RIVERS IN DANGER

The Impact of Development on Water Quality in New Jersey

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EXECUTIVE SUMMARY

Many of New Jersey's most pristine waterways face the risk of contamination from rapidly expanding development. These waterways provide clean drinking water for millions of New Jersey citizens, replenish the state's groundwater supplies, provide ecologically critical habitat for threatened and endangered species, and regionally important recreational opportunities.

New Jersey is using up its land faster than any other state in the country. The Center for Remote Sensing and Spatial Analysis at Rutgers predicted the state would run out of available land within 30 to 50 years if development rates seen in the last two decades continue. These rapid changes are having a strong negative impact on water quality, especially in the most pristine parts of the state. During the 1990s, water quality declined in a third of the state's waterways—in watersheds at the fringes of major development activity.

This report explores the link between development and water quality degradation in the state and highlights a set of valuable but vulnerable rivers that need protection.

Urban land use is a primary factor in water quality degradation.

An analysis of land use and water quality data collected by the New Jersey Department of Environmental Protection indicates that poor water quality is associated with increasingly urban land use. Replacing as little as 5% of the land in a watershed with paved surfaces results in observable water quality decline.

Development harms water quality by increasing levels of runoff and treated sewage discharge.

- Runoff from paved or disturbed land delivers fertilizers, sediment, oil, grit, and other pollutants to water bodies.
- Treated sewage from commercial and residential developments contaminates waterways with nutrients and other chemical pollutants.
- Runoff and wastewater effluent can reduce groundwater recharge and contaminate underground aquifers.

Water quality declined in 35% of watersheds during the 1990s.

Water quality declined in 14 major river systems measured by the NJDEP in the early and late 1990s. The rivers that showed a decline were located in the Northwest, Central, and Atlantic coast areas of the state—areas that are experiencing rapid development. They include:

- The Wallkill, Pequest, and Musconetcong Rivers in Northwest New Jersey.
- Lockatong Creek, Lawrence Brook, and the Neshanic and Millstone Rivers in Central New Jersey.
- The Navesink, Shark, Manasquan, Metedeconk, and Toms Rivers along the Atlantic Coast.

The case of Lawrence Brook and the Millstone River illustrates the connection between development and declining water quality. The land surrounding these rivers includes six of the top 20 municipalities with the most new development between 1986 and 1995, including West Windsor Township (Mercer County), Franklin Township (Somerset County), Manalapan Township, Millstone Township (Monmouth County), South Brunswick Township, and Monroe Township (Middlesex County). During this period, increasing urban area claimed 6.6% of the Lawrence Brook watershed and 7.5% of the Millstone River watershed, yielding a 12% water quality decline in both rivers in the 1990s.

Continued development in pristine watersheds threatens water quality across the state.

Building permit data shows that development activity continues in Central New Jersey and southward along the Jersey Shore. Six municipalities each issued more than 2,000 building permits for residential homes between

1996 and 2001, including Dover Township, Manchester Township, Jackson Township (Ocean County), Monroe Township (Gloucester County), South Brunswick Township (Middlesex County), and Marlboro Township (Monmouth County). In addition, widened roads are increasing development pressure in areas like the New Jersey Highlands. Rivers in these areas are at risk for further water quality declines.

POLICY FINDINGS

Preserving pristine waterways requires protecting forests and wetlands, maintaining buffer corridors, minimizing impervious surface additions, and preventing new or expanded sewage discharges in vulnerable areas. Each of these steps can promote healthy streams and good drinking water quality.

Governor James McGreevey's administration has made protecting drinking water supplies and ecologically significant waterways a priority. There are many steps which could and should be taken to address development pressures and their water quality impacts. One notable step has been the use of the anti-degradation provisions of the Clean Water Act to protect waterways from additional sewage discharge, runoff pollution, and shrinking buffer zones. Under this part of the Clean Water Act, special waterways (called Category One or C1) are protected from any activity that results in a measurable decline in water quality.

The administration can help ensure that New Jersey's pristine waterways remain protected for future generations by improving the scope and effectiveness of this program with the following steps:

- Officially finalizing Category One protection for the 15 waterbodies the administration proposed for Category One status on Earth Day 2002, and the seven trout streams proposed for protection in December.

Vulnerable Rivers

- The Wanaque River, the Ramapo River, tributaries of the Rockaway and Pequannock Rivers, the Wallkill River and the Vernon Valley, and the Musconetcong River in northwest New Jersey.
- Holland Brook, the Neshanic River, and other pristine tributaries of the South Branch of the Raritan River in Central New Jersey.
- Rancocas Creek, Oldmans Creek, the Maurice River, and the Cohansey River in the Lower Delaware region.
- The Manasquan River, the Great Egg Harbor River, and the Toms River along the Atlantic Coast.

- Extending protection to an inclusive and comprehensive list of waterways across the state, emphasizing drinking water sources, habitat for endangered species including coastal areas, headwater areas with low impervious cover, and tributaries of protected rivers or reservoirs. A good example of this type of list was announced by the governor in March 2003 and is currently posted on the DEP website.
- Integrating Category One protection effectively in regulations for septic systems, groundwater protection, stream encroachment, coastal management, water allocation, and wetlands management. For example, the Department of Environmental Protection should officially adopt the recently proposed stormwater management rules, which include a 300-foot buffer zone for Category One waters.
- Strengthening and enforcing existing regulations to ensure no measurable degradation in Category One waterways, including adequate buffer zones and limits on discharge from sewage plants and industry.

INTRODUCTION

New Jerseyans need clean water. Over four million New Jerseyans rely on surface water for drinking supply. Public water companies draw water from 54 different surface water intakes, many located on reservoirs in North Jersey.[1] More than four million additional New Jerseyans rely on underground aquifers for their water, including the Kirkwood-Cohansey and Magothy aquifer systems under New Jersey's coastal plain.

Much of New Jersey's clean water flows from pristine corners of the state. Relatively untouched areas like the Highlands and the Pinelands are home to the headwaters of hundreds of brooks and streams that fill aquifers and reservoirs across the state and eventually supply New Jersey homes and businesses with valuable water. Pristine rivers also provide recreational opportunities and critical wildlife habitat. For example, over 14 million people visit the Highlands ever year for recreation. Families use rivers and their surroundings for canoeing, fishing, and hiking. Places like the Highlands are home to over 247 threatened and endangered species, in addition to providing an important waypoint for migrating birds.[2]

Unfortunately, many of New Jersey's most pristine waterways are becoming polluted. They face contamination from rapidly expanding development. According to an analysis of New Jersey's growth patterns by the Rutgers Center for Remote Sensing and Spatial Analysis, New Jersey could run out of developable land within the next 30 to 50 years if recent trends continue.[3] The state's population has grown by 2.4 million in the last four decades, and the U.S. Census and state planners predict that New Jersey's population will increase by close to one million people in the next 20 years. As a result, the U.S. Environmental Protection Agency classifies nearly all of New Jersey's watersheds as highly vulnerable to further degradation.[4]

Projects like Milligan Farms in Hunterdon County exemplify this threat. K. Hovnanian Co., the state's largest developer, is working to build a 292-home subdivision near Sidney Brook in Union Township. Their project would require a new sewage treatment plant that would discharge 88,000 gallons of treated sewage into the Sidney Brook every day. The state Department of Environmental Protection recognizes this waterway as home to the threatened bog turtle and wood turtle, as well as brook trout, which only live in the cleanest water.[5]

In the face of this rapid growth, New Jersey faces the challenge of accommodating new residents while preserving the natural resources that make New Jersey a great place to live, including clean drinking water supplies. The state must protect the water resources it already has while working to clean up waters that have been degraded.

Scientists have shown that key parts of waterways need special protection, including stream corridors, floodplains, and wetlands. These areas filter out pollutants, minimize flooding, and recharge underground water supplies. Headwater streams provide a continuous flow of clean water and the natural landscapes which surround them slow down and absorb stormwater.[6]

The McGreevey administration has launched a smart growth agenda to meet these challenges. In addition to extending new powers to municipal governments to manage growth within their borders, the administration has consistently made clean water a priority. One of the many tools available to the administration is the anti-degradation provision of the Clean Water Act. Waterways given the highest level of protection under this law are protected from any changes that would measurably harm water quality, including additional sewage discharge, runoff pollution, and shrinking buffer zones. On Earth Day 2002, the administration proposed nine reservoirs and six streams for protection un-

der this provision, known as Category One designation. In March 2003, the governor announced a comprehensive statewide list of waterways currently under consideration for increased protection.

Because New Jersey's pristine waterways are so important—for drinking, recreation, and wildlife habitat—the administration should protect as many of them as possible while they still remain clean. The administration should implement the Clean Water Act to ensure that stream corridors, wetlands, and flood plains remain in their natural state. The outcome of these efforts will play a major role in determining which way New Jersey is going to grow—toward intelligent growth and healthy waterways supporting high quality of life in the state, or toward the gradual pollution of the last clean waterways in the state by overdevelopment.

The Connection Between Land Use and Water Pollution

Human use of land affects water quality in New Jersey more than any other factor.[7] A range of activities cause water pollution, from pesticide application on agricultural land to sewage discharge from residential developments.

Over the past several decades, urban development in New Jersey has grown dramatically. Steady development has transformed farms, wetlands, and forests into residential and commercial areas. According to the Rutgers Center for Remote Sensing and Spatial Analysis, New Jersey added 144,000 acres of urban area from 1986 to 1995. At this rate, New Jersey builders develop 26 acres of farmland, cut back 12 acres of forests, and fill 7 acres of wetlands every day.[8] In simpler terms, new developments claim 33 football fields of land daily.

Pristine parts of the state have been steadily infiltrated by new developments spilling outward, driven by new and expanded roads and sprawl-inducing zoning policies. As this development expands into previously undeveloped areas, New Jersey's pristine waterways—those that supply clean drinking water, recreational opportunities, and wildlife habitat—are facing increased pollution.

The connection between development and water pollution is intuitively easy to understand. New development brings increasing water use, growing discharge from sewage treatment plants, and higher levels of runoff from roads, rooftops, and other man-made surfaces. These changes deliver more sediment, organic nutrients, pesticides, and other chemicals to rivers and lakes.

Major Factors in Declining Stream Quality[9]

- Increased human activity and chemical use.
- Increased paved surface.
- Increased runoff and increased variability of stream flow.
- Decreased forests and wetlands.

Development Near Rivers Harms Water Quality

Encroaching development increases the amount of runoff and treated sewage reaching waterways, making water less sanitary and less able to support a full range of life. Development that shrinks or bypasses the natural buffer zone surrounding a river has the strongest impact on water quality. Buffer zones act to filter water before it reaches the river, removing sediments and chemicals that can kill fish, cause algae overgrowth, and make water less suitable for drinking.[10]

Impervious Surface and Runoff

Rainfall and snowmelt travel across all types of land on the way to surface streams or underground aquifers. On the way, this runoff picks up a variety of pollutants. Soil, fertilizer, and pesticides travel from farmland, lawns, and construction sites. Fragments of tires, shreds of brake lining, salt, and oil contaminate runoff from roads. Even pollution from industry smokestacks and car and truck exhaust pipes fall back to the ground through snow and rain. All of these pollutants eventually end up in streams, rivers, and lakes.

Developing land causes increased runoff. The process of building a home or a commercial facility replaces porous soils and plant life with impervious surfaces like concrete sidewalks and driveways, asphalt roads and parking lots, and rooftops. Instead of flowing into the ground to recharge underground aquifers, water flows off rooftops and along gutters. High volumes of this runoff quickly reach nearby lakes, rivers, and streams, either directly or through a storm sewer outfall.[11]

Impervious Surface: The Facts

- Automobile dependent development patterns in New Jersey have increased the amount of pavement needed to serve new developments, especially in "sprawl" areas in the suburbs.
- Replacing a meadow with a parking lot increases runoff by about 16 times.[12]
- A typical suburban development with 23% impervious cover diverts over 40 million gallons of water per square mile away from underground aquifers annually.[13]
- Covering as little as 5% of a watershed with concrete and rooftops causes observable stream degradation. More severe problems begin above 10% impervious surface cover, with very severe problems above 25% impervious cover.[14]
- Highly developed areas in New Jersey have more impervious surface area and worse water quality than less developed areas.

