474 tons in 2008 to 5257 tons in 2010.

Figure 1. MSW Generation Rates, 1960 to 2009



The second chart from the EPA report shows the strong increase in recycling in the United States, with the percentage of recycling tripling from 10.1% in 1985 to 33.8% in 2009.

Figure 2. MSW Recycling Rates, 1960 to 2009



NJ MUNICIPAL SOLID WASTE RECYCLING AS COMPARED TO THE UNITED STATES

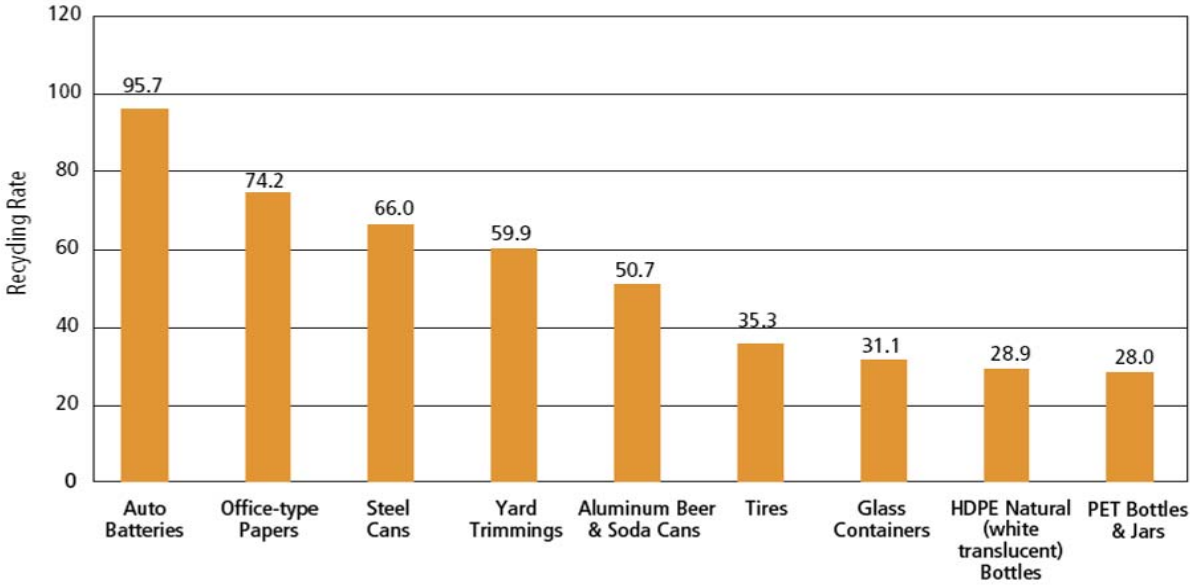
The table below shows the percentage of Municipal Solid Waste this is recycled every year. In the 1990's New Jersey was well ahead of the national average. New Jersey's rate has stayed relatively constant, while the national average has doubled over from 1990 to 2007. However, New Jersey continues to stay ahead of the MSW recycling national average, but by a much smaller margin.

Year	USA[2]	NJ[3]
1990	16%	34%
2000	28.6	38%
2005	31.6	34%
2007	33.3%	36.5%

NATIONAL AVERAGE MSW RECYCLING RATES BY MATERIAL

Recycling rates vary significantly by material. As can be seen from the EPA chart[4] below, the office paper recycling rate was 74.2% in 2009, while glass containers was 31.1%.

Figure 3. Recycling Rates of Selected Products, 2009*



[2] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf
[3] NJ Recycling Rates come from http://www.state.nj.us/dep/dshw/recycling/stat_links/06_revised_trends_table.pdf and http://www.state.nj.us/dep/dshw/recycling/stat_links/07%20disposal%20rates.pdf
[4] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdfU

HISTORY OF RECYCLING PROGRAMS IN NJ

Recycling programs historically were "grass-roots" organizations and trace their recent origins to the first Earth Day in 1970. When New Jersey enacted the legislation enabling environmental commissions in 1972, "pollution control – solid waste, air and hazardous substances – were placed within the commission's purview."[5]

The Recycling Act of 1981 created the Municipal Recycling Tonnage Grant Program whereby municipalities could receive a grant for the amount of materials documented as being recycled during the previous calendar year. At that time, the program was on a voluntary basis. Approximately 250 of NJ's 566 municipalities reported recycling in 1982. The amount of recycling reported was 250,000 tons of materials.

