New Jersey
Source Water Assessment Program
Statewide Summary

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Richard J. Codey, Acting Governor
State of New Jersey

Bradley M. Campbell, Commissioner
Department of Environmental Protection

401 E. State Street
PO Box 426
Trenton, New Jersey 08625-0426
(609) 292-5550

December 2004

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Abstract

As a requirement of the 1996 Amendments to the Safe Drinking Water Act, New Jersey Department of Environmental Protection (DEP) in conjunction with the United States Geological Survey (USGS) performed source water assessments to predict the susceptibility of source water for all community water systems and those noncommunity water systems using surface water. Susceptibility is a measure of the potential exposure of a drinking water source to contamination.

Susceptibility is a function of variables that describe hydrogeologic sensitivity and contaminant-use intensity within the area contributing water to the wells and surface water intakes. The first category of variables, sensitivity, consists of items related to the construction of well (i.e. well depth) and naturally occurring factors (i.e. geology). The second category of variables, intensity, is factors related to human activities on the earth's surface. Intensity factors consist of point (i.e. leaking underground storage tanks) and nonpoint (i.e. land use) sources.

The DEP and USGS determined each public water system source's susceptibility to the following contaminant categories: nutrients (nitrates), pathogens, pesticides, volatile organic compounds (VOCs), inorganics (metals), radionuclides/radon, and disinfection byproduct precursors. Each source received a susceptibility rating of high, medium, or low to each contaminant category.

A low rating for the well or intake indicates the source water is not likely to equal or exceed one-tenth of New Jersey's drinking water Maximum Contaminant Level (MCL), and a medium rating indicates the source water is not likely to equal or exceed one-half the MCL. A high rating includes wells and intakes for which contaminant concentrations in source water may equal or exceed one-half the MCL; therefore, sources with high susceptibility ratings will not necessarily exceed the drinking water standard. If a standard is exceeded DEP has numerous regulatory programs in place to protect New Jersey's drinking water resources.

To determine a source's susceptibility to contamination, DEP and USGS developed a framework that included statistical modeling, evaluation of past studies, and water sample data. The models were developed using water-quality data from ground water and surface water samples collected and analyzed by USGS. These models were applied to each public water system's well or intake.

The results of the susceptibility models show, for ground water and surface water, land use (from 1970, 1986, and 1995) is the most common intensity variable found to determine susceptibility. Of the land use coverages, urban land use and agricultural land use were most often linked to determining a source's susceptibility rating.

For ground water, confinement status was found to be the most frequently occurring sensitivity variable to determine susceptibility. Confinement status was used in each of the susceptibility models for each of the contaminant categories. DEP and USGS determined confined wells to be of low susceptibility to contamination that occurs at the earth's surface. For unconfined wells, depth to the top of the open interval of the well was found to be the most common sensitivity variable to determine a well's susceptibility rating. DEP and USGS determined that the shorter the distance to the earth's surface, the likelihood of the well being affected by contaminants resulting from land use activities increases. Thirdly, percent soil organic matter, was found to be a common sensitivity variable for both ground water and surface water.

For surface water, the three contaminant categories in which the highest percentage of sources received a high rating are inorganics (81%), disinfectant byproduct precursors (98%), and pathogens (100%). For the purpose of the source water assessments, the drinking water derived from all surface water intakes was assumed to be highly susceptible to contamination by pathogens. Therefore, all surface water intakes received a high rating for pathogens (100 percent). Surface water sources are subject to various sources of microbial contamination runoff containing fecal matter.

For ground water, unconfined wells, the three contaminant categories in which the highest percentage of sources received a high susceptibility rating are nutrients (67%), VOCs (61%), and radon/radionuclides (50%/49%).

For ground water, confined wells, only the disinfection byproduct precursors contaminant category contains wells that received a high susceptibility rating (27%). For the remaining seven contaminant categories, 0% of the wells received a high susceptibility rating. When reviewing the results of the medium susceptibility ratings for confined wells, the three contaminant categories in which a high percentage of the wells rated medium are disinfection byproduct precursors (70%), inorganics (47%), and radionuclides (39%).

The DEP is generating individual reports for each of the 606 community water systems and those 3 noncommunity water systems relying on surface water. These reports provide the susceptibility ratings for each of the water system's sources to each contaminant category. The reports and supporting documents are available to the public and can be obtained by contacting the public water system or through DEP's SWAP web page at http://www.nj.gov/dep/swap/assessments.htm.

OVERVIEW

The DEP is pleased to present the Statewide Summary of the New Jersey Source Water Assessment Program established in conformance with the 1996 Amendments to the Safe Drinking Water Act and with NJ State Safe Drinking Water Program Goals. The Safe Drinking Water Act was originally passed in 1974 to protect public health by regulating the nation's drinking water supplies (lakes, rivers, reservoirs, springs, and ground water) by establishing health based standards for drinking water, and by establishing treatment measures to meet these water standards. As a result of the SDWA millions of Americans, including New Jersey residents, receive high quality drinking water each and every day. The 1996 Amendments of the SDWA greatly enhanced the SDWA by recognizing the need for source water assessment and protection measures nationally. The purpose of the Source Water Assessment Program is to identify significant "potential" sources of contamination and to determine how "susceptible" the sources are to these threats.

Source water assessments were prepared in cooperation with the United States Geological Survey (USGS) and the Department of Environmental Protection's (DEP) Water Supply Administration, New Jersey Geological Survey, and the Division of Science, Research and Technology. This program and the results of the individual assessments will be used to lay the groundwork for advancing the State's drinking water protection efforts. Additional detailed information about the Source Water Assessment Program can be found on DEP's website at www.state.nj.us/dep/swap.

Why the Need for Source Water Assessments in New Jersey?

New Jersey's widespread industrial base and dense population increase the risk of susceptibility to water quality concerns. New Jersey has a long history of implementing regulatory controls to protect water resources. Potable water supply resources are protected through improved standards, monitoring and treatment. All of the programs are being enforced through expanded and strict enforcement initiatives.

Overall, the results of the modeling performed by USGS show that of the nonpoint sources, factors related to urban land use and agriculture land use were most often linked to susceptibility of drinking water sources to contamination. For surface water, factors related to the density of point sources were found to be important in determining the potential vulnerability of a drinking water source to certain contaminants. For ground water, point sources were important factors for determining potential vulnerability for VOC, inorganics, and disinfection byproduct precursors.

Over the past 30 years, the DEP and the regulated community made significant strides toward correcting water pollution problems associated with dense land uses and commercial and industrial uses. Major water quality improvements have been made as a result of implementing comprehensive standards, permitting, enforcement and financing programs. These efforts mainly focused at controlling major point source discharges of pollutants. It has been found that though these efforts led to water quality improvements, work was needed to address impacts to water resources from more diffuse nonpoint sources of pollution. Recent adoption of Stormwater Management Rules and Category One designations reflects the Department's expanding efforts to protect water quality from impacts associated with various land use. The DEP continues to increase regulatory efforts to control nonpoint source pollution.

What is the Purpose of the Source Water Assessment Program?

The Source Water Assessment Program was designed to encourage protection of drinking water sources by providing information to state and local regulatory agencies and the public to assist in watershed assessment and planning and to enhance the public's role as "water stewards". While there are already many regulatory programs in place designed to protect the quality of drinking water, the results in the Source Water Assessment Program provide information to allow state and local agencies to determine if increased regulatory controls, including local land use ordinances, are warranted. In addition, individual source water assessments will help determine if the existing monitoring requirements for each public water system need to be revised in two ways. The first will be to help determine if the routine monitoring frequencies required of a community water system should be increased or decreased. Secondly, the results of the Source Water Assessments will help DEP protect public health by targeting wells and surface water sources that are highly susceptible to contamination for additional water quality monitoring. For example, the models were done for groups of contaminants, as described below. In some situations DEP may be aware of contaminants that are in a particular group that are not routinely tested for, and DEP may elect to do that sampling of the community water system for those unusual contaminants. An example of this is the pesticide 1,2,3-trichloropropane, which is not a compound that water purveyors must sample for, but which DEP has found with some frequency in ground water. Based on the results of the Source Water Assessments, DEP can target community water systems that are considered to be highly susceptible to pesticides and sample for 1,2,3-trichloropropane. Finally, the wealth of basic data gathered through the Source Water Assessment Program, including the locations of the public water system wells and surface water sources, within a high degree of accuracy, will now be available for all programs in DEP to consider when implementing regulatory actions, such as cleanup decisions in the hazardous and solid waste programs.

What are the Source Water Assessment Program steps?

New Jersey Source Water Assessments consist of the following four fundamental steps:

1. Determine the source water assessment area of each ground and surface water source of public drinking water.
2. Inventory the potential contamination sources within the source water assessment area.
3. Determine the public water system's susceptibility to regulated contaminants.
4. Incorporate public education and participation.