Mark Rauschkolb

Union Township, Hunterdon County, August 13, 2001—After a 1.1 inch rainstorm, stormwater runoff carried pollution from a housing development built by Toll Brothers into the headwaters of Mulhockaway Creek and Spruce Run Reservoir. The reservoir hosts a drinking water intake for the New Jersey Water Supply Authority.[15]

Treated Sewage Discharge and Failing Septic Systems

Every development needs either a septic system or sewage line to dispose of waste water and feces. These systems can have severe impacts on water quality. Treated sewage discharge from sewage treatment plants serving commercial and residential developments adds phosphorous and nitrogen compounds and industrial pollutants to waterways. Organic pollutants can also leak from failing septic systems and contaminate groundwater.

The federal Clean Water Act passed in 1972 required sewage treatment plants to improve their technology. As a result, these plants are now able to remove at least 85% of the solids and oxygen-depleting pollutants in sewage.[16]

However, despite these improvements, treated sewage discharges remain a problem. In fact, treated sewage makes up most of the flow in some rivers in heavily developed areas. For example, there are over 50 sewage treatment plants on the Passaic River.[17] On an average day, over half of the flow of the Passaic River is sewage discharge at the Passaic Valley Water Commission public drinking water intake, with even higher levels during drought conditions.[18]

Trout Unlimited, Naugatuck Valley Chapter

A sewage treatment plant on the Naugatuck River in Connecticut.

Septic systems can cause problems for groundwater quality. In areas where centralized sewage treatment is not available, household wastewater from toilets, garbage disposals, and sinks is treated in a septic system and discharged into the ground or held for transfer to a treatment plant. Without proper maintenance, septic systems can fail and release harmful bacteria and nutrients into the groundwater, or through surface spills. The U.S. Census estimated that 40% of new housing built between 1996 and 2000 had on-site septic systems, and the U.S. EPA estimates that 10% of all septic systems malfunction during a given year.[19]

Negative Effects on Water Quality

Increasing runoff and sewage discharge damage water quality by increasing pollution levels, increasing the variability of stream flow, and reducing the ability of a stream to support a full and healthy range of aquatic life.

Increased Pollution

Runoff and sewage discharge contain a variety of harmful pollutants, including organic nutrients, bacteria, atmospheric pollution, road particulates, oil, pesticides, and pharmaceutical drugs.

Nutrients like phosphorus, nitrate and related organic compounds come from fertilizer runoff and feces. Human activity can disrupt the natural balance of these nutrients in waterways, promoting excessive growth of harmful aquatic vegetation like algae. As this vegetation dies and decays, it consumes oxygen from the water, which contributes to the death of local species of aquatic plants and fish. This process is known as eutrophication, and it makes waterways less able to support activities like fishing, recreation, industry, and human consumption.[20]

High levels of nitrates in drinking water can cause blue baby syndrome in infants under six months of age. Nitrates can reduce the ability of an infant's blood to carry oxygen to cells, which can be life-threatening in extreme cases. The U.S. EPA has set a 10 milligram per liter limit on the nitrate content of drinking water.[21]

Runoff picks up a variety of additional pollutants through atmospheric deposition of the combustion byproducts of fossil fuels, by passing over areas where chemical pesticides have been used, and by gathering up oil, salt, sediment, and bits of rubber from roadways. Some of these chemicals are toxic to living organisms, from the pesticides used on agricultural fields to the volatile organic compounds that come from automobile exhaust pipes. They can make waterways unsafe to drink and reduce their ability to support a healthy range of life.

Sewage discharge can contaminate waterways with fecal bacteria from human waste. These bacteria, if ingested, can cause sicknesses like gastroenteritis in humans. Bacterial contamination can make rivers, lakes, and the ocean unsafe for swimming, as well as contaminating shellfish beds in harbors and estuaries. Even relatively small areas of urban development can produce high levels of bacteria that cause authorities to close coastal shellfish waters.[22]

Drinking water treatment plants often use chlorine to kill the bacteria in the water before pumping it into homes and businesses. While this step protects the public from bacterial infections, chlorine treatment can produce byproducts when it reacts with organic pollutants and sediments that are also in the water. These chlorinated byproducts, such as trihalomethanes and haloacetic acids, are suspected to contribute to birth defects, miscarriages, and cancer.[23]

Sewage discharge can also contain chemicals from personal care products, antibiotics, and pharmaceutical drugs that are used in the home or pass through the human body. In 2002, the U.S. Geological Survey released a study showing that urban streams contain a variety of chemical pollutants, including caffeine, birth control hormones, pain medications, insect repellent, perfumes, and blood pressure medications.[24] Nationally, they found 22 different antibiotics, 14 prescription drugs, 11 reproductive hormones, seven plasticizing chemicals, seven insecticides, five non-prescription drugs, five detergents, four steroid-type compounds, and an insect repellent. Four waterways in New Jersey—the Assunpink Creek near Trenton, the Whippany River in Morris County, the Singac River in Passaic County, and the Hohokus River in Bergen County—contained chemicals like acetaminophen, caffeine, antacids, nicotine metabolites, and drugs to treat angina and hypertension. More recently, scientists at the New Jersey Department of Environmental Protection and the Rutgers Environmental and Occupational Health Sciences Center found small amounts of a variety of industrial and household chemicals in drinking water systems, including the preservative BHT, fuel oil, drugs, and pesticides.[25]

Very little is known about the potential human health effects of low doses of pharmaceuti-

cally active compounds in mixtures. However, scientists suspect that hormone-like pollutants are interfering with reproductive development in wildlife, contributing to declining sperm counts and reduced fertility in humans, as well as potentially causing or promoting cancer and other diseases.[26]

Decreased Stability of Stream Flow

Runoff diverts water away from the underground aquifer and toward rivers, lakes and streams. As a result, it increases the amount of water reaching a waterway after a storm and disrupts the stability of stream flow. Reduced stability of stream flow leads to higher flood vulnerability in areas around a waterway, destabilizes the banks of the stream, and reduces the rate at which rainfall replenishes aquifers.

Increased runoff causes higher peak flows after storms and raises the elevation of the flood plain surrounding a river. After Hurricane Floyd dropped 11 inches of rain on the New Brunswick area in 1999, the Raritan River escaped its banks and inundated part of the city. Upstream, development had added more than 2,700 acres of impervious surface (an 18.8% increase) in the previous 15 years.[27] The extra water diverted into the Raritan River by this development undoubtedly made the flooding damage in New Brunswick more extensive. A recent analysis by The Record newspaper showed that 11,000 homes were added in floodplains across the state since the 1980s, raising concerns that future floods will be more damaging.[28]

Greater variability in stream flow causes stream channels to erode and banks to destabilize, increasing the amount of sediment in the water.[29] These changes disrupt habitat for aquatic organisms, making the streams less able to support a full and healthy range of aquatic life.

Runoff diverts water from the aquifer and into surface waters. As a result, less rainfall makes it back into the ground to replenish the water pumped out for human use. The water supply in South Jersey comes mainly from underground aquifers. Reducing the rate at which they recharge limits the water supply for the region.

Ecological Integrity: A Measure of Water Body Impairment

The New Jersey Department of Environmental Protection (DEP) monitors stream quality by tracking changes in communities of insects and other small organisms at over 700 sites across the state. This program, known as the Ambient Biomonitoring Network (AMNET), provides a set of information DEP uses to decide which rivers and streams are impaired. Streams that are in their natural condition and not subject to runoff or pollutant discharge almost always have healthy communities with a wide variety of insect species. Because some of these species are less tolerant of pollution and habitat degradation, polluted rivers have fewer sensitive types of organisms and a narrower range of species. DEP monitors these sites every five years to keep an eye on long-term environmental changes.

Based on the types of insects found, DEP assigns an impairment score to each site, ranging from 0 (completely degraded) to 30 (unimpaired).[32] The DEP makes the results available to the public, forming the basis of this report.

Decreased Diversity of Aquatic Life

Water quality degradation can be measured by the response of aquatic organisms living in a river or stream. Increased pollution and degraded habitat will tend to weed out the sensitive species and lead to a shift toward more pollution-tolerant insects and aquatic weeds.

Waterways in New Jersey surrounded by urban areas and with high levels of treated sewage discharge tend to have an impaired aquatic community, with a narrow range of pollution-tolerant species.[30] Waterways fed by land with a large amount of forest and wetlands are more likely to have a full and healthy aquatic community. Forests and wetlands help to maintain a healthy supply of water, food, and habitat for sensitive species, as well as providing a buffer from human activities that can affect water quality.[31]

Development and Water Quality Degradation Across New Jersey

Spanning the distance between two of America's largest cities, New Jersey is experiencing rapid population growth. As a result, nearly every town in the state has felt pressure to build new homes and commercial areas to serve new residents and people moving away from struggling urban areas. During the period between 1986 and 1995, this new development replaced 144,000 acres of farmland, forests, and wetlands, claiming 2.8% of New Jersey's overall area.[33]

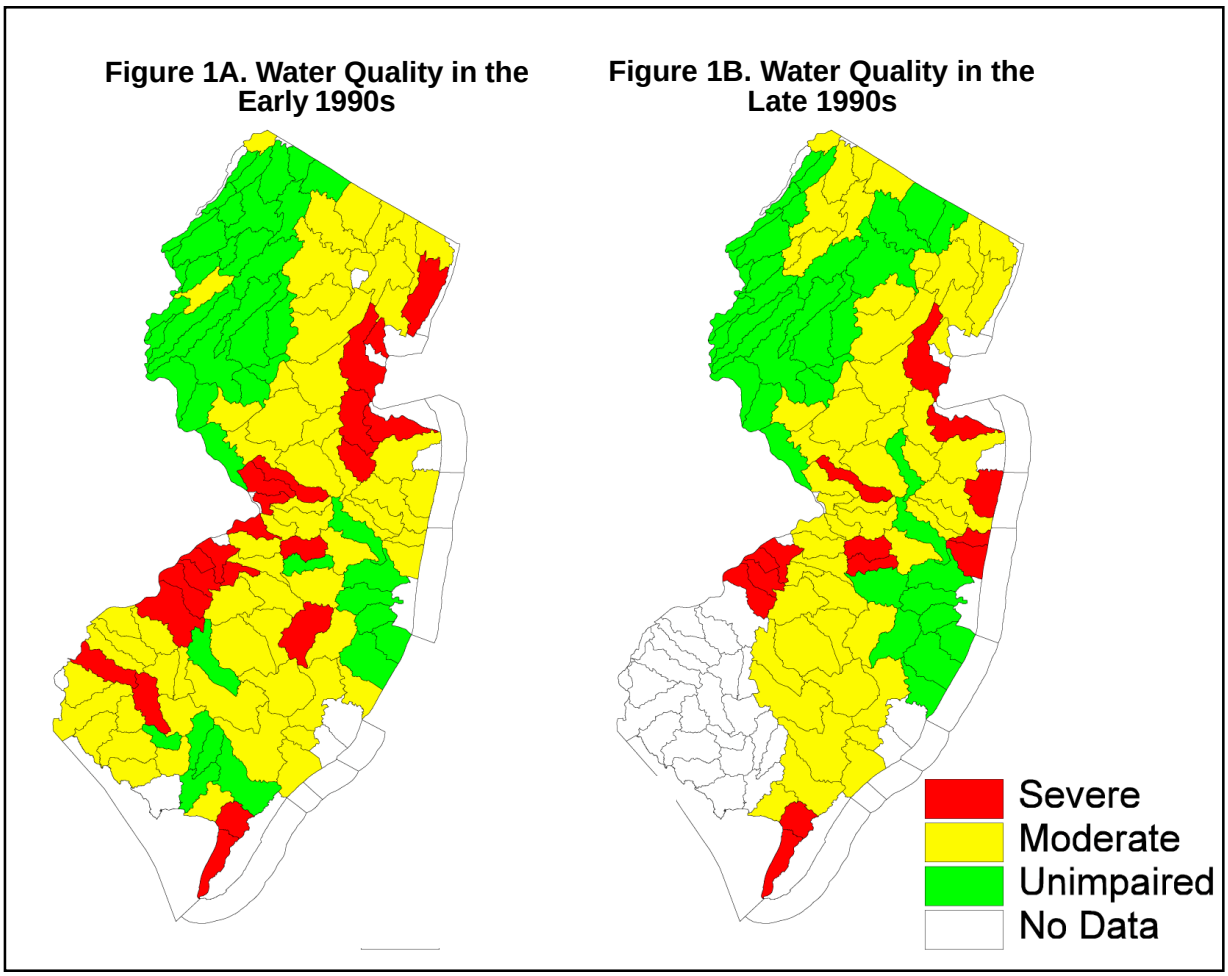
Unfortunately, these changing land use patterns are encroaching upon the relatively pristine parts of New Jersey, the corners of the state that supply clean drinking water for millions of people and provide habitat for threatened and endangered wildlife. According to a U.S. Geological Survey study of the New Jersey and Long Island area, urban growth in the late '80s and early '90s was tied to declining water quality.[34] During the 1990s, water quality in New Jersey declined at the fringes of growth due to the negative impact of poor land-use practices.