Until the 1987 Statewide Source Separation and Recycling Act, many New Jersey environmental commissions ran the recycling programs for the municipalities. The Recycling Act required municipalities to submit tonnage reports as well as separation for recycling of 50 percent of the total municipal solid waste, including vegetative and yard waste. Each county must designate at least three materials and secure markets for them. It also bans dumping leaves at landfills. The Recycling Act gives the municipality the responsibility to:

- Pass an ordinance, naming at least three materials to be separated from residential, commercial and institutional solid waste and requiring the separation of leaves from solid waste;
- Name a recycling coordinator;
- Design a program for the collection of recyclables and a program for the collection of leaves;
- Advertise the recycling program every six months; and
- Submit an annual tonnage report to the Office of Recycling at the new Jersey Department of Environmental Protection, documenting amount of materials recycled.[6]

RECENT NJ STATE REGULATION

An excerpt from the NJDEP website eloquently states:

"Undoubtedly, January 14, 2008 will long be remembered as one of the most important days in New Jersey's recycling history for it was on this date that Governor Jon S. Corzine signed into law the Recycling Enhancement Act (P.L. 2007, c.311). This landmark piece of legislation reestablishes a source of funding for recycling in New Jersey through a $3.00 per ton tax on solid waste accepted for disposal or transfer at in-state solid waste facilities. Solid waste being

[5] Sandy Batty, Environmental Commissioner's Handbook, (4th ed.) Association of NJ Environmental Commissions: 1997, p51.
[6] Sandy Batty, Environmental Commissioner's Handbook, (4th ed.) Association of NJ Environmental Commissions: 1997, p51.

transported out of state, either directly or by railroad, is also subject to the new recycling tax. In such cases, the solid waste collector is responsible for paying the tax. The reestablishment of a funding source for recycling is especially significant, as inadequate funding has been considered one of the key reasons behind New Jersey's declining recycling rates, which have dropped precipitously over the past decade. The New Jersey recycling community has looked forward to this day ever since the expiration of the recycling tax in 1996 and views the signing of this legislation as a watershed moment in our state's recycling history." [7]

The funds generated by the Recycling Enhancement Act are directed as follows:

- 60% to be used for recycling tonnage grants to municipalities and counties.
- 25% to counties for preparing and implementing solid waste management plans, including the implementation of the goals of the State Recycling Plan. Among other things, these funds can be used to pay for household hazardous waste collection events.
- An additional 5% to Counties for public information and education programs concerning recycling.
- 5% to the NJDEP to provide grants to institutions of higher education to conduct research in recycling.
- 5% to the NJDEP for recycling program planning and administrative expenses associated with the program.

"*Other important aspects of the new law include the expiration of the Solid Waste Services Tax (which stands at $1.65 per ton) that has been levied on solid waste disposed at landfills and the requirement that municipal and county recycling coordinators become certified through a formal course of instruction. In addition, the Recycling Enhancement Act calls for an $8,000,000 appropriation from the General Fund to the Recycling Fund for recycling grants to counties and municipalities. The Department must issue these grants within the next twelve months. While recycling funds collected in the upcoming years will be used to repay this amount to the General Fund, this monetary infusion made available by the Act will be helping reinvigorate New Jersey's programs over the short term.*"[8]

The Recycling Enhancement Act (P.L. 2007, c.311) was further refined in 2010 under the Electronics Waste Management Act (EWMA). Effective January 1, 2011 a disposal ban was placed on computers, monitors, laptops and televisions. The EWMA requires all manufacturers that sell these items in NJ to register with the state and submit a plan to the state for the creation of recycling collection sites. In essence, the EWMA states that if a manufacturer sells electronics in NJ, then they must create an acceptable plan to recycle electronics. NJ should expect a combination of specific drop off sites as well as retailer managed recycling of electronics.

[7] http://www.nj.gov/dep/dshw/recycling/whatsnew/Recycling%20Act%20Signed.htm
[8] http://www.nj.gov/dep/dshw/recycling/whatsnew/Recycling%20Act%20Signed.htm

RECENT RECYCLING TONNAGE INFORMATION FOR MADISON

As a result of the Recycling Enhancement Act, Madison pays $3.00 per ton of garbage. In 2010, Madison delivered 5,156.59 tons of garbage to the Morris County Municipal Utility Authority (MCMUA) facility. It is important to note that because Morris County currently has a Waste Flow Order where municipalities are mandated to deliver all garbage generated in the town to the MCMUA tipping station, private commercial haulers that service Borough businesses are also required to abide by this Order. Thus, the 5,156.59 tons of garbage represent a very accurate number of the total garbage—commercial, industrial and residential—generated by all of Madison. At $3.00 per ton of garbage, Madison's 2010 Recycling Tax totaled $15, 469.77.