As part of the Source Water Assessment Program all community water systems[1] and all noncommunity water systems[2] are being evaluated. This Statewide Summary discusses the results of all community water systems and those three noncommunity water systems that rely on surface water. The results of the noncommunity water systems that rely on ground water were

[1] A community water system is a public water system that pipes water for human consumption to at least 15 service connections used by year round residents, or one that regularly serves at least 25 year round residents (e.g. municipality, subdivision, mobile home park).

[2] A noncommunity water system is a public water system that pipes water for human consumption to at least 15 service connections used by individuals other than year-round residents for at least 60 days a year, or serves 25 or more people at least 60 days a year (e.g. a school, factory, restaurant, rest stop with it's own water supply). The three noncommunity water systems with surface water intakes are BASF Corporation and DSM Nutritional Products, both in Warren County, and E.I. Dupont Chambers Works in Salem County.

not complete at the time of publication and are therefore, not included. Sources of drinking water were evaluated to determine the vulnerability, or susceptibility, of water system sources to different types of contamination. It is important to remember that the source water assessment process identifies the potential for a source of drinking water to become contaminated. Based on that potential for a source of drinking water to become contaminated, DEP can initiate a variety of activities to protect the drinking water source if the source is not already adequately protected.

What Safeguards are Already in Place to Protect Drinking Water?

Under the State's Safe Drinking Water Regulations, all public water systems must routinely monitor for contaminants. Community water systems, a type of public water system that serves drinking water to most of the residents of the state, monitor for a wide range of constituents including inorganic compounds (metals), pathogens, nitrates, volatile organic compounds, and radionuclides. If drinking water standards (also known as, Maximum Contaminant Levels[3] or MCLs) are exceeded, the water system must perform additional monitoring and treat the water within specified timeframes. The water system is also required to notify its customers when MCL violations occur. This notification is done through a variety of means, depending on the severity of the violation, and can include public service announcements and publication in a local newspaper. Information about violations must also be included in the Consumer Confidence Reports that community water systems must mail to all their customers by July 1 of each year. The Source Water Assessment Program expands the existing regulatory system to identify opportunities to proactively protect drinking water sources.

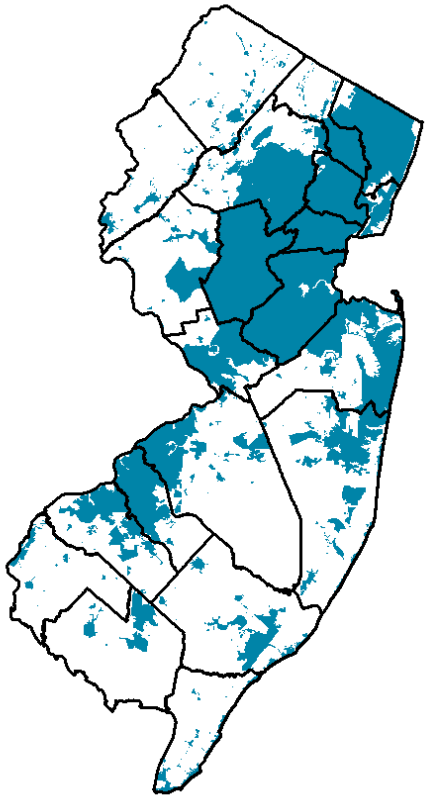
Private wells serve about 1 million of the State's 8.5 million residents and must be tested when installed. In addition, New Jersey passed groundbreaking legislation in March 2002, with the enactment of the Private Well Testing Act (N.J.S.A. 58:12A-26 et seq.) that requires that when property with a certain type of drinking water well is sold or leased, the well water must be tested for contaminants. The results of that water testing must be reviewed by both the buyer and seller, or, in the case of a leased property, by the lessee. Local health officials are notified when results of water testing indicate that the quality of the well water may exceed drinking water standards. The water quality and susceptibility of private wells used for drinking water are not the subject of this Statewide Summary. Additional information about the Private Well Testing Act, including a summary of the first six months of data, can be found at www.state.nj.us/dep/pwta.

What Areas of the State were Assessed as part of the Source Water Assessment Program?

The areas of the state with the greatest population densities are generally served by community water systems, although within those service areas there may be pockets of a township or city that still rely on private wells for drinking water. Figure 1 shows the areas of the state that are served by community water systems and therefore have been assessed as part of this program. The unshaded portions of the State in Figure 1 are not served by community water systems and residents in these areas rely primarily on private wells for drinking water.

[3] Maximum Contaminant Level (MCL) means the maximum permissible level of a contaminant in water measured at the point of entry to the distribution system or at the free-flowing outlet of the ultimate user of a public water system or other water system to which State primary drinking water regulations apply.

Figure 1: Areas Served by Community Water Systems



How was Susceptibility Determined?

In order to determine the susceptibility of drinking water sources under the Source Water Assessment Program, mathematical models were developed by DEP and the USGS to determine the relationship between environmental factors and the likelihood for contamination. For some contaminants, not enough data were available to develop full mathematical models, and in those situations other modeling techniques were used as a framework. This Statewide Summary discusses the results of all those models and techniques.

The results of the models developed by USGS in conjunction with DEP were applied to 2,237 community water supply wells and 64 surface water sources that serve community water systems. The models determined those factors shown to be most significant in predicting the potential for a well or surface water source to be affected by contamination, including surrounding land uses and activities, construction details of the well, and natural factors such as the geology of the area.

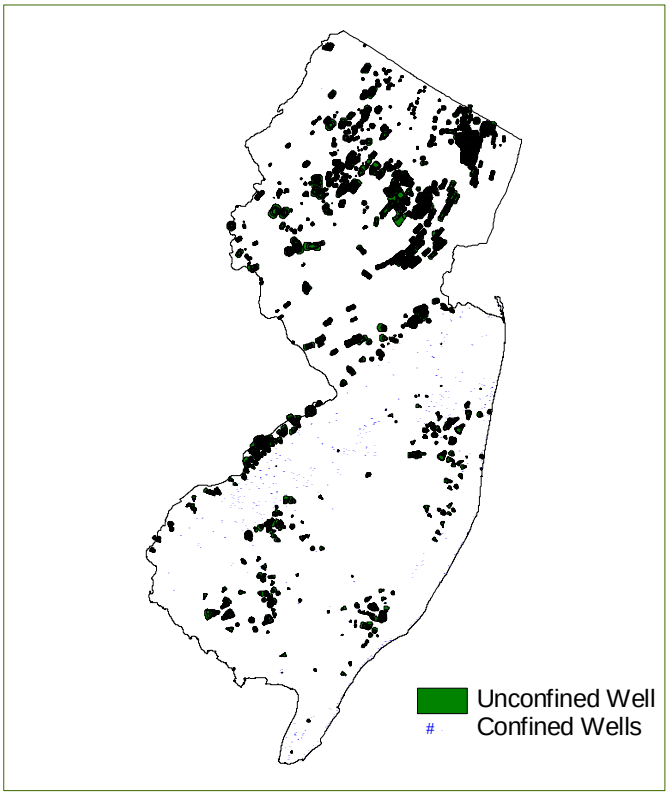
As part of the assessment process, a rating of low, medium or high was determined for each community water system well and surface water intake, by contaminant type. In general, a low rating includes wells or intakes for which contaminants in source water are not likely to equal or exceed one-tenth of New Jersey's drinking water MCL, the medium rating includes wells for which contaminant concentrations in source water are not likely to equal or exceed one-half the MCL, and the high rating includes wells and intakes for which contaminant concentrations in source water may equal or exceed one-half the MCL**. As a result, sources with high susceptibility ratings are still likely to be below MCLs.**

THE PROCESS

Delineation of Source Water Assessment Areas

One of the first steps of the Source Water Assessment Program was to determine the area of land under which water flows to the wells and the area of land from which water flows to the streams or rivers that have surface water sources. A source water assessment area for ground water sources in New Jersey is the area from which water flows to a well within a certain time period. Each ground water source water assessment area in New Jersey contains three tiers, labeled as Tier 1, Tier 2, and Tier 3. Tier 1 is a two year time of travel, which means the ground water within this tier flows to the well within a two year time period. Tier 2 is a five year time of travel; the ground water within this tier will flow and reach the well within five years. The final tier, Tier 3, is a twelve year time of travel, in which the ground water within this tier will flow and reach the well within twelve years. The two year time of travel was chosen based on findings related to migration of bacteria and viruses in ground water. The five year time of travel was chosen based on DEP's experience with effecting mitigation remedies within less than five years. The twelve time of travel was chosen based on previous studies by the New Jersey Geological Survey (NJGS) that indicate that this distance encompasses the full length of most contamination plumes in New Jersey, and that a rough analysis of dilution ratios suggests that this distance would provide sufficient dilution and attenuation to minimize the risk of contamination of the well. In addition, it was felt that most sources outside of this distance would either be too minor to be of special concern or, conversely, are major enough that current DEP regulations would ensure protection of the public well. Figure 2 shows all of the community water supply wells in New Jersey and the areas that flow to the wells over this twelve year period. These areas are also sometimes called "wellhead protection areas."