Water Quality Declined at the Fringes of Growth

Water quality declined in 35% of watersheds measured by the New Jersey Department of Environmental Protection (DEP) during the 1990s (Figure 1). These watersheds were generally located in the Northwest, Central, and Atlantic coast areas of the state—areas of high growth with fair to moderate, and

Figure 1A. Water Quality in the Early 1990s

Figure 1B. Water Quality in the Late 1990s



thus vulnerable, water quality, near the fringes of the state's sprawl corridor (Figure 2).[35]

The rivers showing water quality decline include:

- The Wallkill River, the Pequest River, the Musconetcong River, and Papakating Creek in Northwest New Jersey.
- The Middle Passaic River in northeast New Jersey.
- Lockatcong Creek, Lawrence Brook, and the Neshanic and Millstone Rivers in Central New Jersey.
- The Navesink, Shark, Manasquan, Metedeconk, Upper Great Egg Harbor, and Toms Rivers along the Atlantic Coast.
- Rancocas Creek on the Lower Delaware River.

The connection between development and declining water quality is best illustrated by the cases of the Upper Toms River, Lawrence Brook and the Millstone River.

Lawrence Brook and the Millstone River flow through some of the most rapidly developing areas of the state. The land surrounding these rivers includes six of the top 20 municipalities with the most new development between 1986 and 1995, including West Windsor Township (Mercer County), Franklin Township (Somerset County), Manalapan Township, Millstone Township (Monmouth County), South Brunswick Township, and Monroe Township (Middlesex County). During this period, increasing urban area claimed 6.6% of the Lawrence Brook watershed and 7.5% of the Millstone River watershed, yielding water quality declines in both rivers of over 12%.

Figure 2A. Change in Water Quality, Early to Late 1990s

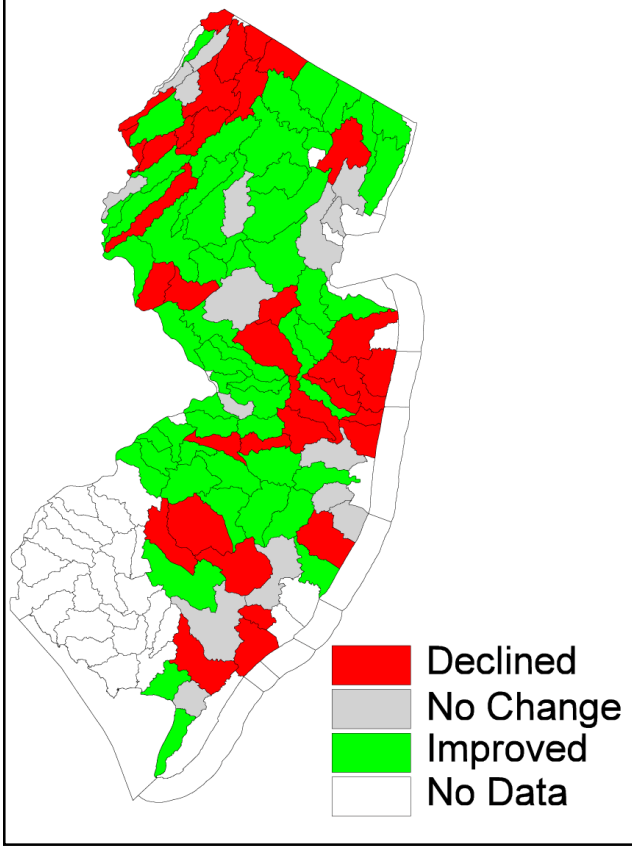


Figure 2B. Acres of New Development, 1986-1995

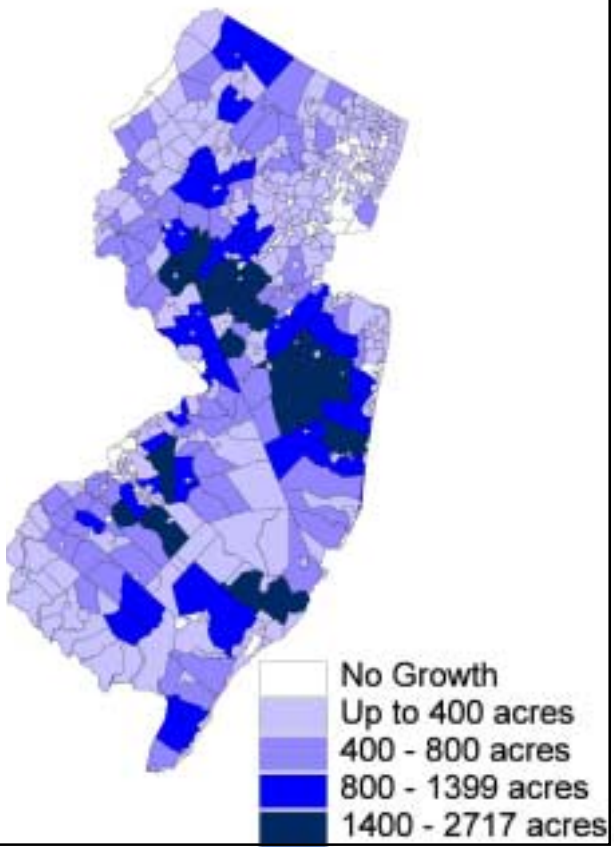


Table 1. Development and Water Quality Degradation in 12 Major New Jersey Watersheds[36]

River	% of Land Developed 1986-1995	Impervious Surface in Watershed	Water Quality Decline	Acres Developed 1986-1995	Acres of Impervious Surface	Testing Sites Showing Impairment	Sites with Severe Impairment
Shark River	4%	21%	14%	1,700	8,200	100%	43%
Lawrence Brook and Millstone River	7%	18%	12%	6,700	11,600	95%	20%
Metedeconk River	4%	12%	10%	1,600	6,000	82%	9%
Manasquan River	6%	10%	4%	3,100	5,600	77%	8%
Navesink River	6%	10%	3%	2,600	6,000	100%	20%
Great Egg Harbor River above Hospitality Brook	4%	8%	11%	1,900	3,550	58%	0%
Rancocas Creek, North Branch	3%	8%	29%	620	2,000	100%	40%
Toms River above Oak Ridge Pkwy	6%	5%	14%	2,200	1,900	40%	0%
Neshanic River	6%	4%	6%	2,100	1,200	85%	0%
Wallkill River and Papakating Creek	3%	4%	16%	2,600	3,100	80%	0%
Musconetcong River	4%	4%	6%	1,800	1,700	70%	0%
Pequest River and Bear Creek	2%	3%	11%	1,100	1,250	70%	0%

The Upper Toms River flows through Jackson and Dover Townships in Ocean County and Freehold Township in Monmouth County. Between 1986 and 1995, these townships each added over 1,700 acres of new development, ranking in the top 13 most rapidly developing areas of the state. This development claimed 6% of the Toms River watershed area, yielding a water quality decline of 14%. Results for additional watersheds are listed in Table 1.

Recent negative impacts of development on water quality overlay water quality improvements driven by stronger clean water laws passed during the last three decades. Thanks to the federal Clean Water Act of 1972, New Jersey sewage treatment plants have been required to upgrade technology, resulting in cleaner discharge. State laws like the Clean Water Enforcement Act of 1990 enforced mandatory penalties for permit violations, resulting in less discharge. These laws are likely responsible for the improving conditions in the most densely urban parts of the state.

Development Patterns

The heaviest locations for development extended around the Camden area toward Atlantic City, and from the northern end of the Jersey Shore, through Central Jersey and up toward Sussex County. Between 1986 and 1995, some townships developed more than 10% of their land area, including Washington Township in Gloucester County, West Windsor Township in Mercer County, and Mount Laurel Township in Burlington County (Table 2).

A lack of coordinated land use planning characterized much of this growth. A recent study of the New Jersey and New York coastal areas by the Natural Resources Defense Council found poor land-use planning at all levels of government. For example, state and federal agencies approved more than 98% of development projects subject

to wetland permits in the years 1995-1997, making the permit process little more than a formality.[37] Dover Township and Mount Laurel Township each issued building permits for more than 5,000 residential homes and apartments from 1986 to 1995.

Increasing Impervious Surface Coverage

Although water quality changes from development are subtle, they are progressive and extremely difficult to reverse. The overall trend can be seen in the relationship between the water quality within each watershed and the amount of impervious surface (Figure 3). Increased impervious surface within a watershed results in more nutrient pollution, more sedimentation, and a river less able to support a healthy range of aquatic life.

Figure 3A. Total Impervious Surface Cover, 1995

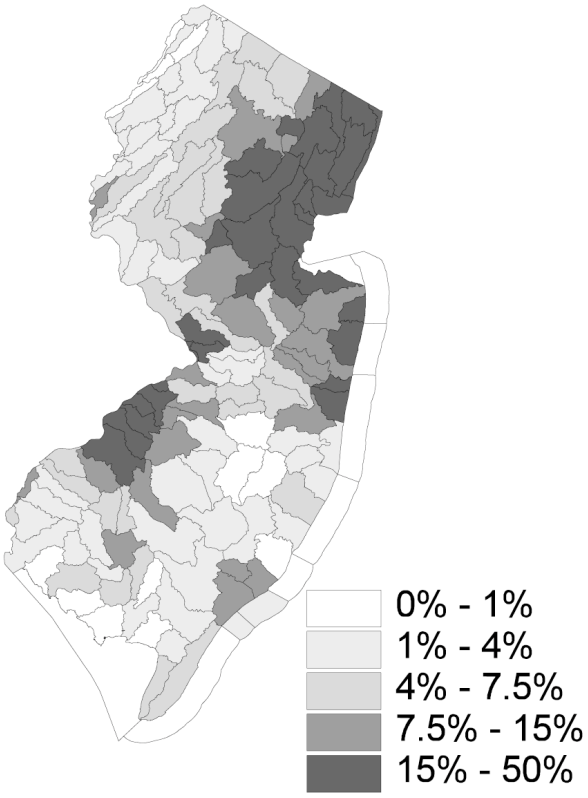
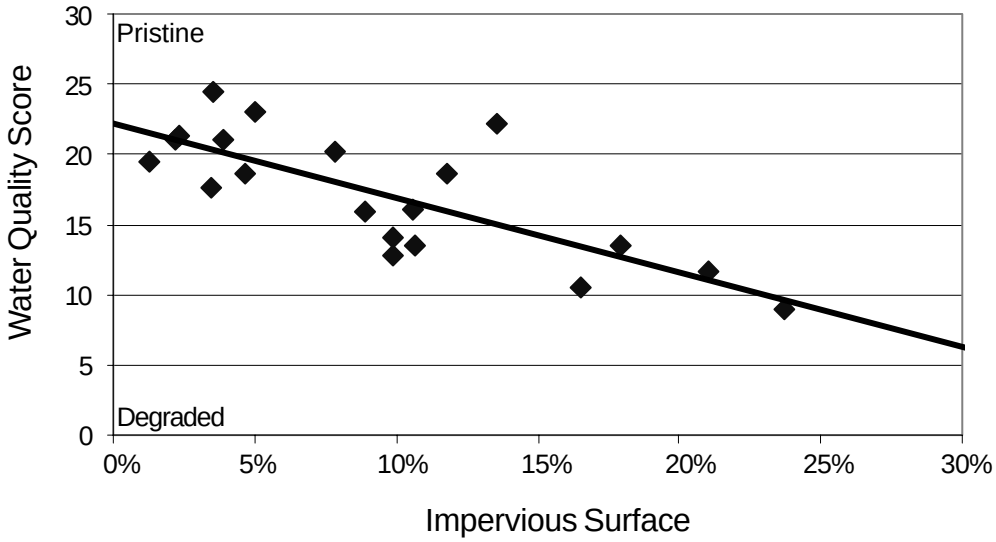


Figure 3B. Water Quality and Impervious Surface in Watersheds with Declining Water Quality[39]



Recent Urban Expansion

Building permit data shows that development activity continues to be heavy in Central New Jersey and especially southward along the Jersey Shore (Figure 4). Dover, Manchester, and Jackson Townships in Ocean County, Monroe Township in Gloucester County, South Brunswick Township in Middlesex County, and Marlboro Township in Monmouth County each issued more than 2,000 building permits for residential homes and apartments between 1996 and 2001. Rivers in these areas are at risk for further water quality declines.