Because Madison's garbage tonnage has remained fairly consistent, so has the yearly Recycling Tax. In addition, Madison received recycling grants from the State of New Jersey totaling over $34,000 in 2009 and over $29,000 in 2010—a total of $63,000 in grant funds. This means that Madison is receiving more from the Recycling Fund then it is paying into it.

Current Recycling Tonnage Information for Various Materials

MATERIAL	2007 tons	2008 tons	2009 tons	2010 tons
Corrugated paper, mixed paper, newspaper and junk mail	3,618.7	3,183.8	3,108.0	3,657.6
Glass Containers	473.3	514.9	535.4	545.0
Aluminum Containers	33.7	37.4	35.1	54.8
Steel Containers	70.0	75.8	72.5	82.2
Plastic Containers	101.1	109.8	105.2	121.2

There are other additional categories that are included on the State Tonnage Report (30 total) and they also include: various metals; automotive materials including batteries, tires, used motor oil, auto scrap and anti-freeze; various vegetative materials including stumps, leaves, brush grass clippings and tree parts; consumer electronics; construction material including concrete, asphalt and brick; food waste, and oil contaminated soil.

New Jersey has recently enacted legislation requiring that electronic recycling be mandatory. Fortunately, Madison has been ahead of this thanks to the efforts of the Madison Environmental Commission (MEC). In 2010, the MEC created a partnership with the Borough, local merchant PC Problems and the electronic recycling firm, e-Revival. PC Problems now accepts all electronic recycling at their shop on Main Street. In turn, they bring the electronics to a container at the DPW yard that was provided by e-Revival for free. E-Revival, in turn, collects the electronics and recycles over 99% of the materials. E-Revival operates an EPA and NJDEP notified and compliant facility and is a member of the International Association of Electronic Recyclers. Their goal is zero waste and zero export.

Pictured above are PC Problems staff and members of the Madison Environmental Commission.

RECYCLING PROCEDURES IN MADISON

Madison residents' recyclable materials are collected weekly by crews from The First Occupational Center of New Jersey. Materials alternate week to week—commingled bottles and cans one week; newspapers and magazines the next and so on. Recyclables must be put out on the curbside the night prior to or by 7 am of collection day.

On commingled collection days acceptable materials include glass, aluminum, tin and steel, food and beverage containers, and plastic soda, milk, water and detergent bottles. The Borough of Madison recycles plastics 1-7. This includes yogurt cups, large jugs, margarine containers, Styrofoam egg cartons and alike. On newspaper days, acceptable materials include newspaper, junk mail, magazines, and cardboard.

Recycling by Madison businesses must be done by either using a private hauler or by bring the materials at no charge to the Madison Borough Garage on John Avenue on Mondays and Fridays between 9 a.m. and 11:30 a.m.

Special arrangements can be made for the pick up of refrigerators, air conditioners, freezers, or white goods by calling the Department of Public Works at 973-593-3088. A payment of $25 must be submitted in advance. Pick up occurs on Fridays, except on Holidays, when pick up will occur on a Thursday.

Motor oil, used tires, and car batteries can be properly disposed of at many local service stations, or through the Morris County Household Waste program.

Household hazardous waste, which includes pesticides, herbicides, oil based paints/stains, paint thinners; antifreeze, motor oil, transmission/brake fluid and batteries cannot be recycled and have special disposal procedures. For Morris County residents, the Morris County Muncipal Utilities Authority offers two household hazardous waste collection days. A permanent site located in Flanders where hazardous materials can be brought is available by appointment only. For information, and to make an appointment, please call the County at 973-829-8006.

SOURCES OF INFORMATION

U.S. Environmental Protection Agency
The USEPA website at http://www.epa.gov/waste/index.htm is one of the most thoughtful and comprehensive waste and recycling websites in available. It is worth noting that the current EPA Commissioner, Lisa Jackson, is the immediate past Commissioner of the NJDEP.

NJ Department of Environmental Protection
The NJDEP at http://www.state.nj.us/dep/dshw/ is not as dynamic as the USEPA site, but it does contain a significant amount of information and data related to New Jersey.

FOOTNOTES

[1] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf

[2] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf

[3] NJ Recycling Rates come from:

http://www.state.nj.us/dep/dshw/recycling/stat_links/06_revised_trends_table.pdf and

http://www.state.nj.us/dep/dshw/recycling/stat_links/07%20disposal%20rates.pdf

[4] http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf

[5] Sandy Batty, Environmental Commissioner's Handbook, (4th ed.) Association of NJ Environmental Commissions: 1997, p51.

[6] Sandy Batty, Environmental Commissioner's Handbook, (4th ed.) Association of NJ Environmental Commissions: 1997, p51.