Figure 2: Source Water Assessment Areas for Confined and Unconfined Community Water Supply Wells



For the Source Water Assessment Program, a drinking water surface water source was considered to be any surface water body where water is withdrawn for use as a potable water supply. Four types of surface water sources were evaluated as part of the Source Water Assessment Program, specifically rivers, reservoirs, canals, and "ground water under the direct influence of surface water" (GWUDI).[4] For the purposes of the Source Water Assessment Program, all raw water transfer points were considered a distinct source of surface water. For most surface water sources, the source water assessment area contains the entire drainage area that flows past the surface water source location, including all tributaries up to their headwaters. DEP used a variety of Geographic Information System tools to determine that area. Many surface water sources have controlling structures downstream of the intake, i.e. a dam or a weir, which affect downstream flow. When this occurred, DEP delineated the downstream boundary at the controlling structure.

There were some exceptions to the general delineation methodology, mainly at intakes where the size of the drainage area was extremely large (in some cases greater than the area of the State itself). It was felt that the results of the models would not be meaningful with such a large

geographic area for consideration. For some intakes, DEP delineated a source water assessment area using travel time considerations (25 hours, for intakes on the Delaware River). If the Department had used the same methodology for intakes on the Delaware River, the source water assessment area would have been as large as the area of the entire state. For others, such as those on the Delaware and Raritan Canal, DEP evaluated previous studies of travel time on the canal.

Figure 3 shows all surface water source water assessment areas in the state and includes Physiographic Province. The relationship of the results to Physiographic Province is discussed later in this Summary.

Figure 3: Source Water Assessment Areas for Public Water Supply Intakes

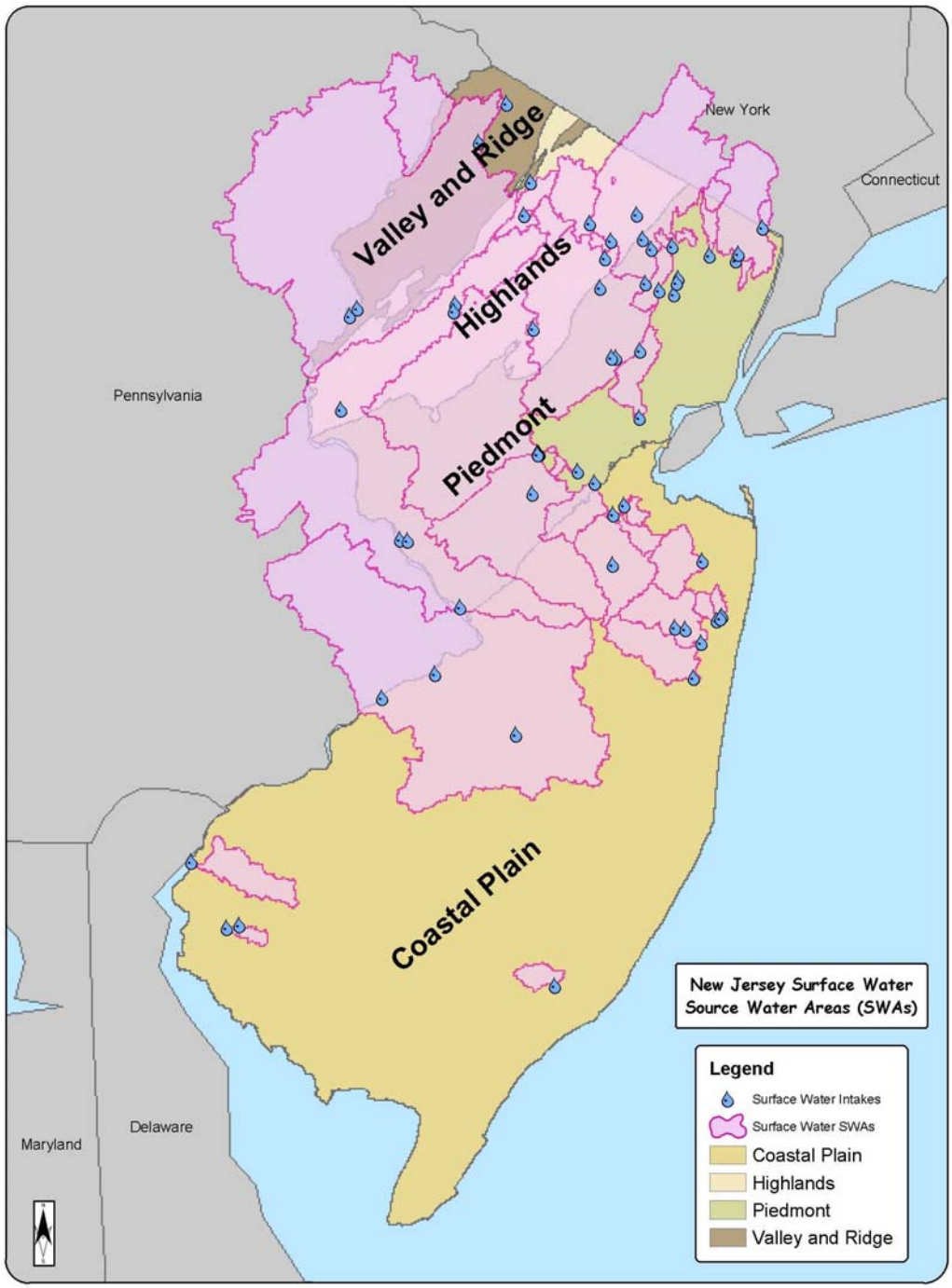
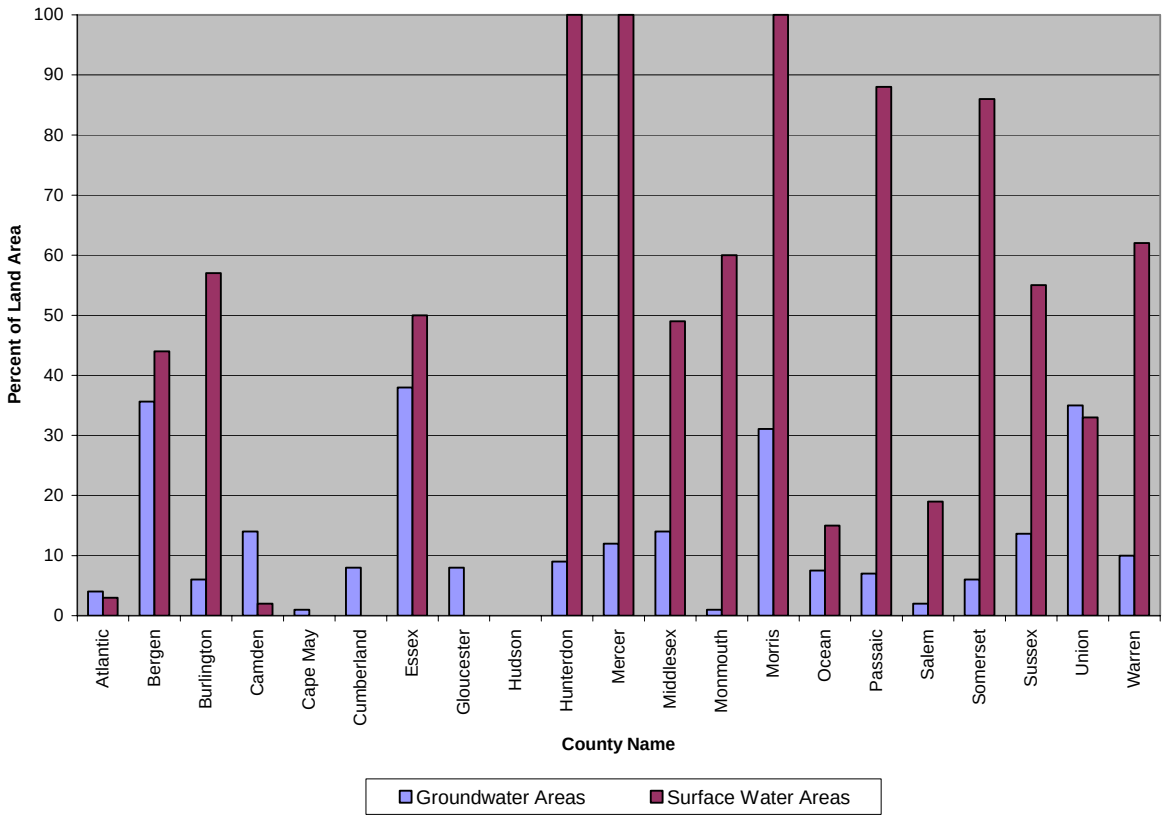


Figure 4 shows the percent of land contained within a source water assessment area, by source type (well or surface water intake) and by county. Overall, approximately 10% of the state is contained within a source water assessment area for a community water supply well for the purposes of source water assessments. In some of the counties with the largest population (Bergen, Essex and Union Counties, for example), over 30% of the land is within a source water assessment area for a community water supply well. Approximately 53% of the land in the state is contained within a source water assessment area for surface water. It is clear that a significant portion of the northcentral and northwestern parts of the state, including the Highlands, lie within a source water assessment area for surface water intake locations.