In addition, the attractiveness of the Highlands area is making it the target of new projects. The opening of Interstate 287 and the expansion of Route 15 to three lanes are making this area more accessible and increasing the pressure to develop available land.

Figure 4. Permits Issued for Single-Family Homes and Apartments, 1996-2001[40]

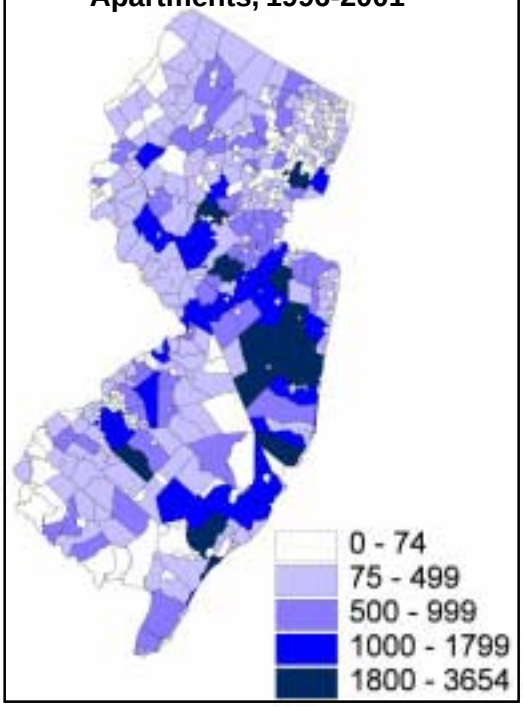


Table 2. Top 20 Townships with Fastest Rate of Development (1986-1995)[38]

Township	County	Acres of New Development	% Area Developed	Permits Issued
West Windsor	Mercer	2,717	16%	2,614
Raritan	Hunterdon	2,266	9%	1,807
Readington	Hunterdon	2,176	7%	1,592
Washington	Gloucester	2,071	15%	1,399
Mount Laurel	Burlington	2,032	14%	5,868
Jackson	Ocean	1,975	3%	3,347
Franklin	Somerset	1,905	6%	1,962
Manalapan	Monmouth	1,878	10%	2,486
Millstone	Monmouth	1,782	8%	1,042
Dover	Ocean	1,782	5%	5,238
S. Brunswick	Middlesex	1,773	7%	4,855
Montgomery	Somerset	1,773	9%	2,716
Freehold	Monmouth	1,706	7%	1,592
Hillsborough	Somerset	1,704	5%	2,280
Howell	Monmouth	1,690	4%	2,845
Galloway	Atlantic	1,605	2%	4,009
Evesham	Burlington	1,483	8%	2,286
Winslow	Camden	1,440	3%	2,895
Bridgewater	Somerset	1,399	7%	3,367
Monroe	Middlesex	1,394	5%	3,604

New Jersey's Top Waterways to Save

Many of New Jersey's most pristine waterways face the risk of contamination from rapidly expanding development. These waterways provide clean drinking water for millions of New Jersey citizens, replenish the state's groundwater supplies, provide ecologically critical habitat for threatened and endangered species, and represent regionally important recreational opportunities.

Over four million New Jerseyans rely on surface water for drinking supply. Public water companies draw water from 54 different surface water intakes, many located on reservoirs in North Jersey.[41] In 1995, these companies withdrew over 272 million gallons of drinking water from rivers and reservoirs, 58% of the statewide total.[42] More than four million additional New Jerseyans rely on underground aquifers for their water, including the Kirkwood-Cohansey aquifer system under New Jersey's coastal plain. In 1995, public water companies withdrew over 195 million gallons of water from wells drilled into these underground storage systems.[43]

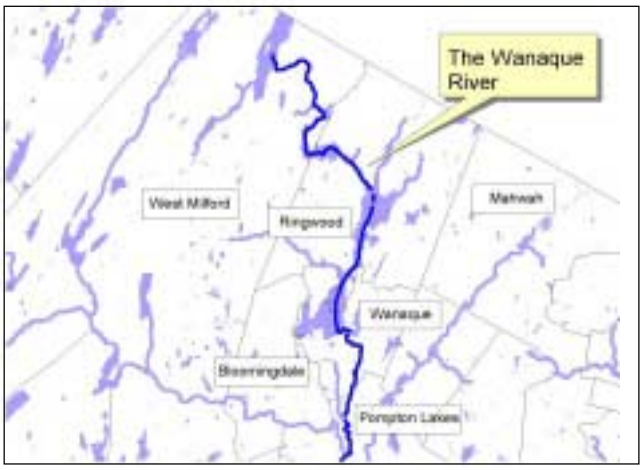
Both of these water sources are highly vulnerable to contamination. The U.S. Environmental Protection Agency classifies almost all of New Jersey's watersheds as highly vulnerable to further degradation.[44]

Clean water for Northern New Jersey comes from the forested expanse of the New Jersey Highlands. Every year 14 million people visit the Highlands to hike, canoe on 500 miles of pristine rivers, and observe wildlife including 247 threatened and endangered species.[45] According to a recent report by the United States Forest Service, over 100,000 acres of critical lands in this region are in immediate danger from development.[46] Clean water for Southern New Jersey comes from areas like the Pinelands Preservation Area, whose streams flow slowly over the coastal plain and recharge underground aquifer systems. The Pinelands are home to over 223 threatened and endangered species, including the bald eagle.[47] Because the aquifers in this region are close to the surface, they are especially vulnerable to contamination.[48]

Municipalities across the state are facing one development proposal after another. Large and powerful developers have been pressing these projects forward using a variety of tactics.[49] In some cases, local governments and citizens groups have been able to prevent inappropriate projects from moving forward, but some projects that would damage water quality in pristine rivers have been built. More projects that threaten New Jersey's clean water are proposed every day.

New Jersey's precious but threatened waterways are critically important for the health of the people of the state as the state's drinking water supply, for the tourism and fishing industries, and for the abundant wildlife they support. Recognizing their value, the New Jersey Department of Environmental Protection released a list of waterways nominated for increased protection from the threat of development under the federal Clean Water Act on March 11, 2003.[50] The Department selected major drinking water reservoirs and their tributaries, headwaters of rivers that drain to public drinking water supply intakes with less than 10% impervious cover, waters with exceptional ecological value, and waters in open space areas.[51]

Here we highlight some of the major waterways in the state threatened by expanding development. Their protection should be a priority.



Passaic and Hackensack River Basins

The Wanaque River

The Wanaque River feeds the Wanaque Reservoir and provides drinking water for residents of Northeast New Jersey, including areas of Essex, Passaic, and Hudson counties. In April 2002, Governor McGreevey announced strengthened protection for Wanaque Reservoir under the Clean Water Act because of its exceptional significance as a drinking water source.[52] The Wanaque River corridor is home to threatened and endangered species, including the bog turtle, the wood turtle, the red-shouldered hawk, and the barred owl. Much of the land in this watershed is covered with lush forests. However, residential development clusters along the edge of waterways, especially around the Wanaque Reservoir and Lake Inez.

Water quality in the Wanaque River is threatened by increasing development pressure. For example, Pulte Lifestyle Communities, Inc. is moving to build up to 4,000 homes and a nine-hole golf course on 440 acres in Powder Hollow, just opposite the Wanaque Reservoir dam.[53] In March of 2000, the Borough of Wanaque rezoned their largest tract of open space to accommodate this project. While the Wanaque Planning Board has given final approval for the construction of 1,190 homes, the DEP has not granted approval for expanded sewage capacity. However, the DEP has granted preliminary approval for 755 units at the site. Additional projects proposed or under construction include Roaring Brook in West Milford and West Brook Hills in Ringwood, which will impact West Brook and Meadow Brook, tributaries of the Wanaque Reservoir.[54] Bloomingdale has also proposed rezoning 105 acres to accommodate a high-density housing development on an environmentally sensitive site draining to the lower Wanaque.[55] Projects like these will increase runoff and sewage discharge into the river, harming water quality.

The lower stretch of the Wanaque River below the reservoir needs protection from these threats. In addition, the streams and brooks which supply water to the protected reservoir deserve protection, including parts of Cupsaw Brook, Erskine Brook, Posts Brook, Belchers Creek, Mine Brook, and Blue Mine Brook. The New Jersey DEP has nominated parts of these waterways for increased protection under the Clean Water Act because they are a public drinking water supply and their watersheds have less than 10% impervious surface.[56]


Pierre Jaborska

The Ramapo River[57]

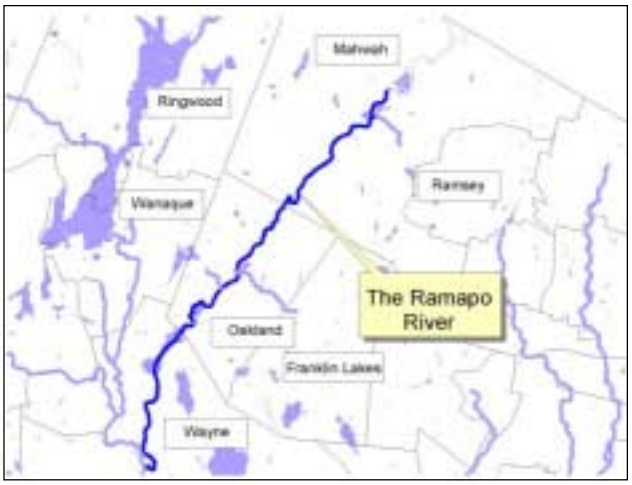
The Ramapo River is a source of drinking water for two million residents of New York and New Jersey. It flows through the majestic Ramapo Mountains, with beautiful scenery, wild expanses of forest, and critically important wildlife habitat in areas like the Torne Valley, the Sterling Forest, and the Tuxedo Reserve. It is home to rare species that require pristine water quality for survival, potentially including the Eastern Lamp Mussel, which may be listed by the state as a threatened species.[58] From the state line, it extends 15 miles until it joins the Pequannock River in Wayne Township.

Development pressure is the main threat to water quality in this relatively pristine river. In 1995, most of the developed areas in the watershed were located on the east side of the river.[59] The construction of I-287 has significantly increased the accessibility of this area and increased the pace of development.

Oakland Environmental Commission

Nearly 4% of the land area was developed between 1986 and 1995, leading the New Jersey Department of Environmental Protection to note in 1996 that "new development is extensive in many areas of the watershed," resulting in "both a loss of habitat for biota and an apparent decline in water quality."[60] Now, development is beginning to spread across to the western side.

The construction of the Ramapo Reserve development, the first on the western bank of the river, exemplifies the threat facing the region. Baker Residential Co. built 400 townhomes on 300 acres of ledges blasted



into the Ramapo Mountains above the Ramapo River in Oakland. This area used to be a Boy Scout camp called Camp Todd. There was a trail down the mountain from Todd Pond to the Ramapo River, following a stream with waterfalls, pools, deep shade, and trout. Now the stream flows through a pipe under the development.[61] Because the homes were built on steep slopes, runoff pours down into the Ramapo River. In 1999, disturbed soil picked up by runoff from a rainstorm caused a damaging mudslide in this area. The project earned the Sierra Club's "Worst Development" title in 2000.[62]

Other projects in the area include proposals to build 1,300 housing units on 2,200 acres in Sterling Forest, a stone quarry on 500 acres along Torne Brook, two gas-fired power plants along the Ramapo River in the Torne Valley, and another large housing development on 2,000 acres in the Tuxedo Reserve.[63] Another recently proposed development would add 90 homes to the top of a mountain just north of Ramapo Reserve.