[7] http://www.nj.gov/dep/dshw/recycling/whatsnew/Recycling%20Act%20Signed.htm

[8] http://www.nj.gov/dep/dshw/recycling/whatsnew/Recycling%20Act%20Signed.htm

XIII. REGIONAL RELATIONSHIPS

Land use planning in Madison is directly and indirectly affected by development in nearby municipalities in the northeast New Jersey region. Conversely, decisions made in Madison affect neighboring communities. Important considerations such as preservation of open space, transportation, location of existing and planned commercial and industrial centers, water quality and quantity issues, sewage disposal, and other local concerns are influenced by events in the area. In this chapter these matters are discussed from a regional point of view.

An obvious and long-standing example of regional cooperation close to home is the Madison-Chatham Joint Meeting wastewater treatment plant. Established by an act of the state legislature in 1909, the Joint Meeting enables Madison and Chatham Boroughs to construct, own, and jointly operate the sewage treatment plant (1).

Opening on November 1, 1911, the Madison-Chatham Joint Meeting is one of the oldest sewage treatment plants in the state. Located on North Passaic Avenue in Chatham, the plant discharges to the Passaic River. Since the Passaic River is the source for a portion of many towns' drinking water, e.g., Florham Park, occasional inflow and infiltration problems at a sewer treatment plant can result in overloading and inadequate treatment during rainy periods. This creates problems for water quality for water purveying providers. Expanded and improved over the years, the Joint Meeting facility was upgraded in 1990 via $16.2 million in additions and improvements to meet Level 4 water quality requirements for ammonia removal and dechlorination. The plant's capacity was also expanded to an average daily flow of 3.5 million gallons per day (MGD) and a peak flow of 13 MGD. The improvements consisted of the addition of two new oxidation channels with aeration, two new final clarifiers, a new sludge handling the building and additional dechlorination facilities. (2)

REGIONAL PLANNING

A factor in the life of New Jersey's communities since World War II, suburban sprawl has intensified in the last thirty years to dramatic proportions. Painfully aware of the sprawl's concomitant ills, i.e., traffic congestion, rising property taxes, air and water pollution, and loss of community character, New Jersey residents have become increasingly interested in regional planning to address these inter-municipal issues of concern. Regional planning is important to protect open space and water quality and quantity, and to address regional transportation, infrastructure, and commercial and residential development needs.

STATE PLANNING IMPACT

In 1985 the State Legislature found that New Jersey must plan for its future to preserve and maintain its abundant natural, cultural, economic and social assets and its quality of life. In response, the Legislature adopted the State Planning Act. The goals of the act are to "conserve natural resources, revitalize urban centers, protect the quality of the environment and provide needed housing and adequate public services at a reasonable cost while promoting beneficial economic growth, development, and renewal". The first state plan to follow these precepts was adopted in 1992, and a revision, titled "The New Jersey State Development and Redevelopment

Plan" (SDRP) was released in 2001. Under the State Plan, planning is to consider preventative measures to mitigate pollution, excessive traffic congestion and excess land consumption.

According to the Business Action Center within the NJ Department of State, the 2001 SDRP provides "a vision for the future that will preserve and enhance the quality of life for all residents of New Jersey. The State Plan is the result of a cross-acceptance process that included thousands of New Jersey citizens in hundreds of public forums, discussing all of the major aspects of the plan - its goals, strategies, policies and application. This process ensures that the plan belongs to the citizens of New Jersey, whose hopes and visions have shaped it."

The purpose of the State Plan is to:

> Coordinate planning activities and establish Statewide planning objectives in the following areas: land use, housing, economic development, transportation, natural resource conservation, agriculture and farmland retention, recreation, urban and suburban redevelopment, historic preservation, public facilities and services, and intergovernmental coordination (N.J.S.A. 52:18A-200(f)).

In general, the State Plan recommends the "Smart Growth" concept touting the development of mixed use developments rather than single use or multi-use developments. Such developments should be concentrated near or in urban and community infrastructure hubs and near existing nodes of regional transportation networks.(3) On the surface, the plan is laudable and has been shown to be effective in certain cases (i.e., in municipal litigation defenses against developers). The courts have sided with the municipality conformance with the State Plan. However, it must be recognized that the Plan identifies guidelines, not regulations. Since creating mixed-use developments is usually not consistent with developers' short term maximization of "return on investment," there is not a strong economic incentive to push Smart Growth. The real test of the State Plan, however, will be in coordination of planning on a regional level, especially where development in one municipality will impact heavily on adjoining communities. This is why the old Exxon property is being scrutinized – to see if the project will conform to the State Plan and whether regional planning considerations will be met.