Figure 4. Approximate % of County Land in Source Water Assessment Areas



Determination of Contaminant Groups and Susceptibility Factors

DEP and USGS looked at factors that might affect the quality of drinking water sources and broke them into two categories. The first category consists of *sensitivity factors*, and includes items related to the construction of a well (such as well depth and whether the well is in a confined or unconfined aquifer) and naturally occurring factors. Naturally occurring factors include the geology of the unit in which a well was drawing water from or over which water flows to the surface water intake point. For instance, some rocks in the state are naturally rich in radionuclides or arsenic.

The second category consists of *intensity of use* factors and addressed the susceptibility to contamination resulting from man's activities at the land surface. Intensity of use factors include those coming from a specific *point source*, such as a landfill or leaking underground storage tank, and *nonpoint sources* of contamination grouped by land-use characteristics, such as agriculture or urban land use. USGS evaluated Geographic Information System (GIS) coverages of a large number of point sources and non-point sources. Coverages of nonpoint sources included land use and land classification data for the 1970s, 1986, and 1995. Coverages of point sources included sites on DEP's Known Contaminated Site List (KCSL), registered underground storage tanks, and New Jersey Pollutant Discharge Elimination System (NJDPES) permit locations.

The contaminants evaluated by DEP and USGS were broken into groups. Contaminants in each group share chemical and physical characteristics. A description of each group follows:

Pathogens
This group of contaminants includes disease-causing organisms such as bacteria, protozoans, and viruses. Sources of pathogens include animal and human fecal waste. The sources of pathogens in the environment include point sources discharges such as effluents from sewage treatment plants, and nonpoint sources such as discharges from septic fields, runoff from facilities where livestock is kept, boats, and wildlife. USGS developed a model for pathogens in ground water. However, for the purpose of source water assessment, USGS and DEP assumed all surface waters are highly susceptible to contamination by pathogens, and a pathogens model was not developed for surface water. All surface water sources received a high rating for pathogens.

Nitrates
The sources of nitrates are both natural and manmade. Nitrate has serious human health concerns. High levels of nitrate are linked to the occurrence of methemoglobinemia or "blue baby disease" in infants. Other nutrients may adversely impact the efficiency of the water treatment plant but were not included in this evaluation, primarily because the relatively large amount of data needed to develop the models was not readily available. Nitrates can originate from many sources including point sources such as effluents from sewage treatment plants, nonpoint sources such as discharges from septic fields, land where fertilizers are used such as on agricultural and residential land, areas where animal waste is stored, and from sludge application areas.

Volatile Organic Compounds (VOCs)
These manmade compounds are the most common organic contaminants in ground water in New Jersey. They are chemicals that are used as solvents, degreasers, and gasoline components. VOCs include known human carcinogens such as benzene and vinyl chloride and probable human carcinogens such as trichloroethylene and tetrachloroethylene. Other VOCs are associated with chronic health effects such as toluene and xylene.

Pesticides
Pesticides are a group of man-made chemicals used for control of insects, weeds, fungi, and bacteria. There are many different pesticides with many different chemical characteristics and toxicities. Point sources would include manufacturing, formulating, and distribution centers,

while nonpoint sources would include land application of pesticides such as on agricultural land, residential land, and golf courses.

Synthetic Organic Compounds (SOCs)
These compounds are also man-made, and sources include both point and nonpoint activities. Common sources include chemical manufacturing plants, pharmaceutical plants, sewage treatment plants, and discharges from contaminated sites. Separate models were developed for two groups of synthetic organic compounds, specifically pesticides and volatile organic compounds. DEP had intended to work with USGS to develop an SOC model, which would have included other non-volatile, non-pesticide synthetic organic compounds, but during model development it was realized that there was insufficient data to develop a stand-alone model. DEP believes that most of these other synthetic organic compounds have similar sources to the volatile organic compounds, and thus for the purpose of Source Water Assessment assumed that the susceptibility rating for synthetic organic compounds is the same as that developed for volatile organic compounds.

Inorganics (Metals)
Inorganics are mineral based compounds that have both naturally occurring and man-made sources. Inorganics include chemicals such as arsenic, cadmium, lead, and chromium. The sources can be point source discharges from manufacturing facilities and releases from contaminated sites. Inorganics can also impact source water quality due to past land use. For example, mercury and arsenic were used as pesticides until the 1950s. In addition, inorganics such as arsenic can be naturally present in the subsurface material and can be released into the drinking water source over time.

Radionuclides
Radionuclides have both natural and manmade sources. Common sources include the decay of naturally occurring minerals, leaching of subsurface material (for example rocks and sedimentary materials) into ground water, and improper disposal of radioactive waste. For modeling radionuclides, USGS evaluated gross alpha particle activity, radium, and uranium. A separate model was developed for radon, as discussed below. USGS and DEP did not develop a radionuclide model for surface water, as radionuclides are primarily a concern of ground water.

Radon
A separate model for radon was developed instead of including radon in the radionuclide model. Radon is chemically and physically different from the other radionuclide constituents. In addition, while radon is an important public health issue, currently there is only a proposed regulatory framework, with no final MCL at this time.

Disinfection Byproduct (DBP) Precursors
The precursors of disinfection byproduct formation are natural organic matter such as leaves and organic debris in surface waters. When disinfectants are used to kill pathogens in source water, the disinfectant may also react with any dissolved organic matter present to form disinfection byproducts. Chlorine is the most common disinfectant in New Jersey. Common disinfection byproducts include trihalomethanes, haloacetic acids, and haloacetonitriles. The concentrations of disinfection byproducts formed are a function of the amount of precursor material available

(total organic carbon concentration), the concentration of disinfectant applied, time of contact, pH, and temperature.

RESULTS AND DISCUSSION

Through the modeling process, USGS and DEP determined which of the sensitivity and intensity factors were most likely to describe the potential for a drinking water source to become impacted by the different types of contamination. The following tables show the factors deemed most important for each model:

Table 1a: Significant Environmental Factors that May Affect Source Water Quality Upstream of Public Water Supply Surface Water Intake Points

Constituent/Variable	Pathogens*	Nitrates	Pesticides	VOCs	Inorganics	Radionuclides*	Radon	DBP Precursors
Sensitivity Factors								
% Soil Clay			X					
% Soil Organic Matter				X	X			X
PH of Water Quality Sample					X			
Physiographic Province					X			
Water Region					X			
Intensity Factors								
% Agricultural Land Use, 1995		X						
% Commercial/Industrial Land Use, 1995					X			
% Developed Land, 1995					X			
% Residential Land Use, 1995			X					
% Urban Land Use, 1995		X		X	X			
Distance to Agricultural Land, 1995			X		X			
Distance to Wetlands, 1995								X
Density of New Jersey Pollutant Discharge Elimination System Surface Water				X	X			
Density of New Jersey Pollutant Discharge Elimination System Storm Water				X	X			
Compost Facilities				X	X			
Density of Known Contaminated Site List				X	X			
Density of Solid Waste Landfills				X	X			
Density of Solid Waste Resource Recovery Facility					X			
Density of Solid Waste Transfer Facility 2001					X			
Density of Class B Recycling					X			
Density of Discharge Prevention and Countermeasures Plans and Discharge Cleanup and Removal Plans					X			
Density of Underground Storage Tank					X			
Density of New Jersey Pollutant Discharge Elimination System Ground Water					X			
Sewage Treatment Plant Density		X						
Total Pesticide Application			X					

*For the purpose of developing susceptibility models, a pathogen model was not developed because all surface water sources are considered highly susceptible to pathogens. A radionuclide model was not developed because radionuclides are not a concern in surface water.