The entire length of the Ramapo is threatened and needs increased protection from water quality degradation. The New Jersey DEP has nominated parts of this waterway for increased protection under the Clean Water Act because it is a public drinking water supply and its headwaters have less than 10% impervious surface.[64]

The Farny Highlands[65]

The Farny Highlands in northern Morris County is a regionally important recreational area, where people go to enjoy fishing, hiking, and viewing wildlife. The area also forms the headwaters of five rivers and contains over 150 different waterways. The Farny Highlands surrounds the Boonton and Split Rock Reservoir system which supplies drinking water to 300,000 people in Jersey City, Hoboken, West Caldwell, and Lyndhurst.

The main threat to water quality in the region is overdevelopment. According to a regional study of the New York and New Jersey Highlands conducted by the U.S. Forest Service, the Highlands region loses more than 5,000 acres a year to development. The study identified 100,000 acres of sensitive and vulnerable lands in this area, including Sparta Mountain in the Farny Highlands.[66]

Threatened Drinking Water Reservoirs in the Passaic and Hackensack River Basin

- Lake Tappan Reservoir – A drinking water source for Northern Bergen County, this reservoir is facing increasing development pressure around its shores. Gov. McGreevey announced in March 2003 that Lake Tappan and Woodcliffe Lake and their tributaries would be proposed for increased protection under the Clean Water Act.[76]
- Point View Reservoir in Wayne
- Canistear Reservoir (Vernon/ Hardyston)
- Echo Lake (West Milford)
- Oak Ridge Reservoir (Jefferson/West Milford)
- Clinton Reservoir (West Milford)

Several recent development efforts exemplify the pressure facing this area:

- In 1997 the Denville Council was considering rezoning 435 acres of former Jersey City watershed land in the Beaver Brook watershed to accommodate a housing developer.[67]
- The Green Acres program was not able to purchase all of an 879-acre property near Buck Mountain in Kinnelon. This area was slated for 2,000 homes and a golf course. After the Green Acres purchase, 256 acres remained for the housing development.[68]
- On the east side of the Farny Highlands, the Department of the Army owns 6,000 acres of land called the Picatinny Arsenal. The site is mostly forested. However, the U.S. Fish and Wildlife Service reported in 1997 that the arsenal may be phased out and sold in the near future.[69]

Although the state has used the Green Acres program to protect some sensitive lands in this area, other lands remain unprotected, including the Beaver Brook Greenway, the Waughaw Mountain Greenway, Mase Mountain, the Buck Mountain corridor, and the Stony Brook extension of Pyramid Mountain. Many rivers in this area are tributaries to the Rockaway River and deserve additional defense from potential development threats. These rivers include Timber Brook, Stony Brook, and Beaver Brook, as well as waterways near the border between Sussex and Passaic County like Holland Brook and Russia Brook.


New Jersey Sierra Club

The Split Rock Reservoir and Farny State Park in Morris County

New Jersey Sierra Club

The Pequannock River and its Tributaries[70]

The Pequannock River is a beautiful stretch of water that begins in Sussex County and flows east, delineating the Morris/Passaic County line. It is a favorite for fishing because of its abundant trout, and the area surrounding it draws hikers from across the region. It passes through verdant forests and mountains in the New Jersey Highlands area. The river supplies drinking water to hundreds of thousands of New Jersey citizens in Newark and surrounding communities. The watershed is home to a variety of rare, threatened, and endangered wildlife, including bobcat, barred owl, red-shouldered hawk, bog turtle, and the timber rattlesnake.[71]

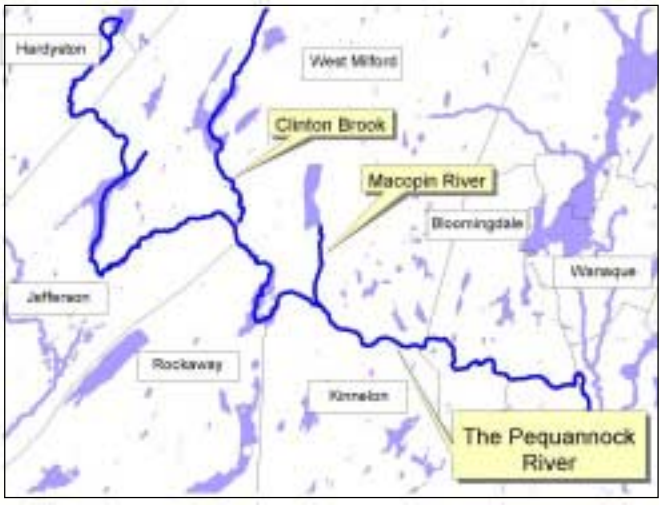
The Pequannock River and its tributaries are threatened by runoff and sewage discharges from continued sprawling development along its tributaries. Pending projects in the area include a strip mall on the Pequannock River in Riverdale, a high density housing project in Kinnelon's Weber Tract, and a Ramapo Reserve-style development on Federal Hill in Bloomingdale.

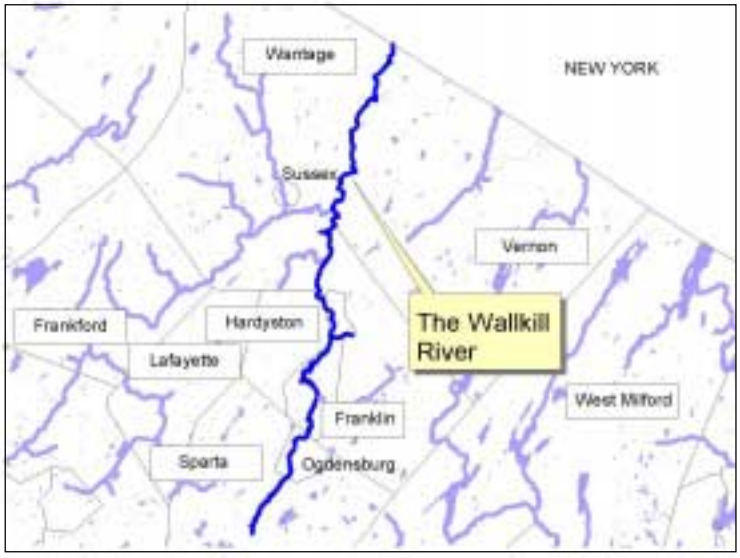
The proposed strip mall in Riverdale would be located 50 feet from the banks of the Pequannock River, and would replace a 278-year-old farm estate. Plans for the site include construction of a 48,000-square-foot concrete building and a paved parking lot large enough to hold over 200 cars.[72]

In Kinnelon, a 164-acre plot of land known as the Weber Tract has been rezoned for the construction of 150 units of high-density housing. Development in this site would affect a tributary of the Pequannock that runs through the property. The Weber Tract has steep, heavily wooded slopes that descend to the river, and is prone to elevated runoff and high erosion when disturbed by construction. The same level of development at nearby "Kinnelon Ridge" caused large amounts of sediment and mud to flow into the Pequannock.[73]

A company called Bloomingdale Joint Venture is trying to win approval to sell property to another developer, Baker Residential, to build a Ramapo Reserve-style development on Federal Hill in Bloomingdale.[74] Federal Hill is one of the last large tracts of undeveloped land in the lower Pequannock watershed. Several Pequannock tributaries begin here. The area is designated as an environmentally sensitive area in the State Plan. Baker Residential proposed building 360 townhouses on this site, on steep slopes. Runoff would be certain to degrade water quality in the Pequannock if the project moves forward.[75]

Other proposed developments have regularly targeted 35,000 acres of Newark watershed lands in the Pequannock watershed. The extension of I-287 through this area has increased both the accessibility of these areas and the pressure to develop them.





The Wallkill River and the Vernon Valley

The Wallkill River flows into the Wallkill National Wildlife Refuge, a region nationally recognized for its diverse plant and animal life. It is also a favorite of river runners, who bring their canoes to paddle through lush meadows and old farmland between the mountains of the Highlands. The Appalachian Trail passes through this region. The river stretches 27 miles through primarily rural areas, providing groundwater recharge and drinking water for 100,000 people in New Jersey and New York.[77]

Overdevelopment is the primary threat to water quality in the area. The stresses on the rocky Wallkill River start immediately with sewage plants and encroaching development in Sussex County, driven by increased accessibility with the widening of Route 15. The Wallkill River and nearby Vernon Valley have been the target of many recent development proposals that would harm water quality, including a proposed resort on Hamburg Mountain.

In July 2000, Intrawest Corporation, an international developer, announced plans for a resort in the forests and valleys of Hamburg Mountain above the Vernon Valley. The plans included 1,600 condominiums, three hotels, two golf courses, a conference center and a village of retail shops, restaurants and night clubs. This part of Hamburg Mountain forms the headwaters of both the Wallkill and Pequannock rivers, and is home to several threatened and endangered species.[78] Hamburg Mountain was originally a protected State Wildlife Management Area until the late 1980s, when the state Legislature sold it to a ski resort developer. Since then, Vernon Township has been approving a series of unsuccessful development schemes for the area.[79] Now, New Jersey is buying the tract back with Green Acres funding, but Intrawest is still planning development in the area. The corporation is now looking at Black Creek Valley at the base of Hamburg Mountain, where they have plans to build up to 1,000 new housing units, retail shopping, and a conference center.[80] In 1996, DEP officials described some of the tributaries to this river as being "devoid of aquatic life" mainly due to runoff from suburban and urban construction activities leading to sediment loading and stormwater contamination.[81]

In the 1990s, developers successfully pushed to expand the capacity of the Sussex Municipal sewage treatment plant several times, supporting capacity for tens of thousands of new residents to move into new de-

Walkill National Wildlife Refuge

New Paltz, NY Chamber of Commerce

velopments in the area. This treatment plant discharges millions of gallons of treated sewage per day into the Wallkill River.[82]

Stormwater runoff continues to be a problem in the area. Sparta recently approved a 120-unit development by Sparta Builders, LLC, which will divert surface runoff into a pipe underneath Marion Road and directly into the Wallkill River, or through a connection to the recently constructed town sewer system, which also empties wastewater into the Wallkill River.[83]

In 1987 and again in 1993, the DEP discussed providing greater protection against degradation for the Wallkill River, but never followed through.[84] On February 22, 1994, the DEP stated in the New Jersey Register that if significant progress in watershed management and planning was not made within six months, providing stronger protection under the Clean Water Act would be reconsidered. The watershed planning process is still under development today.[85] An additional reason to protect the Wallkill comes from a deal worked out between former New Jersey Governor Christine Todd Whitman and New York Governor George Pataki. According to this deal, New York will only protect the Ramapo River above New Jersey if New Jersey protects the Wallkill River south of the New York border.[86]

In addition to the Wallkill, several streams in the Vernon Valley, including Black Creek Brook, Pochuck Brook, Papakating Brook and Wawayanda Brook are at risk of water quality degradation from increased development. Because of their exceptional importance as drinking water sources, recreational areas, and wildlife habitat, they need to be protected. The U.S. Fish and Wildlife Service has recommended that the Wallkill and its tributaries be protected because of their ecological value, and the DEP has nominated parts of this river due to ecological significance and the relatively low amount of impervious surface around its headwaters.[87]

Upper Delaware River Basin

The Musconetcong River

The Musconetcong River flows out of New Jersey's largest spring-fed lake, Lake Hopatcong, then slices through a deep limestone river valley to meet the Delaware River at Riegelsville. Along the way, it passes state and county parks, bustling towns, and some of the most productive farmland in the state. The beauty of this valley draws visitors from across the region, and it has been proposed for federal "Wild and Scenic" recognition. In addition, the river provides drinking water to the residents of Hunterdon and Warren counties through two supply intakes near Lake Hopatcong, as well as refilling the underground aquifer.[88]

Unfortunately, the same fields used for farming present attractive areas for development, the main threat to the Musconetcong River. According to the Musconetcong Watershed Association, "the river is already showing the effects of increased runoff from roads, roofs, and parking lots in the form of streambank erosion and streambed scouring."[89] Of all the waterways in the Upper Delaware River Basin, the Musconetcong River, Pohatcong Creek and the Pequest River had the highest levels of nutrient pollution, sediment, and fecal coliform bacteria in a USGS study of the area from 1985 to 2001.[90]

According to the DEP 1996 305(b) water quality report, "The upper reaches of the Musconetcong are believed to be receiving increasing amounts of pollution as a result of area-wide suburban development." The lower reaches of the river face increasing levels of bacteria, silt, and runoff from roadways, while agricultural pollutants decline. In addition, Lake Hopatcong suffers from eutrophication linked to nutrient-laden runoff.