Recent history in the area has typified where projects that don't adequately address regional planning can have an impact on the quality of life. Two projects where regional impacts were not adequately addressed over the past decade were in the completion of Route 24 and the construction of 550 housing units on North Passaic Avenue in Florham Park just north of the Chatham border. In the Route 24 project, the NJDOT estimated the peak road utilization during rush hour at 40,000 vehicles. The actual utilization 10 years later is almost twice that at approximately 78,000 vehicles, causing increased commuting traffic throughout the area. Often during rush hour Route 24 through Madison comes to a standstill, exacerbating our air quality. Regarding the North Passaic Avenue project, as the units continue to become occupied at this time, the amount of traffic on Main Street in Chatham (and Madison) has been increasing towards pre-Route 24 levels.

The SDRP designates five (5) "Planning Areas," or areas that "share common conditions with regard to development and environmental features," which include:

- Areas for Growth: Metropolitan Planning areas (Planning Area 1), Suburban Planning Areas (Planning Area 2) and Designated Centers in any planning area.

- Areas for Limited Growth: Fringe Planning Areas (Planning Area 3), Rural Planning Areas (Planning Area 4), and Environmentally Sensitive Planning Areas (Planning Area 5). In these planning areas, planning should promote a balance of conservation and limited growth—environmental constraints affect development and preservation is encouraged in large contiguous tracts.

- Areas for Conservation: Fringe Planning Area (Planning Area 3), Rural Planning Areas (Planning Area 4), and Environmentally Sensitive Planning Areas (Planning Area 5).

"Environmentally Sensitive Planning Areas" or Planning Area 5 cover areas where development will be limited. Most of the Great Swamp Watershed is designated as PA5 because the Great Swamp has been designated as a National Wildlife Refuge. A portion of Madison, mostly in the hilly and down-slope southern area of town, lies within the Great Watershed recharge area.

WATERSHED PLANNING AND MANAGEMENT

Watersheds are natural hydrologic units, where all of the water that falls in a given area drains to a common outlet, such as a lake, river, or pond. Madison Borough, a political designation, is split between the Great Swamp and Whippany watersheds, with the northern portion of the borough draining to the Whippany River and the southern portion draining into the Great Swamp watershed. All of Madison is part of the much larger Passaic River watershed.

A recent initiative of the New Jersey Department of Environmental Protection (NJDEP) has been to delineate the state according to its primary watersheds. The Whippany, Great Swamp, and Rockaway watersheds are together delineated by the DEP as Watershed Management Area #6. (The state is divided into 20 separate watershed management areas comprising 96 separate watersheds.). Watershed Management Are #6 occurs through portions of Morris, Essex, Somerset, Sussex, and Union Counties and contains 52 separate municipalities. According to NJDEP, the watershed management approach "provides a scientific basis for holistic management of water and water-related resources within a watershed by government, private sector and citizens. The work of this group will focus on characterization and assessment of the watershed and its water and water-related resources. The results of this report will be used to develop environmental protection goals for the protection of the watershed in the next millennium. (4)

OPEN SPACE PLANNING

In the fall of 1998, New Jersey residents voted by a greater than 2 to 1 margin to preserve open space in the state, agreeing to dedicate $98 million per year from the state sales tax to preserve one million acres of the state's potentially developable lands. Many organizations and agencies work to help preserve open space. At the state level, the NJDEP's Green Acres program helps towns and counties finance the purchase of open space for passive and active recreation and for natural resource protection. In 1996, the Green Acres program published New Jersey open Space and Outdoor Recreation Plan, which identified the need to protect "an additional 271, 561

acres of open space to meet balanced land use goals" in New Jersey, both through the protection of farmland and of large, privately-owned parcels of land.

Here in Morris County protection of open space became a top priority over the past decade. The Morris County Open Space and Farmland Preservation Trust Fund Program has preserved hundreds of acres of open space for numerous Morris County communities. In November, 2001 voters voted to allow the county Freeholders to increase this fund's levy form 3 to 5 cents per $100 of property value in order to purchase more open space. The Trust has been active in Madison, helping the Borough secure purchase of the Loantaka Moraine, a 25-acre parcel on Loantaka Way, and the Gibbons Pines, a 3-acre parcel across from Moraine on Gibbons Place. The moraine was sold to Morris County and annexed into the Loantaka Brook Reservation. In the Gibbons Pines purchase, the Trust had assistance from the Morris Land Conservancy, a private, nonprofit land conservation organization that works directly with towns to preserve open space.