Table 1b: Significant Environmental Factors that May Affect Source Water Quality of Public Water Supply Wells

Constituent/Variable	Pathogens	Nitrates	Pesticides	VOCs	Inorganics	Radionuclides*	Radon	DBP Precursors
Sensitivity Factors								
Confinement Status of the Well	X	X	X	X	X	X	X	X
% Soil Organic Matter				X	X			X
Conceptual – Ground Water Under the Direct Influence	X							
Depth to Top of Open Interval	X	X	X		X		X	
Depth of Well						X		
Dissolved Oxygen of Water Quality Sample					X			
Conceptual – Length of Open Interval		X	X					
NJGS Hydrologic Unit								X
PH of Water Quality Sample					X	X		
Physiographic Province					X	X	X	
Conceptual –Soil Available Water Capacity	X							
Soil Hydraulic Conductivity					X	X		
% Soil Clay					X		X	
Intensity Factors								
% Agricultural Land Use, 1970						X		
% Agricultural Land Use, 1986		X	X					
% Agricultural Land Use, 1995							X	
Distance to Agricultural Land, 1995	X		X		X	X		
% Barren Land Use, 1995					X			
% Commercial/Industrial Land Use, 1995				X				
% Urban Land Use, 1970					X			
% Urban Land Use, 1995		X	X					
Square Miles of Urban Land Use, 1995				X				
% Urban Land Use, Tier 1, 1995						X		
% Developed Land, Tier 1, 1995						X		
% Impervious Surface, 1995				X				
Conceptual – Distance to Golf Course			X					
Distance to Department of Transportation Roads					X			
Distance to Sewage Treatment Plant					X			
Distance to Wetlands, 1995							X	
Square Miles of Wetlands, 1995								X
Number of New Jersey Pollutant Discharge Elimination System Surface Water								X
Number of New Jersey Pollutant Discharge Elimination System Ground Water								X

Table 1b Continued

Constituent/Variable	Pathogens	Nitrates	Pesticides	VOCs	Inorganics	Radionuclides*	Radon	DBP Precursors
Density of New Jersey Pollutant Discharge Elimination System Ground Water					X			
Number of New Jersey Pollutant Discharge Elimination System Storm Water								X
Number of Compost Facilities								X
Number of Solid Waste Resource Recovery Facility								X
Density of Solid Waste Resource Recovery Facility					X			
Number of Solid Waste Transfer Facility 2001								X
Density of Solid Waste Transfer Facility 2001					X			
Number of Class B Recycling								X
Density of Class B Recycling					X			
Number of Discharge Prevention and Countermeasures Plans and Discharge Cleanup and Removal Plans								X
Density of Discharge Prevention and Countermeasures Plans and Discharge Cleanup and Removal Plans					X			
Density of Known Contaminated Site List				X	X			
Density of Solid Waste Landfill				X	X			
Density of Underground Storage Tank				X	X			
Population Density					X			
Population Density, Tier 1					X			
Conceptual – Septic Tank Density	X							
Septic Tank Density in Piedmont						X		
Sewage Treatment Plant Density					X			
Conceptual – Presence of Streams, Tier 1	X							
Length of Railroads					X			

Sensitivity Factors

- For ground water, confinement status was by far the most frequently occurring sensitivity factor in predicting susceptibility to contamination and in fact was a factor in all the models. Confined wells are protected from activities at the land surface by relatively thick, laterally extensive units of low permeability (e.g. clay layers) and are a sufficient distance from the outcrop area of the geologic unit so that the source water is less likely to be affected by contamination at the land surface. Confined wells were determined to be of low susceptibility to contamination occurring at the land surface. All of the wells that were determined to be confined for Source Water Assessment evaluations are located in the Coastal Plain

Physiographic Province, in the southern half of the State. For five of the models (pathogens, nitrates, pesticides, volatile organic compounds, and inorganics), all confined wells are considered to be of low susceptibility because they are not generally affected by activities at the land surface. For unconfined wells, meaning with a direct connection to the land surface, modeling by USGS showed that the depth to the top of the open interval of the well was the most common sensitivity factor to affect the potential for contamination of a well. Depth to top of open interval was found to be a factor in the following five models: pathogens, nitrates, pesticides, inorganics, and radon. The shorter the distance to the land surface, the more likely for the well to be affected by contamination originating at the surface from point sources and certain land uses.

- For surface water and ground water, percent soil organic matter was found to be a frequently occurring sensitivity factor. Percent soil organic matter was a factor in the volatile organic compound, inorganic, and disinfectant byproduct precursor models for both the surface water and ground water models.

Intensity Factors

Nonpoint Sources

Overall, the results of the modeling performed by USGS show that of the nonpoint sources, factors related to urban land use and agricultural land use were most often linked to susceptibility of drinking water sources to contamination.

- For surface water, factors related to urban land use from the 1995 coverage (including percentage of commercial/industrial land use, percentage of developed land, percentage of residential land) were important in predicting the quality of the source water for four contaminant groups, specifically nitrates, pesticides, volatile organic compounds (VOCs), and inorganics. Agricultural land use was found to be a significant factor in three of the surface water models, specifically nitrates, pesticides, and inorganics.
- For ground water, factors related to urban land use from both 1970 and 1995 were important in predicting the quality of the source water for five of the models, specifically nitrates, pesticides, volatile organic compounds, inorganics and radionuclides models. Agricultural land use in 1970 and 1995 coverages were explanatory variables in six of the ground water models, specifically the models for pathogens, nitrates, pesticides, radionuclides, radon, and inorganics.

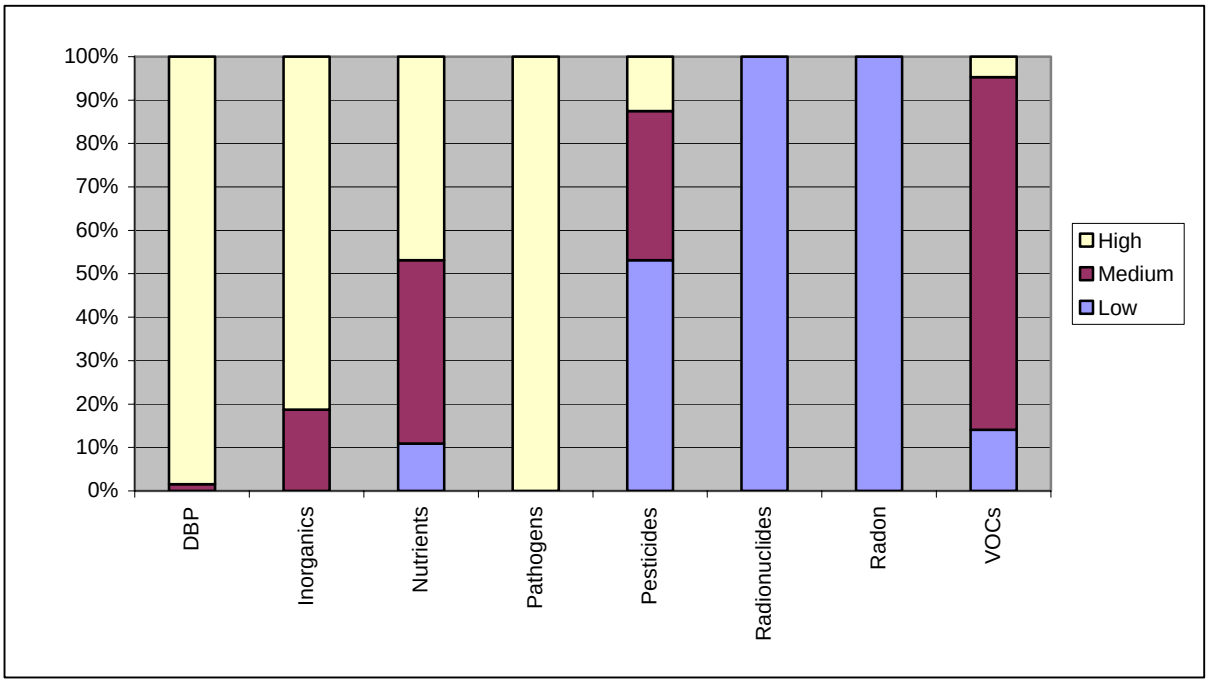
Point Sources

- For surface water, factors related to New Jersey Pollutant Discharge Elimination System /Discharge to Surface Water (NJPDES/DSW) permits and sewage treatment plant density were found most often to be important factors, specifically for the nitrates, volatile organic compound, and inorganics models. NJPDES stormwater permitted locations, compost facilities, sites on DEP's Known Contaminated Site List (KCSL) and solid waste landfills were found to be factors in two of the models, specifically the VOC and inorganics models.
- For ground water, no one point source factor stood out. Quite a number of point sources categories were found to be important in two of the models. What is significant is that the point sources were found to be significant only in the models for VOC, inorganics, and disinfection byproduct precursors. No point sources were found to be important in the models for pathogens, nitrates, and pesticides.

Summary of Susceptibility Ratings

Each well and surface water source was assigned a rating of low, medium or high susceptibility to each type of contamination. As noted previously, a low rating generally includes wells or intakes for which contaminants in source water are not likely to equal or exceed one-tenth of New Jersey's drinking water MCL, the medium rating includes wells for which contaminant concentrations in source water are not likely to equal or exceed one-half the MCL, and the high rating includes wells and intakes for which contaminant concentrations in source water may equal or exceed one-half the MCL. As a result, sources with high susceptibility ratings are still likely to be below MCLs. Table 2 and Figure 5, below, show the susceptibility of surface water intakes to the contaminant of concern. DEP and USGS decided that all surface water intakes in New Jersey would be considered highly susceptible to pathogens. Almost all (98%) surface water sources are considered highly susceptible to disinfectant byproduct precursors. The factors deemed important for the surface water disinfectant byproduct precursor model were average percent soil organic matter and distance to wetlands. Disinfectant byproducts are a known public health problem in surface water drinking water supplies nationwide. Most surface water systems have had to routinely sample for trihalomethanes, a common disinfectant byproduct. Fortunately, under the Stage 1 Disinfectants and Disinfection Byproduct Rule, as of January 1, 2002, all surface water systems in New Jersey must sample for disinfectant byproducts including trihalomethanes and haloacetic acids. In addition, under this new rule, the MCL for trihalomethanes was recently lowered from 100 parts per billion to 80 parts per billion. This new rule also sets an MCL for haloacetic acids for the first time, at 60 parts per billion.