Although the Musconetcong River has been proposed for Wild and Scenic status, the river and its tributaries north of Hackettstown are vulnerable to further degradation from stormwater runoff and sewage discharges resulting from continued development in the area. Developer K. Hovnanian's efforts to build large projects in Lebanon, Bethlehem, and Union townships exemplify the pressure facing the region.

Developers have been eyeing Musconetcong Mountain in Hunterdon County as a potential site for future projects. Several years ago, K. Hovnanian Company began pushing a plan to construct 2,000 townhouses, condos, and single-family homes on farm land in a fertile river valley in Bethlehem Township. Hovnanian is one of the nation's largest developers, and a major contributor to political campaigns in the state.[91]

Musconetcong River Watershed Association

The Musconetcong River in Point Mountain Park.

Hovnanian is also advancing plans to build a development called Milligan Farms in Hunterdon County. The development would be a 292-home subdivision near Sidney Brook in Union Township. The project would require a new sewage treatment plant that would discharge 88,000 gallons of treated sewage into the Sidney Brook every day. The state Department of Environmental Protection recognizes this waterway as home to the threatened bog turtle and wood turtle, as well as brook trout, which only live in the cleanest water.[92]

The widening of Route 15 will increase the pressure to build developments like this near the headwaters of the Musconetcong. The full length of this river needs protection from further water quality decline. The U.S. Fish and Wildlife Service and the DEP Endangered and Nongame Species Prorgram nominated portions of this river and its tributaries for further protection based on its relative lack of impervious cover and its ecological value.[93]

Other Vulnerable Waterways in the Upper Delaware Area

- Lopatcong Creek
- Pohatcong Creek
- Paulinskill River, West Branch
- Rivers on the Hunterdon Plateau, including Alexauken Creek and Swan Creek
- The Delaware River above Washington Crossing

South Branch Watershed Association

Raritan River Basin

The Raritan River Basin carries water from the southeastern expanse of the Highlands in Morris and Hunterdon Counties to the coastal marshes of Middlesex County. The area hosts two of the state's largest drinking water reservoirs, Spruce Run Reservoir and Round Valley Reservoir. These reservoirs are a major drinking water source for populated cities in central New Jersey.

The headwaters of the Raritan River flow through some of the most rapidly developing areas of the state. A proposed project by Pulte Homes near the South Branch of the Rockaway Creek clearly shows the type of threat facing the region. The 911-home project, known as Windy Acres, would occupy 292 acres in Clinton Township. The construction of Windy Acres would require a new sewage treatment plant, which would discharge wastewater in to the Rockaway Creek, a high-quality waterway home to brown trout and wood turtles. The project was unanimously rejected by the Clinton Township Planning Board in July 2001, but Pulte Homes is currently suing to overturn the decision.

For another example, look at the Neshanic River watershed, a tributary of the South Branch. Much of this watershed lies within the boundaries of Raritan Township. Between 1986 and 1995, Raritan Township added 2,266 acres of urban area. Between 1990 and 2000, the township added 4,193 new residents and issued 1,517 permits for residential housing units. As a result, six percent of the Neshanic watershed was claimed by development between 1986 and 1995, leading to a 6% decline in water quality during the 1990s.

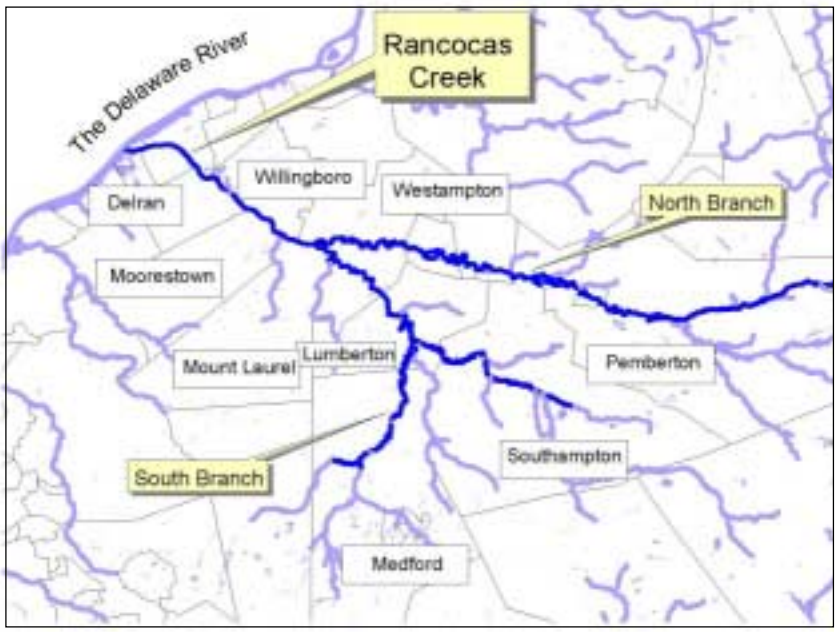
However, only four percent of the Neshanic River watershed was covered by impervious surface in 1995. There is still time to protect it, as well as other vulnerable parts of the headwaters of the Raritan River.

Mark Rauschkolb

Union Township, Hunterdon County, August 13, 2001—Runoff after a 1.1 inch rainstorm overwhelmed the stormwater drainage system in a neighborhood at the headwaters of Mullhockaway Creek, a tributary of Spruce Run reservoir and a drinking water source for much of central New Jersey.

Vulnerable Waterways in the Raritan River Basin

- Assicong Creek
- Allerton Creek
- Neshanic Creek
- Spruce Run Creek
- Prescott Brook
- Back Brook
- Cramers Brook
- Pleasant Run
- Holland Brook
- Middle Brook
- Walnut Brook
- Rockaway Creek
- Sidney Brook



Lower Delaware River and Bay

Rancocas Creek

Rancocas Creek flows from the Pinelands Protection Area in the coastal plain of New Jersey to the Delaware River, providing clean drinking water for the people of Pemberton, Medford, Evesham, Mount Holly, Mount Laurel, and Willingboro. Surface water intakes are located near Delran and on the upper part of the north branch of the creek.[94] In addition to its importance as a drinking water source for the region, Rancocas Creek is home to several bald eagle pairs and other threatened and endangered species.[95]

Overdevelopment is the main threat to water quality in Rancocas Creek. The heavy development pressure felt in this area is exemplified by the continued expansion of suburban area in Mount Laurel. On December 28, the Mount Laurel Township Planning Board gave final approval to Rancocas Pointe, a new 326-home development planned for 86 acres on the south bank of Rancocas Creek by J.S. Hovnanian and Sons, Inc.[96] The development has nearby residents worried that the creek will change forever.[97] The New Jersey DEP Endangered and Nongame Species Program and the U.S. Fish and Wildlife Service have recommended the Rancocas Creek for stronger protection under the Clean Water Act because of its ecological significance.[98]

Burlington County Land Use Office

Oldmans Creek

Dan Grenier, South Jersey Watershed Alliance

A farm along Oldmans Creek.

Oldmans Creek flows from the coastal plain to the Delaware River, marking the boundary between Gloucester and Salem counties. It meanders through lush green farms, cool forests, and expansive tidal wetlands. It is an important source of groundwater replenishment and wildlife habitat for the region.[99]

However, new developments are rapidly transforming the area, threatening water quality. Non-point sources are the only contributor to water quality problems in Oldmans Creek above the tidal line. The creek is affected by agricultural and suburban sources of runoff, including runoff from road and housing construction, urban surfaces, mining activities and leachate from septic systems. All these sources have been identified by local officials to be responsible for a decline in water quality and some minor habitat destruction in the 1990s.[100]

The development pressure in this area is exemplified by the recent battle over the mammoth Weatherby project in Woolwich, the state's second fastest-growing township. Summit Homes is building 4,500 homes in the area, putting a heavy strain on the area's drinking water supplies. Three years ago, the state said that development along the Gloucester-Salem county border had to stop, or the aquifer which supplies drinking water to the region would be rapidly depleted. Summit Homes then sued the state, seeking to advance the project despite the water supply concerns. In 2001, the Legislature passed a bill that allowed water companies to temporarily pump 283 million more gallons per year from the endangered aquifer while a $6 million pipeline is built to supply treated water from the Delaware River.[101] Currently, the mayor of Woolwich is appealing the DEP's decision to grant temporary permits to withdraw excess water from the aquifer, citing concern about the depletion of other residents' well water.

Projects like this threaten to degrade water quality in Oldmans Creek, slow aquifer recharge by increasing runoff from impervious surface, and exhaust drinking water supplies for current and future residents. Because of its ecological significance as habitat for rare and threatened species, the U.S. Fish and Wildlife Service and New Jersey's DEP Endangered and Nongame Species Program have recommended parts of Oldmans Creek for increased protection under the Clean Water Act.[102]

The Maurice River

The Maurice River is a nationally recognized "Wild and Scenic" river with nationally and internationally important resources. Millions of migrating birds flock to its clean waters in late summer every year, and the river provides a critical link between the Delaware Estuary and the Pinelands.[103] It is home to 20-30 pairs of threatened osprey and four pairs of bald eagles.[104] It passes through wide fields of crops, untouched forests, the scenic town of Vineland, and finally reaches an expansive tidal marsh.

The Maurice River already has some water quality problems:[105]

- In the lower sections of the river, sewage treatment plant discharge contaminated the shellfish beds with bacteria, resulting in a ban on shellfish harvesting.
- Tributaries including Still Run, Little Ease septic tank leachate and runoff from crop and pasture lands, urban surfaces, road and home construction, and road maintenance.

Although 10 miles of the Maurice River and 24 miles of its tributaries are federally designated Wild and Scenic rivers, much of the waterways are vulnerable to further decline in water quality. Much of the development pressure is happening at the headwaters of the Maurice River.

Between 1996 and 2001, Monroe Township issued more than 2,600 building permits for residential homes in part of the watershed that already has 5% impervious surface cover. In 1990, Monroe issued permits for only 54 homes, while in 1999 the township issued permits for 490 homes.

The full length of this river, especially its headwaters, needs full protection from water quality degradation under the Clean Water Act. The U.S. Fish and Wildlife Service and New Jersey's DEP have identified the Maurice River as a candidate for further protection because of its proximity to undeveloped open space and its significance as wildlife habitat.[106]

Cape May Times

Purple martins and swallows flock to the wetlands surrounding the Maurice River every year.

The Cohansey River

The Cohansey River stretches 30 miles through eastern Salem County, passing through important agricultural land and wide tidal marshes along the Delaware Bay. It helps to refill the groundwater aquifers that supply drinking water and irrigation water for the region.

Pollution in the Cohansey River comes from both agriculture and suburban development activities. Specifically, leachate from septic systems and runoff from croplands, pasturelands, housing developments, roads, and urban surfaces impact water quality.[107] As a result, the tidal sections of the Cohansey do not support shellfishing because of bacterial contamination.

Further development could make the pollution problem more severe. Hopewell Township is the most rapidly growing area in the watershed. The number of housing units permitted by the township tripled from the 1980s to the 1990s. From 1996 to 2001, the township issued permits for almost 1,000 homes.


New Jersey DEP

A DEP employee collects insect samples in the Cohansey River at Silver Lake Road.