Other nonprofit organizations also work regionally to protect open space. The Great Swamp Watershed Association, a 2,500-member organization located in Madison, published *Saving Space: The Great Swamp Watershed Association Greenway and Open Space Plan* in 1997. *Saving Space* was the first regional open space planning effort undertaken in the communities of the Great Swamp watershed, of which Madison Borough is a part. In addition to cataloguing existing open space, the plan identifies critical areas for protection efforts in the future, several of which are located in the Borough.

PLANNING FOR WATER QUALITY AND QUANTITY

The Federal Water Pollution Control Act of 1972 (FWPCA) and its 1997 amendments, together known as the Clean Water Act, stress regional cooperation in several areas. In our region of the state, the Environmental Impact Statement for the Upper Passaic River Basin 201 Facilities Plan addresses secondary impacts of population growth, water quality impacts to the Great Swamp National Wildlife Refuge, chlorine and toxicity impacts to the headwaters of the Passaic River, and impacts associated with expanding treatment facilities in flood plains.

Sections 208, 209, and 303 of the FWPCA authorize planning on a broader scale. Section 208 requires are-wide planning, concentrating on comprehensive means of controlling urban industrial pollution and non-point source pollution from storm water runoff. One New Jersey response to these requirements was the 1979 development of the Water Quality Management Plan for Northeast New Jersey.

Numerous other planning efforts have been undertaken in the past two decades to address water-related issues in our region. Studies have been conducted on water quality, water quantity, point and non-point sources of pollution, urban and suburban runoff, impervious cover, and aquifer contamination.

Some of the most interesting and useful work has occurred through the efforts of two regional groups, the Ten Towns Great Swamp Watershed Management Committee and the Whippany River Pilot Project. Each of these groups is of use to Madison, which partly falls in the Great Swamp watershed and partly in the Whippany watershed. Formed in 1995 through the

efforts of Morris 2000, the Ten Towns Committee has a number of substantial accomplishments for helping protect the natural resources of the region. After receiving formal presentations over a one-year period from 24 experts in watershed-related issues, the Committee developed a comprehensive watershed management plan in 1997. This plan was adopted by all ten watershed communities, including Madison, by the fall of 1998. The committee also analyzed model ordinances and presented recommendations on their use in the watershed in such areas as soil erosion and sediment control, riparian buffer conservation zones, tree protection and removal, storm water management, wetlands protection, and steep slopes. At the time of this publication, each of the ten towns is working to adopt these ordinances to further preserve the resources of the watershed.

Work has been equally intensive in the Whippany watershed. There, the Whippany Watershed Action Committee undertook a pilot study of the Whippany River.

Finally, non-profit organizations work on a regional basis to ensure natural resource protection and conservation. Locally, the Great Swamp Watershed Association assists towns like Madison assess the subdivision and site applications before its Planning and Zoning Boards with respect to water resource protection and land use. The GSWA is active in policy efforts regionally and at the state level, and it works broadly to maintain the public and natural resources of the watershed and to protect and conserve the Great Swamp National Wildlife Refuge. The Passaic River Coalition works to protect water quality through its Wellhead Protection Program, of which Madison, with its sole source aquifer, is an integral part. The program has identified and mapped through Geographic Information Systems (GIS) technology each wellhead in our region. The goal is to protect the land surrounding these wellheads from contamination.

Working on a regional basis has become an increasingly accepted and important method for addressing environmental protection concerns in New Jersey. Regional planning to protect water quality and quantity and open space for our state and the regional management of these precious resources will help insure that Madisonians continue to enjoy a high, and sustainable, quality of life into the new millennium.

REFERENCES

1. League of Women Voters, Madison, New Jersey, a Know Your Town Study. League of Women Voters of Madison, New Jersey, 1956-7.
2. *Madison – Chatham Joint Meeting Dedication [Brochure], October 5, 1990*
3. *The New Jersey State Development and Redevelopment Plan.,* the New Jersey State Planning Commission, Adopted March 1, 2001.
4. Highlights of the Initial Watershed Characterization and Assessment for Watershed management Area 6 (Upper Passaic, Whippany and Rockaway Watersheds). (Trenton, NJ: Department of Environmental Protection), February 1998, p. 3.

XIV. MAP DATA SOURCES

The Following data sources were used in preparing the GIS maps for the 2011 Madison Borough ERI Update.

BASE MAP CONTENTS

Unless otherwise noted, the Base Map for each map contains:

→ *Municipal Boundary*: the latest available municipal boundary layer from the New Jersey Office of Information Technology (OIT), Office of Geographic Information Systems (OGIS). It is not a survey document and does not represent legal boundaries. This data set improves upon previous versions of municipal boundaries through the integration of coincident features from several high quality source data sets, as a component of the OGIS statewide Parcels Normalization Project concluded in March 2010. For the 2011 ERI Update, this municipal boundary layer was updated to include the 49-acre annexed property from Florham Park by digitizing a survey of the property dated August 3, 2010.