Figure 5: Surface Water Susceptibility Ratings by Contaminant Group



Eighty one percent of surface water supplies were determined to be highly susceptible to inorganics. The inorganics rating for surface water was developed by creating three separate models (arsenic, lead, and fluoride) and then using the highest of the three ratings. Results may be skewed high because of this.

Forty-five percent of all surface water intakes are considered to be highly susceptible to nitrates. The variables for the nitrate surface water model are a combination of percent urban land (1995), percent agricultural land (1995) and density of sewage treatment plants per square mile. DEP regulates discharges from sewage treatment plants, however, control of nitrates from nonpoint sources is much harder to regulate, and typically has to be handled through public education means and development of best management practices.

Table 2 – Susceptibility Ratings for Surface Water Intakes

Model Type	Low Susceptibility Rating		Medium Susceptibility Rating		High Susceptibility Rating	
	Number of Surface Water Intakes	Percentage of Surface Water Intakes	Number of Surface Water Intakes	Percentage of Surface Water Intakes	Number of Surface Water Intakes	Percentage of Surface Water Intakes
Disinfectant Byproduct Precursors	0	0%	1	2%	63	98%
Inorganics	0	0%	12	19%	52	81%
Nitrates	7	11%	27	42%	30	47%
Pathogens	0	0%	0	0%	64	100%
Pesticides	34	53%	22	34%	8	13%
Radionuclides	64	100%	0	0%	0	0%
Radon	64	100%	0	0%	0	0%
VOCs	9	14%	52	81%	3	5%

As noted previously, confinement status is the single most common sensitivity factor affecting susceptibility for the ground water models. Table 3, with Figures 6 and 7 show the stark difference between susceptibility of unconfined and confined wells. A significant number of unconfined wells are highly susceptible to volatile organic compounds (VOCs) and nitrates, while all confined wells are considered to be of low susceptibility to VOCs and nitrates. Both of these types of contamination are caused by man's activities at the land surface, and confined wells are protected from that contamination by a layer of less permeable material. A significant number of unconfined wells in New Jersey are highly susceptible to radionuclides and radon. Although all of the radionuclides that were modeled are naturally occurring, human activities do influence the concentrations found in ground water. For instance, radium is the radionuclide constituent that is most affected by man's activities. Radium is much more soluble in low pH water, and the addition of agricultural chemicals tends to lower the pH of water in unconfined aquifers, but has little or no affect on water in confined aquifers. In addition, radium is actually found in higher concentrations in geologic material in northern New Jersey than in the southern part of the State, but it doesn't dissolve because of the geochemical conditions in the north. For

radon, another naturally occurring contaminant, geologic unit and Physiographic Province are most important in determining susceptibility.

Figure 6: Susceptibility Rating of All Unconfined Wells by Contaminant Type

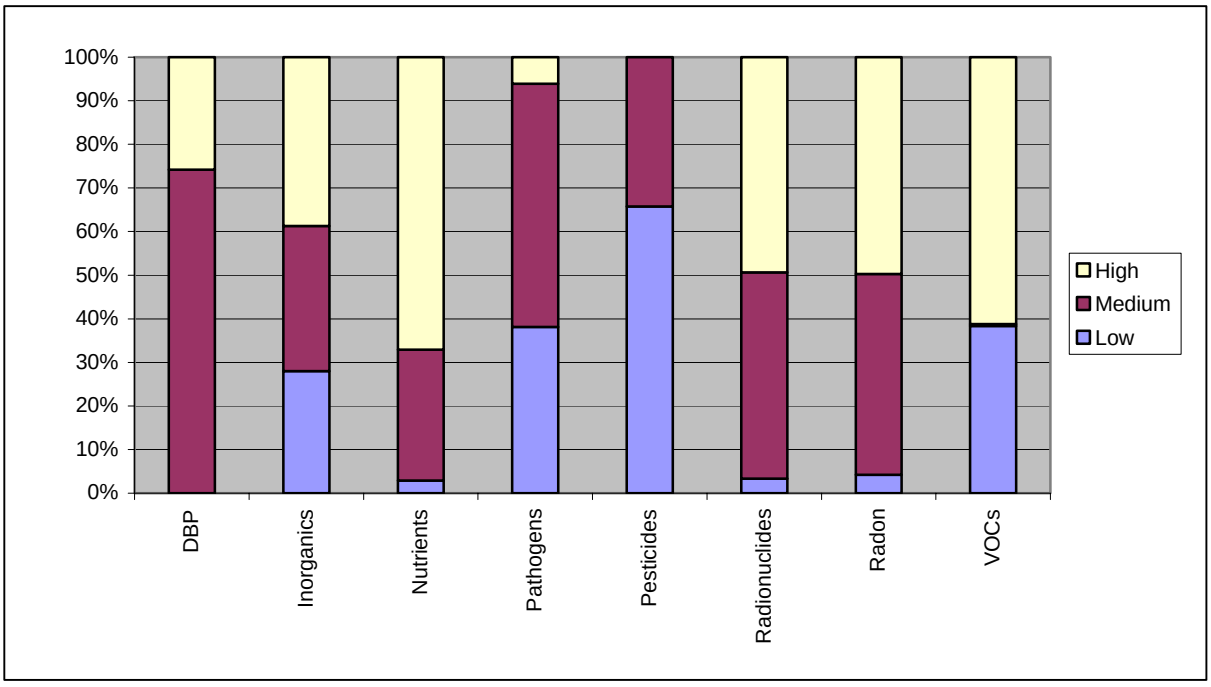
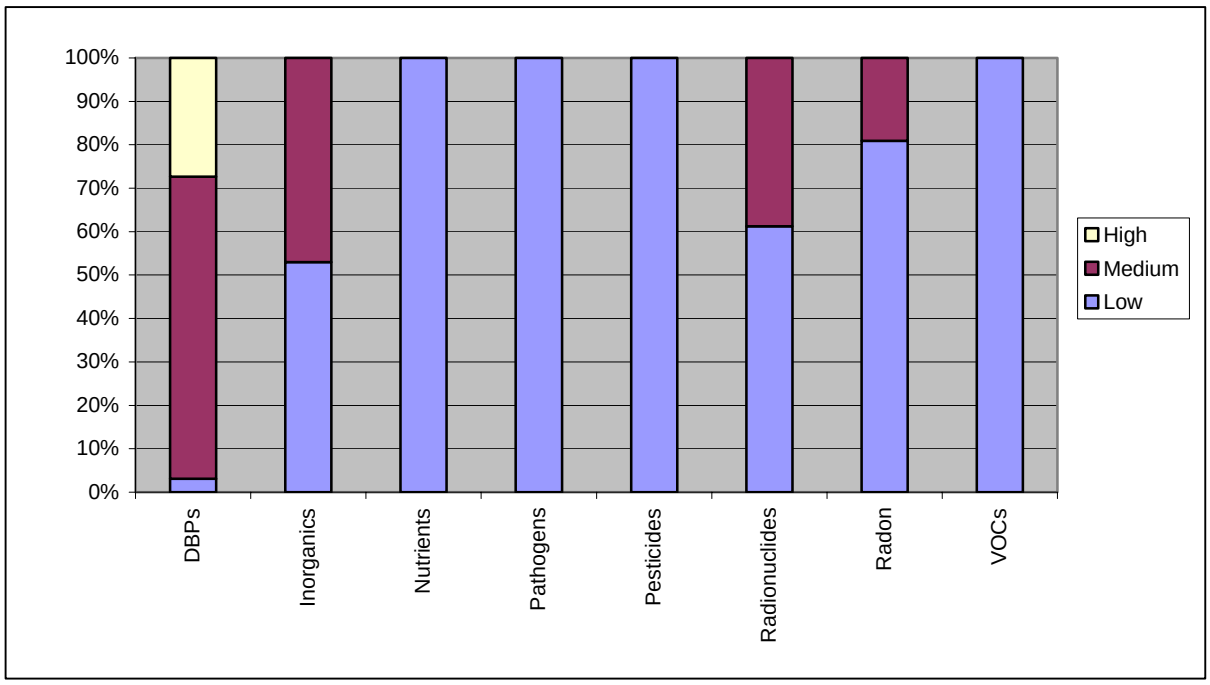


Figure 7: Susceptibility of All Confined Wells by Contaminant Group



Modeling resulted in a surprising number of medium and high susceptibility ratings for the disinfectant precursor model for ground water. This model is being reviewed with data collected by DEP and may be further refined in the future. One important distinction that should be made between the ground water disinfectant precursor model and the other models is that the disinfectant byproduct precursors, for which the model was developed, in combination with the disinfection process, form the actual disinfectant byproducts. The disinfectant byproducts are regulated, not the precursors. All other susceptibility models were developed using the regulated contaminant rather than constituent that reacts to form the regulated contaminant. The predominant sources of disinfectant byproduct precursors, similar to radionuclides and arsenic, are naturally occurring. Thus, the occurrence of disinfectant byproduct precursors, and the susceptibility ratings, can be regarded in a similar manner to susceptibility ratings or occurrences of radionuclides or arsenic rather than the predominantly human influenced susceptibility ratings of volatile organic compounds or nitrates. The assessments should be viewed as potential susceptibility. Different disinfection techniques, other types of treatment at a facility, and residence time of the water within the entire water system prior to consumption may result in different concentrations of disinfectant byproducts being formed. Up until recently, most ground water systems were not required to sample for disinfectant byproducts. With the advent of the Stage 1 Disinfectants and Disinfectant Byproduct Rule, as of January 1, 2004, all community water systems that use ground water and add a disinfectant to the drinking water during any part of the treatment process must sample for disinfectant byproducts and meet a new MCL of 60 parts per billion.