The full length of this river needs protection from future water quality decline. The U.S. Fish and Wildlife Service and the New Jersey DEP have identified the Cohansey River as a candidate for further protection because of its proximity to undeveloped open space and its significance as wildlife habitat.[108]

Other Vulnerable Rivers in the Lower Delaware River and Bay Area

- Salem River[109]
- Alloway Creek[110]
- Mad Horse Creek
- Stow Creek[111]
- Cedar Creek[112]
- Nantuxent Creek
- Orandaken Creek
- Dividing Creek
- West Creek
- East Creek

Atlantic Coastal Region

The Manasquan River

The Manasquan River flows from central Monmouth County to the Atlantic Ocean. The river is a favorite for fishing and boating, and the bay and beaches at its tidal end are popular places for swimming. The river also supplies drinking water for hundreds of thousands of Jersey Shore residents through several drinking water intakes.[113]

Development strained drinking water supplies in this area as early as the 1980s. Due to heavy use of the groundwater, the DEP forced Monmouth County to slash groundwater use by up to 60%. In return, the state spent more than $75 million building a reservoir fed by the Manasquan River that supplies 16 million gallons of water to more than half a million people.[114] This reservoir was proposed for protection by the McGreevey administration on Earth Day 2002 in recognition of its significance as a drinking water source.

About half of the land in this watershed was used for growing crops and grazing animals in 1995, but large-scale development is transforming the area from an agricultural past into a suburban future. This development is the main threat to water quality in the Manasquan River.

The Manasquan watershed region is one of the most rapidly growing areas of the state. This growth can clearly be seen in a few statistics:[115]

Other Vulnerable Rivers in the Atlantic Coastal Region

- Shark River
- Tributaries of the Swimming River Reservoir[127]
- Navesink River
- Cedar Creek

- Private-sector employment in the area grew by 23.2% in the 1990s, while it grew only 6.0% statewide.
- 34,000 new residents moved into the area in the 1990s.
- Urban area in the watershed grew by 17.6%.
- Freehold, Howell, and Wall all grew by more than 25%, compared to 8.6% for the state as a whole.
- Over 12,000 new housing units were built in the 1990s.
- Approximately 6,500 acres, or 6.1% of the total land area in the watershed was developed between 1986 and 1995.
- At this rate, build-out will happen by the year 2031.

If development continues until the watershed is completely built-out, an additional 6,150 residential homes and 63 million square feet of impervious surface will be added, mostly in the towns of Freehold, Howell, and Wall.[116]

Recent headlines from local papers describe the development pressure facing the region:

- "Planners OK 135 homes on Hascup Farm."[117] HOWELL — US Home, Freehold Township, has received final approval to build 135 homes on Route 524 on the 203-acre Schuch-Hascup tract between Howell and Havens Bridge roads.

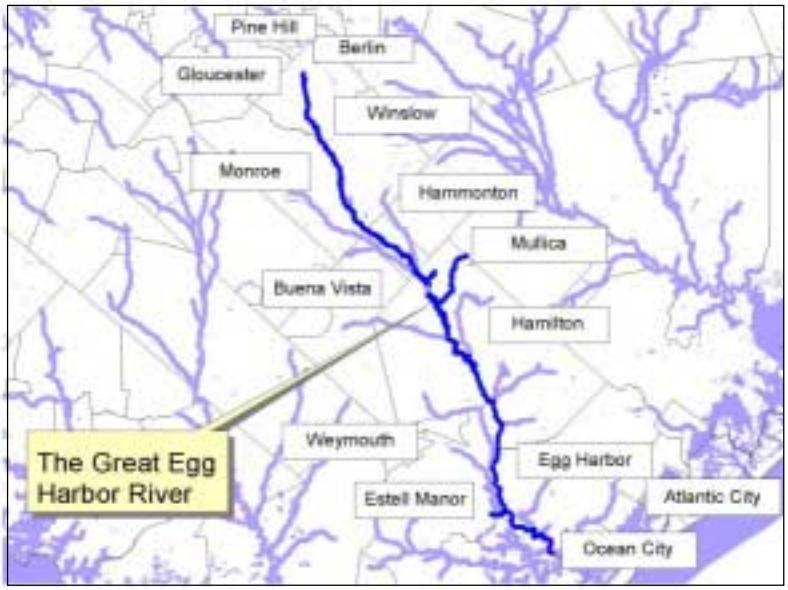
Monmouth County Park System

A kayaker on the upper Manasquan River.

- "Planners begin hearing plan for adult community: Toll Brothers has plans for Riviera at Freehold on Jackson Mills Road."[118]

FREEHOLD TOWNSHIP — Toll Brothers wants to subdivide a 227-acre lot and build a 300-unit age-restricted community at Jackson Mills and Bergerville roads.

Because of its significance as a drinking water source and recreational area, this river needs protection from further pollution under the Clean Water Act. The NJDEP lists parts of the Manasquan River as candidates for further protection because of its proximity to undeveloped open space and less than 10% impervious cover draining to a public water supply.[119]



The Great Egg Harbor River

The Great Egg Harbor River is a nationally recognized "Wild and Scenic" river, passing through some of the most pristine forests in the state, including the Pinelands Protection Area. It is home to 41 species of fish and 87 species of birds, including the nationally endangered peregrine falcon and the nationally threatened bald eagle and piping plover.[120] Hundreds of boaters can be found along its length, fishing and watching wildlife. Hikers flock to enjoy isolated spots along its banks.

However, the headwater areas in particular are threatened by increasing development in eastern Camden and Gloucester counties. The river begins flowing from a spring which is routed around the Berlin Circle Shopping Center and a parking lot, emerging from a pipe at the Camden County Park in Berlin.[121]

The Winslow Township sewage treatment plant in Sicklerville exemplifies the problem of sewage discharge in the upper Great Egg Harbor watershed. In the last few years, pressure from increasing development led to a 600,000 gallon-per-day expansion of the plant's discharge capacity, bringing it to 2.25 million gallons of discharge per day. This discharge flows into the environmentally sensitive Great Egg Harbor River. As a result of the expansion, projects in the area like Woodpeak Development's 684-single family home community were able to go forward.[122]

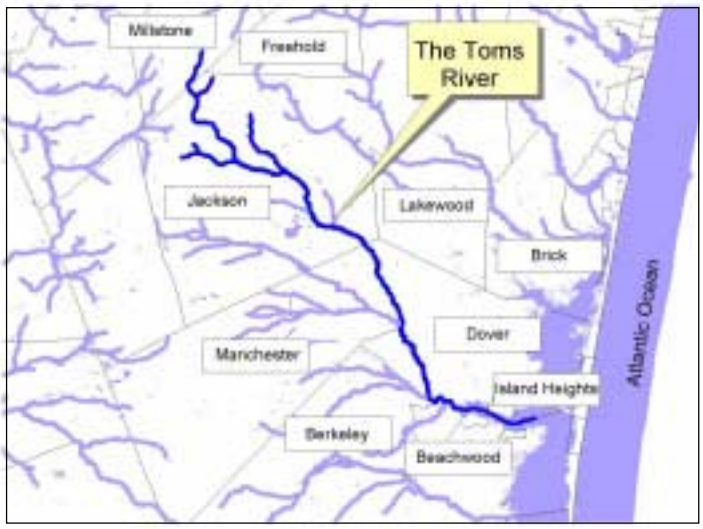
The upper Great Egg Harbor River is polluted with nutrients and sediment from sewage treatment wastewater, runoff, septic system leachate, and agricultural runoff, and residential development in the watershed outside the Pinelands is rapidly consuming wildlife habitat.[123]

This important river needs stronger protection from development-related pollution, especially along its headwater streams. Because of the ecological significance of the Great Egg Harbor River, the U.S. Fish and Wildlife Service and New Jersey's DEP have nominated it as a candidate for additional protection under the Clean Water Act.[124]

Weymouth Township

Canoe enthusiasts launching onto the Great Egg Harbor River at Weymouth Furnace Park.

The Toms River



The Toms River and its tributaries drain a significant portion of the eastern Pinelands Protection Area, and recharge the Kirkwood-Cohansey, Magothy, and Piney Point aquifers that supply much of the drinking water for the region. Because the aquifers in this region are close to the surface, they are especially vulnerable to contamination.[125] The Toms River eventually reaches Barnegat Bay, an ecologically important estuary very popular with boaters and fishermen.

Development is the main threat to water quality in the Toms River. The Upper Toms River flows through Jackson and Dover Townships in Ocean County and Freehold Township in Monmouth County. Between 1986 and 1995, these townships each added over 1,700 acres of new development, ranking in the top 13 most rapidly developing areas of the state. This development claimed 6% of the Toms River watershed area. The Toms-Mullica Watershed Area was listed as an Area of Probable Concern in the U.S. EPA's National Sediment Inventory (1997) due to sediment contamination.

Despite this rapid development, the upper part of the river still contained less than 5% impervious surface. There is still opportunity to preserve the high water quality of this river.

Water supply is a major issue in the Toms River watershed. In 1990, the area was using 16 million gallons of water more than supplies could sustainably provide, a level that may rise to 40 million gallons by 2040.[126] Reducing runoff and pollution in this river with stronger protection under the Clean Water Act can help maintain groundwater recharge rates.

POLICY FINDINGS

Preserving pristine waterways requires protecting pristine forests and wetlands, maintaining buffer corridors, minimizing impervious surface additions, and preventing new or expanded sewage discharges in vulnerable areas. Each of these steps can promote healthy streams and good drinking water quality to provide long-term protection for public health and public drinking water supplies.

Under the Clean Water Act, states can designate waterbodies as "high quality" waters and protect them from any changes that would measurably harm water quality. This anti-degradation provision, officially known as the Category One or C1 program, can be an effective tool for the state to use to protect pristine waterways from development-related pollution. Eligible rivers and streams include those with exceptional significance as drinking water sources, wildlife habitat, or recreational areas.

Waterways designated as C1 are protected with buffer zones surrounding their banks, providing filters to reduce runoff and increase groundwater recharge. Developers wishing to build sewage treatment plants on these rivers are required to ensure that sewage discharge will not measurably degrade water quality. As a result, the C1 program can be an effective tool to protect water quality from the negative effects of development.

Governor McGreevey's administration has made protecting our drinking water supplies a priority. During the 2003 State of the State Address, Governor McGreevey cited uncontrolled development as a major threat to our drinking water supplies.[128] On Earth Day 2002, the administration proposed protection for nine drinking water reservoirs and six streams using the Category One program, with seven new trout streams added in December 2002. In March 2003, the administration announced a broad list of waterbodies as candidates for this same level of protection, including the Metedeconk River and Lake Tappan.[129]

The administration can help ensure that New Jersey's drinking water sources remain protected for future generations by improving the scope and effectiveness of the Category One program with the following steps:

Officially finalizing Category One status for the waterbodies the administration has already identified as high-quality.

The administration has already selected a set of drinking water reservoirs and pristine streams across the state for protection under the Clean Water Act beginning on Earth Day 2002. Fifteen waterways were first proposed for protection in April 2002, with an additional seven trout streams selected in December. The Department of Environmental Protection should finalize the regulations for these waterbodies, ensuring that their current water quality is preserved.

Extending protection to an inclusive and comprehensive list of waterways across the state, similar to the list of waterways nominated by both the DEP and the public in March 2003.

The Department of Environmental Protection should emphasize drinking water sources, habitat for threatened and endangered species including coastal areas, headwaters with low impervious cover, and the tributaries of protected rivers or reservoirs in selecting waters for Category One status. Since water flows into reservoirs and other drinking water sources from wide headwater areas, projects that pollute headwaters can also pollute protected waterbodies downstream. Accordingly, waters upstream of protected areas should be treated with the same level of care. The department should move quickly to officially propose protection for waterways on this comprehensive list.

Integrating implementation procedures for protecting C1 waterways to all state water quality rules to ensure that they are effective.

A law is only as effective as its implementation. The Department of Environmental Protection should ensure that the anti-degradation provisions work to prevent pollution by incorporating the full intent of the law in relevant regulations, including the rules governing septic systems, groundwater protection, stream encroachment, wetlands management, coastal management, water allocation, and stormwater management. For example, the recently proposed stormwater management rule provides a 300-foot buffer zone around Category One waterways. This rule change is a good start. Further changes like this, including tougher sewage discharge standards for Category One waterways, will be necessary to ensure the full effectiveness of the anti-degradation program.