→ *Parcels*: Shapefile provided by Morris County which shows all parcels and condominium delineations for all of Morris County and clipped for Madison. The original file (ParcelsandCondos2009.shp) was clipped to the municipal boundary. A "join" was performed to attach ModIV tax data.

→ *Roads*: Shapefile provided by Morris County (StreetCenterlines.shp), which includes jurisdictional information.

→ *Rail*: Shapefiles provided by Morris County (railroad centerlines.shp and railroad stations.shp)

INDIVIDUAL MAPS DATA SOURCES

Aerial Map

The Aerial Map includes NJDEP orthoimagery from 2007. The map includes the ESRI basemap "World Boundaries and Places," which shows transportation features and boundary an place names. The data was created by ESRI, DeLorme, and Tele Atlas, http://goto.arcgisonline.com/maps/Reference/World_Boundaries_and_Places.

Road Map

The Road Map includes the Base Map data represented above, with the addition of a building footprint layer. The building footprint layer was made available by the Borough Engineering Department. The Street Centerline data from Morris County was updated to include a field for road hierarchical information to show Arterial and Collector Streets. The listing of Arterials and Collectors is from the Borough's 1992 Circulation Element of the Master Plan.

Land Use / Land Cover, Land Use/Land Cover Change, Vegetated Lands, Wetlands, and NJDEP Impervious Surface Maps

These maps were prepared using the NJDEP's 2007 LU/LC digital data. The 2007 LU/LC data set is the fourth in a series of land use mapping efforts that was begun in 1986. Revisions and additions to the initial baseline layer were done in subsequent years from imagery captured in 1995/97, 2002 and 2007. This present 2007 update was created by comparing the 2002 LU/LC layer from NJ DEP's Geographical Information Systems (GIS) database to 2007 color infrared (CIR) imagery and delineating and coding areas of change. Work for this data set was done by Aerial Information Systems, Inc., Redlands, CA, under direction of the New Jersey Department of Environmental Protection (NJDEP), Bureau of Geographic Information System (BGIS). LU/LC changes were captured by adding new line work and attribute data for the 2007 land use directly to the base data layer. All 2002 LU/LC polygons and attribute fields remain in this data set, so change analysis for the period 2002-2007 can be undertaken from this one layer. The classification system used was a modified Anderson et al., classification system. An impervious surface (IS) code was also assigned to each LU/LC polygon based on the percentage of impervious surface within each polygon as of 2007. Minimum mapping unit (MMU) is 1 acre.

Surface Geology Map

The Surface Geology map was prepared with data from the New Jersey Geological Survey in cooperation with the U. S. Geological Survey (USGS) National Geologic Mapping Program, and was last updated June 8, 2011. This GIS data sets depict the surface extent of the surficial materials in the quadrangles. These deposits are mapped at 1:24,000 scale using U. S. Geological Survey 7.5-minute topographic quadrangles as base maps. The data are from various Geologic Map Series and Open-File Maps at 1:24,000 scale. Additional data may be available by contacting the New Jersey Geological Survey. This may include: well and boring logs, bedrock-surface contours, geophysical data, cross sections, discussion of geologic history and hydrologic and engineering properties of the surficial materials, age and correlation of the surficial materials, lithologic data, glacial and landform features, and detailed unit descriptions.

Surface Water Map & Flooding Map

Several sources of data were used to create this map, primarily provided by the NJDEP. These include the waterbodies and streams layers, which come from the NJ National Hydrography Dataset (NHD) Waterbody and Stream Network. In August 2010, NJDEP completed the statewide attribute transfer of the USGS 1:24000 high-resolution National Hydrography Dataset (NHD) to the 2002 Waterbody and 2002 Stream Network data layers. The 14-digit hydrologic units (HUC14s) in New Jersey is a revision of the 2006 version of these units. This version corrects some boundaries to be consistent with a new hydrography coverage based on 1:2,400 aerial photographs (NJDEP, 2008). It also makes some changes to be more consistent with a new 12-digit hydrologic unit coverage (EPA, 2009). This editing process created 42 new HUC14s, deleted one inland HUC14 and five coastal HUC14s in the Delaware Bay, and changed over 100 boundaries. The 14-digit boundaries are clipped to New Jersey's political boundary. The only data layer not supplied by the NJDEP is the flood plain data. That data was obtained from the Federal Emergency Management

Agency (FEMA) and shows Special Flood Hazard Areas (SFHAs). SFHAs are areas with a one percent chance of being flooded in any given year; hence they are known as 100-year floodplains.