Table 3 – Susceptibility Ratings of Unconfined and Confined Wells

Model Type	Low Susceptibility Rating		Medium Susceptibility Rating		High Susceptibility Rating	
	Percentage of Unconfined Wells	Percentage of Confined Wells	Percentage of Unconfined Wells	Percentage of Confined Wells	Percentage of Unconfined Wells	Percentage of Confined Wells
Disinfectant Byproduct Precursors	0%	3%	74%	70%	26%	27%
Inorganics	28%	53%	33%	47%	39%	0%
Nitrates	3%	100%	30%	0%	67%	0%
Pathogens	38%	100%	56%	0%	6%	0%
Pesticides	66%	100%	34%	0%	0%	0%
Radionuclides	3%	61%	47%	39%	50%	0%
Radon	4%	81%	46%	19%	50%	0%
VOCs	38%	100%	1%	0%	61%	0%

Regions of the State

DEP also reviewed the results by physiographic province. Physiographic province is defined as a region of similar geologic structure and climate, with relief features that are different from those of surrounding regions. The characteristics of a particular physiographic province result in a distinct hydrologic setting in which water quality may be affected by a particular combination of factors such as soils, surface slopes, runoff patterns, stream morphology, recharge rates, mineralogy and subsurface flow patterns. A consequence of this kind of effect is that a particular

physiographic province may be associated with a specific water-quality concern. There are four physiographic provinces in New Jersey: Valley and Ridge, Highlands, Piedmont, and Coastal Plain. The four physiographic provinces can be seen in Figure 3, with the surface water source water assessment areas overlain.

Figures 8, 9, 10, and 11 show the breakdown of surface water source susceptibilities by predominant physiographic province. Predominant physiographic province in this situation means that the greatest portion of the source water assessment area is from that physiographic province.

Figure 8: Susceptibility of Surface Water Sources in the Valley and Ridge Physiographic Province

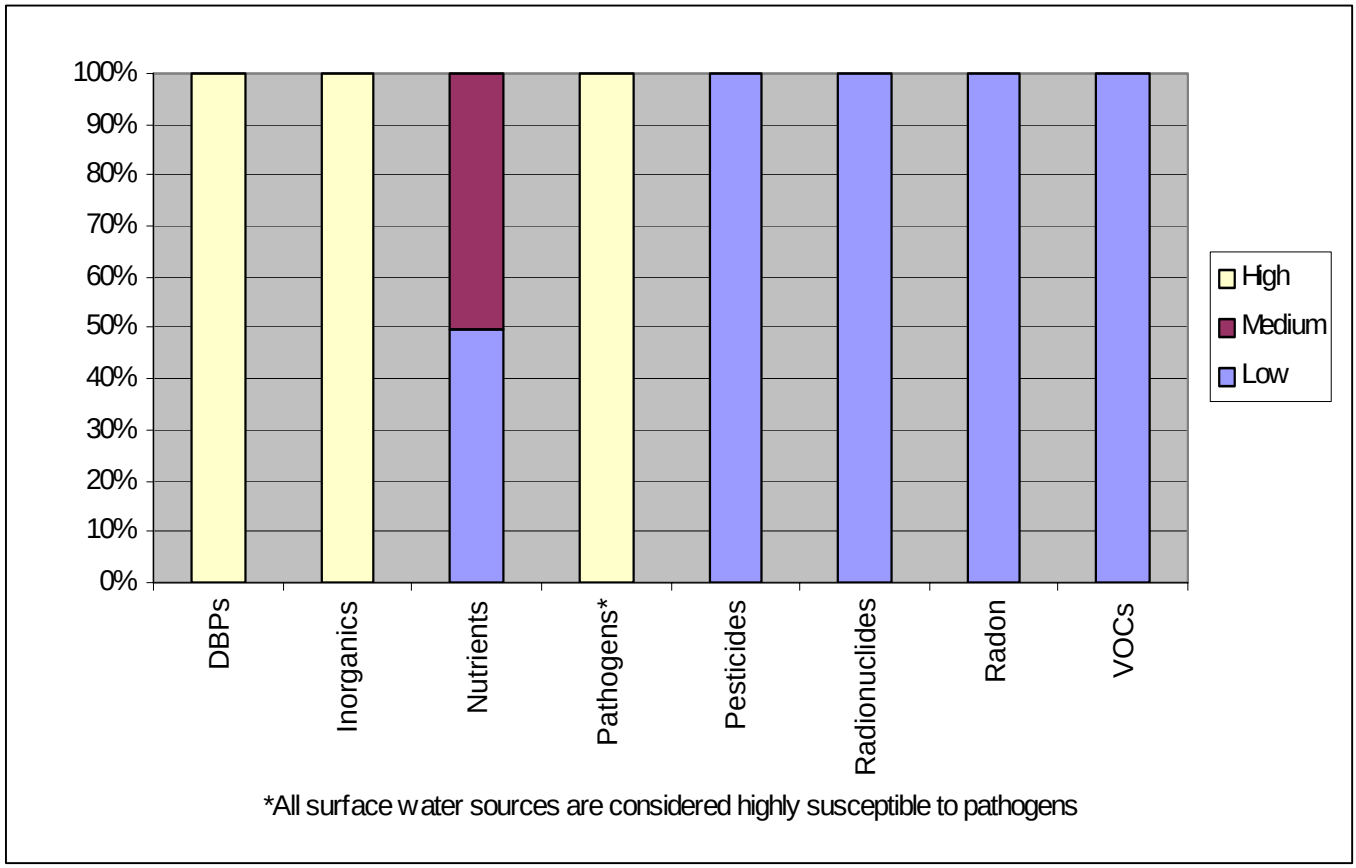


Figure 9: Susceptibility Rating of Surface Water Sources in the Piedmont Physiographic Province

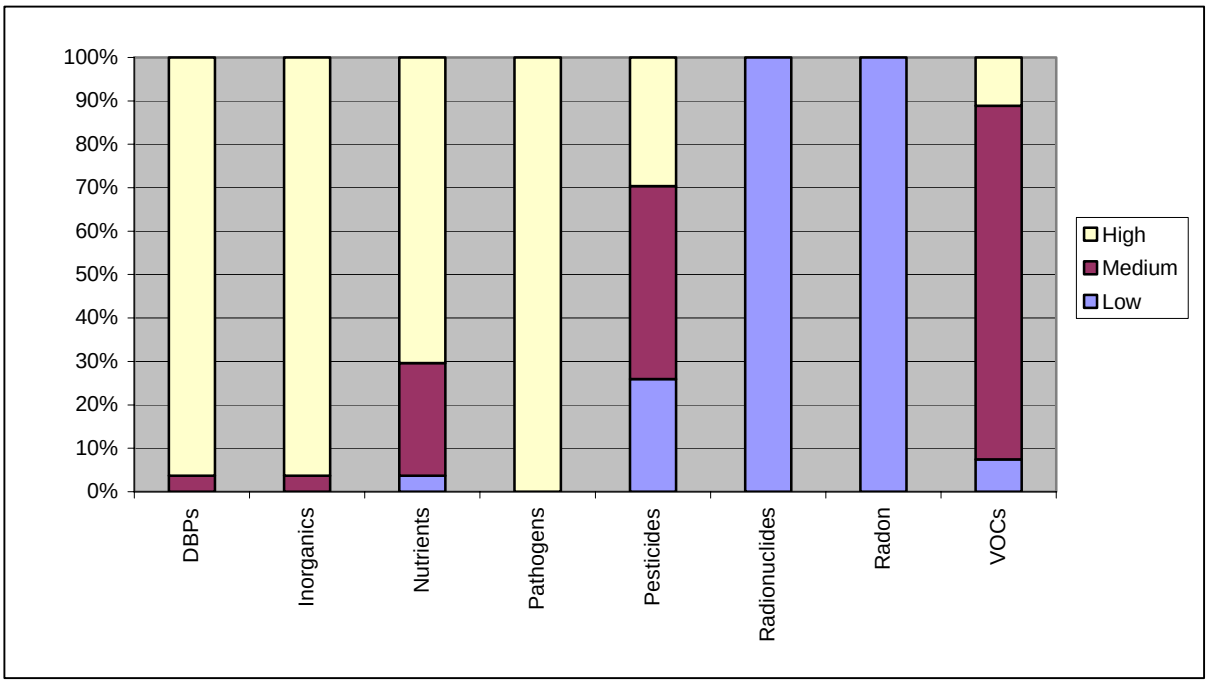


Figure 10: Susceptibility Rating of Surface Water Sources in the Highlands Physiographic Province