Strengthening and enforcing existing regulations to ensure no measurable water quality decline in Category One waterways.

The Department of Environmental Protection should enact and enforce buffer zone rules, limits on discharge from sewage treatment plants, and limits on discharge from industry for current Category One waters across the state. Increased enforcement should prevent any pollution from harming water quality in these special waterways. Regardless of the location of these waterways on the DEP's "BIG Map," which lays out a growth plan for the state, Category One waters should receive the same level of protection.

APPENDIX: DEVELOPMENT AND WATER QUALITY BY REGION

Northwest New Jersey

In the Highlands area of Northwest New Jersey, water quality declined in the Wallkill River, the Papakating Creek, the Pequest River, and the Musconetcong River.

Wallkill River

The Wallkill River drains into the Wallkill National Wildlife Refuge and provides drinking water for roughly 100,000 people in New York and New Jersey.

Increasing development in this area accompanied dramatic water quality changes in this river during the last decade. Overall water quality in the Wallkill declined by 16%, while water quality in Papakating Creek declined by 23%. Over 80% of the testing sites in this watershed showed moderate impairment.

- Three percent of the total land feeding the Wallkill River was developed between 1986 and 1995.
- 2,579 acres of land were developed, the equivalent of over 1,900 football fields.
- As of 1995, these watersheds contained 3,122 acres of pavement, rooftops, and other impervious surfaces, roughly four percent of the watershed.
- During the 1990s, 9 of 13 sites showed significant water quality decline, 2 of 13 showed no change, and 2 of 13 improved.

These water quality declines are likely tied to the repeated expansion of the Sussex County sewage treatment plant in Sussex and runoff from increasing development activity.

Pequest River

Bear Creek and the Pequest River above Bear Swamp declined in quality by more than 11% during the 1990s.

- Slightly more than 2% of total land in these watersheds was developed between 1986 and 1995.
- 1,058 acres of land were developed, the equivalent of over 750 football fields.
- As of 1995, these watersheds contained 1,250 acres of pavement, rooftops, and other impervious surfaces, roughly 3% of the watershed.
- During the 1990s, 4 of 7 testing sites showed significant water quality decline, while 3 showed no change, with over 70% of these sites moderately impaired.

Musconetcong River

Below Trout Brook, the Musconetcong declined in quality by 6%.

- Four percent of total land was developed in this watershed between 1986 and 1995.
- 1,760 acres of land were developed, the equivalent of over 1,300 football fields.
- As of 1995, these watersheds contained 1,670 acres of pavement, rooftops, and other impervious surfaces, or 3.5% of the watershed.
- During the 1990s, 4 of 7 sites showed significant water quality decline, while 3 showed no change, with over 70% moderately impaired.

Central New Jersey

In Central New Jersey, water quality declined in the Neshanic River, Lawrence Brook and the Millstone River.

The Neshanic River

The Neshanic River declined in water quality by 6% during the 1990s.

- 6% of total land was developed in watersheds feeding the Neshanic River between 1986 and 1995, bringing the watersheds to 22% urban land use.
- 2,100 acres of land were developed, the equivalent of nearly 1,600 football fields.
- As of 1995, these watersheds contained 1,226 acres of pavement, rooftops, and other impervious surfaces, or about 3.5% of total land area.

- 5 of 7 testing sites showed significant water quality decline, with over 85% moderately impaired.

A large amount of the new development in this area was located just below the confluence of the First, Second, and Third Neshanic Rivers.

Lawrence Brook and the Millstone River

The watersheds containing the Lawrence Brook and the Millstone River faced some of the heaviest development pressure during the late 80s and early 90s. These waterways experienced a water quality decline of about 12%.

- 7% of total land was developed in these watersheds between 1986 and 1995.
- 6,688 acres of land were developed, the equivalent of over 5,000 football fields.
- As of 1995, these watersheds contained 11,570 acres of pavement, rooftops, and other impervious surfaces. That represents 18% of the Lawrence Brook watershed and 10% of the Millstone.
- As of the last testing, 4 of 20 sites tested in this basin showed severe impairment, 15 of 20 showed moderate impairment, and only 1 showed no impairment.

The Atlantic Coast

Along the Atlantic Coast, water quality declined in the Navesink River, the Shark River, the Manasquan River, the Metedeconk River, Tom's River, the Manahawkin River, the Mullica River, the Great Egg Harbor River, and the Tuckahoe River.

Navesink

- 6% of total land was developed in watersheds feeding the Navesink River between 1986 and 1995.
- 2,576 acres of land were developed, the equivalent of over 1,900 football fields.
- As of 1995, these watersheds contained 5,998 acres of pavement, rooftops, and other impervious surfaces. That represents 10% of the watershed.
- In the late 1990s, 12 of 15 sites tested in this basin showed moderate impairment and 3 of 15 showed severe impairment, representing a 3% water quality decline.

Manasquan

- 6% of total land was developed in watersheds feeding the Manasquan River between 1986 and 1995.
- 3,100 acres of land were developed, the equivalent of over 2,300 football fields.
- As of 1995, these watersheds contained 5,587 acres of pavement, rooftops, and other impervious surfaces. That represents over 10% of the total watershed.
- In the late 1990s, 1 site was severely impaired, 9 were moderately impaired and 3 were unimpaired, representing a 4% water quality decline.

Metedeconk

The North Branch of the Metedeconk showed an 8% water quality decline, while 3 sites in the lower Metedeconk watershed showed a 33% water quality decline.

- Over 4% of total land was developed in watersheds feeding the North Branch of the Metedeconk River between 1986 and 1995.
- 1,600 acres of land were developed, the equivalent of over 1,200 football fields.
- As of 1995, these watersheds contained 6,000 acres of pavement, rooftops, and other impervious surfaces. That represents over 23% of the North Branch watershed, and 12% of the Lower Metedeconk watershed.
- In the late 1990s, 1 testing site was severely impaired, 8 were moderately impaired and 2 were unimpaired.

Shark River

Water quality in the Shark River watershed declined by 14% during the 1990s.

- Over 4% of total land in this watershed was developed between 1986 and 1995.
- 1,700 acres of land were developed, the equivalent of nearly 1,300 football fields.
- As of 1995, these watersheds contained 8,170 acres of pavement, rooftops, and other impervious surfaces. That represents over 21% of the watershed.
- In the late 1990s, 3 sites were severely impaired, and 4 were moderately impaired.

Toms River

Water quality in Toms River above Oak Ridge Parkway declined 14% in the 1990s.

- Six percent of total land in this watershed was developed between 1986 and 1995.
- 2,178 acres of land were developed, the equivalent of over 1,600 football fields.
- As of 1995, these watersheds contained 1,920 acres of pavement, rooftops, and other impervious surfaces. That represents 5% of the watershed.
- In the late 1990s, 4 sites were moderately impaired, and 6 were unimpaired.

Great Egg Harbor River

Water quality in the Great Egg Harbor River above Hospitality Brook declined by 11% in the 1990s.

- Four percent of total land in this watershed was developed between 1986 and 1995.
- 1,900 acres of land were developed, the equivalent of over 1,400 football fields.
- As of 1995, these watersheds contained 3,557 acres of pavement, rooftops, and other impervious surfaces. That represents 8% of the watershed.
- In the late 1990s, 4 sites were moderately impaired, and 3 were unimpaired.

Table A1: Development in Watersheds with Worsening Water Quality

Watershed	Region	% New Development	% Impervious Surface	Impairment Score Late 1990s	Water Quality Change
Millstone River (above Carnegie Lake)	Millstone	7.5	9.9	14	Declined
Lawrence Brook	Lower Raritan	6.6	17.9	14	Declined
Millstone River (below Carnegie Lake)	Millstone	6.6	8.9	16	Declined
Neshanic River	S. Branch Raritan	5.9	3.4	18	Declined
Manasquan River	Monmouth	5.9	10.6	16	Declined
Toms River (above Oak Ridge Parkway)	Barnegat Bay	5.6	5.0	23	Declined
Metedeconk River	Barnegat Bay	5.0	23.7	9	Declined
Kettle Creek / Barnegat Bay North	Barnegat Bay	4.5	16.5	11	Declined
Toms River (below Oak Ridge Parkway)	Barnegat Bay	4.4	13.5	22	Declined
Whale Pond Brook / Shark River	Monmouth	4.4	21.0	12	Declined
Navesink River / Lower Shrewsbury River	Monmouth	4.3	9.9	13	Declined
Great Egg Harbor R (above Hospitality Brook)	Great Egg Harbor	4.2	7.8	20	Declined
Metedeconk River, North Branch	Barnegat Bay	3.9	11.8	19	Declined
Musconetcong River (below Trout Brook)	Upper Delaware	3.7	3.5	25	Declined
Absecon Creek	Great Egg Harbor	3.6	10.7	14	Declined
Paulins Kill (above Stillwater Village)	Upper Delaware	3.4	3.9	21	Declined
Papakating Creek	Wallkill	3.0	2.3	21	Declined
Bear Creek	Upper Delaware	2.6	1.3	20	Declined
Wallkill River (above road to Martins)	Wallkill	2.5	4.6	19	Declined
Wallkill River (below road to Martins)	Wallkill	2.4	2.2	21	Declined

METHODOLOGY

Data Sources

Water quality data comes from the New Jersey Department of Environmental Protection's (NJDEP) Ambient Biomonitoring Network (AMNET). GIS shape files containing this data were obtained from the DEP website at www.state.nj.us/dep. Land Use and Land Cover data was prepared by NJDEP using aerial photographs taken in 1986 and again in 1995. This data is also available on the NJDEP website, along with GIS shape files describing USGS Hydrologic Unit Code (HUC) watershed boundaries, and municipal boundaries. Building Permit information is from the New Jersey Department of Labor and the U.S. Census, available at www.njpin.net.

Land development and impervious surface data come from an analysis of the NJDEP 1986-1995 Land Use/Land Cover GIS data set using watershed boundaries described by USGS 11-digit codes; Water quality data comes from a comparison of the NJDEP AMNET surveys carried out in the early and late 1990s, using the average value for all testing sites within a watershed described by USGS 11-digit codes; Testing sites showing impairment data reflects the number of testing sites within a watershed showing impairment (AMNET score 21 or below) and severe impairment (AMNET score 6 or below).

Data Analysis

Water Quality

The average water quality score was derived for each watershed as described by United States Geological Survey eleven-digit codes (HUC 11) by determining the average value of all of the AMNET sites within a watershed, both for the early and late 1990s. For the purpose of generating the relative color categories on the maps in Figure One, we defined "Serious" impairment as a score of 11 out of 30 or below. "Unimpaired" was defined as 24 or above, and "Moderately impaired" included values between these two categories. For allocating individual sites to a category as in Table One, we used the same scale as the NJDEP. Severely impaired sites have a score of 6 or below, impaired sites have a score of 9 to 21, and pristine sites have scores of 24 to 30. We compared average measurements in the early 1990s to those from the late 1990s to determine water quality trends.

Land Use

For the land use analysis, we relied on the NJDEP 1986-1995 Land Use/Land Cover data set, and the pioneering work of the Rutgers Center for Remote Sensing and Spatial Analysis.[130] We defined new development as areas which changed from a natural state or agricultural use to urban use—including both residential and commercial areas. We calculated the area of new development and impervious surface in 1995 in each watershed and municipality using ArcView, a GIS program.

Building Permits

We created the building permit maps using information on the yearly issue of building permits from each New Jersey municipality. We looked at single family units and apartments and coded each municipality with the corresponding building permit information using ArcView.

Selection of Endangered Rivers

We chose endangered rivers based on the following criteria:

1) Rivers with relatively pristine water quality that may have seen degradation in recent years.
2) Waterways that supply drinking water and groundwater recharge for large numbers of people.
3) Habitat for threatened and endangered species, as defined by the New Jersey DEP Endangered and Nongame Species Program's Landscape Project. GIS maps describing habitat for rare and threatened species are available at the DEP website.
4) Areas of the state coming increasingly under development pressures
5) Watersheds that have relatively low impervious cover and have not reached build-out.

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