- *Wellhead Protection & Contaminated Sites Map*

There are three important data sets in this map: public community supply wells (PCSW), wellhead protection areas (WHPA), and known contaminated sites (KCS). The PCSW and WHPA datasets are produced by the NJDEP's New Jersey Geological Survey NJGS, are mapped at a scale of 1:24,000, and last updated July 11, 2011. The PCSW dataset contains information for the wells in New Jersey that supply potable water to public communities. The NJDEP has cataloged and field located, using the Global Positioning System (GPS), the PCWS wells as part of the Source Water Area delineation process. The data in this database and coverage originate from the NJGS Wells Database. The WHPA delineations for New Jersey's PCSWs were prepared as a requirement of the NJ Source Water Area Protection Program (SWAP), which was established by the Safe Drinking Water Act Amendments of 1986 and 1996. NJDEP created the WHPA delineations using a model approved by EPA under the SWAP, well documented in the NJDEP publication: *Guidelines for Delineation of Wellhead Protection Areas in New Jersey*. http://www.state.nj.us/dep/njgs/whpaguide.pdf
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The Known Contaminated Sites List (KCSNJ) for New Jersey, Fall 2009 are those non-homeowner sites and properties within the state where contamination of soil or ground water has been confirmed at levels equal to or greater than applicable standards. This list of Known Contaminated Sites may include sites where remediation is either currently under way, required but not yet initiated or has been completed. The dataset is prepared by the NJDEP, Site Remediation Program (SRP), Division of Remediation Support (DRS), Information Support Element (ISE), Bureau of Information Services and Program Support (BISPS) and is supposed to be updated quarterly.

- *Groundwater Recharge Map*

Groundwater Recharge GIS data was obtained for NJ Watershed Management Area 6 (Upper Passaic, Whippany and Rockaway Rivers), from the NJDEP, NJGS, Bureau of Water Resources (BWR), last updated in 2005. Groundwater Recharge GIS coverages were created by applying the methodology outlined in NJ Geological Survey Report GSR-32 "A Method of Evaluating Ground-Water-Recharge Areas in New Jersey" by E. G. Charles and others (1993). The data was created by overlaying three coverages; 1) soils, 2) land use and land cover (LULC); and 3) municipality boundaires. These three coverages provided the following attributes: soil series names, land-use and land-cover categories, and climate factors; respectively. Calculated ground-water recharge values from each area in the coverages were rounded to the nearest inch and ranked into 5 categories based upon the natural breaks in the percentage of total volume.

- *Soils Map*

The Soils map was prepared using spatial data from the "soil data mart" run by the Natural Resources Conservation Service (NRCS) within the USDA, at: http://soildatamart.nrcs.usda.gov/.

The tabular data, which was then joined to the shapefile, was obtained through the NRCS's "Web Soil Survey" available at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. The data provided in the Soil Data Mart and Web Soil Survey were orginally compiled by the United States Department of Agriculture's Natural Resources Conservation Service (NRCS) in 1989. The Soil Survey Geographic (SSURGO) data base is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The digital data includes a detailed, field verified inventory of soils and non-soil areas that normally occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The data set is not designed for use as a primary regulatory tool in permitting or citing decision, and should be used for planning purposes only. The map does not eliminate the need for on-site sampling, testing and detailed study of specific sites for intensive uses.

- *Topography*

The Topography data was obtained from the Borough of Madison Engineering Department. The data includes polylines with elevations at five-foot-contour intervals. The Borough's data surpasses the scale of available New Jersey statewide elevation contours, which are at twenty foot intervals, and created by USGS DEM 100 meter lattice

- *Tree Canopy Map*

The National Land Cover Database 2001 tree canopy dataset measures the per-pixel density of tree cover across the United States and Puerto Rico. The layer was produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies (www.mrlc.gov), consisting of the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA) Forest Service (USFS), the National Park Service (NPS), the U.S. Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM) and the USDA Natural Resources Conservation Service (NRCS).

- *Open Space Map*

Information on the open space and other parcels was obtained from a variety of sources, including: the NJDEP 2007 Land Use/Land Cover dataset to show natural areas (forest, shrubbery, field, etc.); the Green Acres ROSI listing (for official park names); the Morris County GIS Department; the USA Landmarks and Parks basemap prepared by ESRI; the Madison parcel layer with MOD-IV tax assessor data;, and input from members of the Madison Environmental Commission.

REFERENCES

1. Anderson, et al. *A Land Use and Land Cover Classification System for Use with Remote Sensor Data*, U.S. Geological Survey Professional Paper 964, 1976.

Appendix A:
Recommended Environmental Checklist for Specific Development Applications