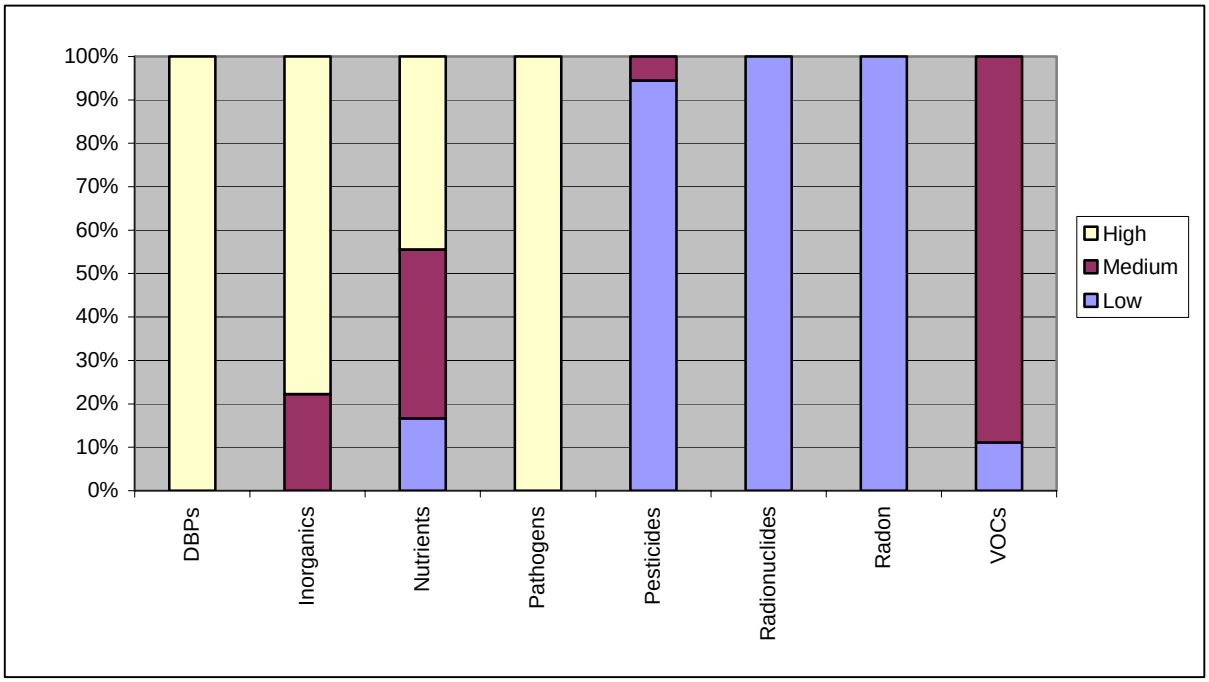
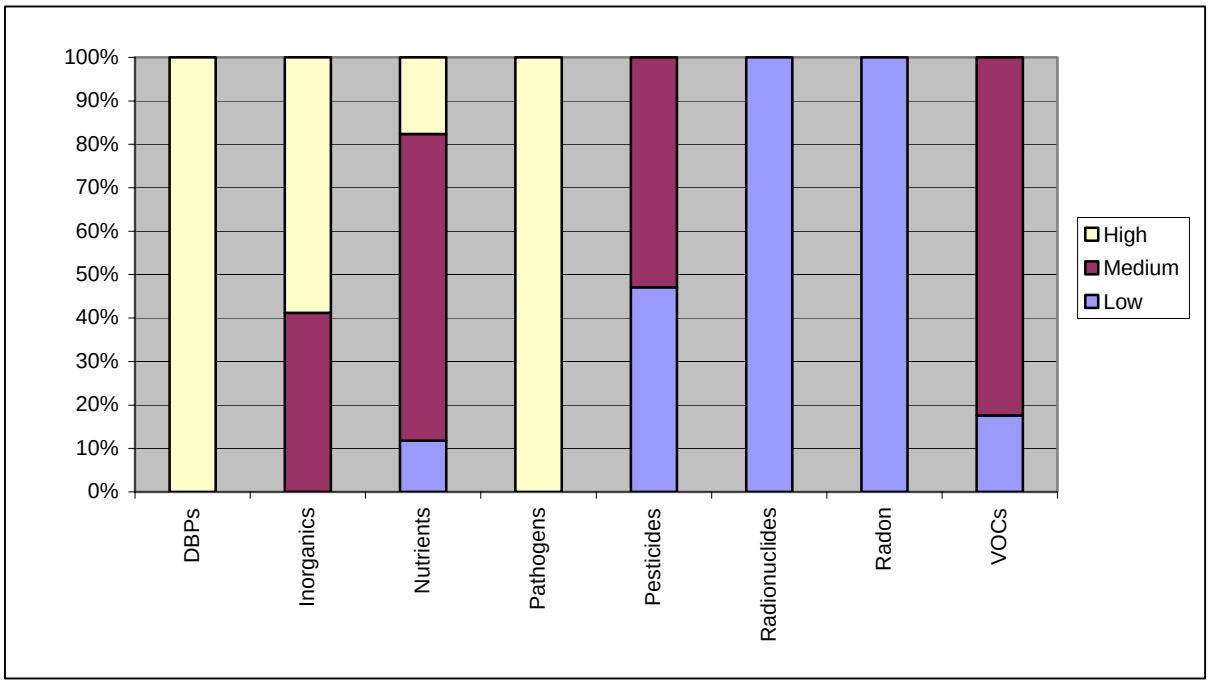


Figure 11: Susceptibility Rating of Surface Water Sources in the Coastal Plain Physiographic Province



The contaminant factors most affected by man's activities, through point sources and nonpoint sources, are nitrates, pesticides, volatile organic compounds (VOCs), and inorganic compounds. Of the four physiographic provinces, the Valley and Ridge Province (Figure 8) has the greatest percentage of surface water sources that are highly susceptible to contamination by inorganics, followed closely by the Piedmont Province (Figure 9) and the Highlands Province (Figure 10). For nitrates, the physiographic province with the greatest percentage of source water intakes that are highly susceptible is the Piedmont, followed closely by the Highlands. Looking at susceptibility to volatile organic compounds and pesticides, it appears that the surface water sources that have assessment areas primarily in the Piedmont Province are the most highly susceptible, followed by the Coastal Plain Province (Figure 11) and the Highlands Province.

By looking back at Figure 3, it is seen that most of the Highlands Province is within a source water assessment area for a surface water source. A significant portion of the Valley and Ridge Province and the Piedmont Province also fall within a source water assessment area for a surface water source. These surface water sources provide drinking water to a significant portion of New Jersey residents, and DEP and other regulatory agencies, as well as the public at large, are charged with protecting those sources so that they will continue to be a valuable resource into the future.

PROTECTING DRINKING WATER

State and local agencies, as well as the regulated community, have made significant strides over the last 30 years to protect the quality of our water resources and the ecosystems that rely on them. Major water quality improvements have been made as a result of water quality and drinking water standards and programs (both regulatory and nonregulatory) designed to ensure standards are met. Waste management and clean up programs have had success in controlling releases and ensuring actions are taken to achieve standards if releases occur. Recent measures to control non-point sources have expanded the DEP's water quality protection programs by recognizing the link between land use change and water resource impacts. In addition, the Safe Drinking Water Program is designed to ensure that water delivered for human consumption meets drinking water standards. For more information on the existing water resource protection programs administered by DEP, please visit the applicable DEP website listed on the attached for the regulatory program of interest.

In addition to the many long-standing programs implemented in New Jersey for water resource protection, the following major initiatives have recently been accomplished:

- **Highlands Water Protection and Planning Act:** The Highlands Water Protection and Planning Act, enacted on August 10, 2004 addresses water resource impacts that result from nonpoint sources and modifications of natural land cover. In particular, the Highlands Act preserves open space and protects a diversity of natural resources including the precious water resources that supply drinking water to more than half of New Jersey's inhabitants.
- **Surface Water Quality Standards and Category One Designation:** The DEP designated a number of surface waters as Category One under the SWQS to prevent water quality degradation and discourage development where it would impair or destroy natural resources and environmental quality. Enhanced protection for exceptional water supply sources including reservoirs and their natural drainage areas has been provided.
- **Safe Drinking Water Arsenic Standard:** Adoption by the DEP of an MCL for arsenic in drinking water of 5 ug/L has made New Jersey's arsenic standard for drinking water the most stringent in the country.
- **Municipal Stormwater Regulation Program:** In 2004, the DEP adopted the Municipal Stormwater Regulation Program, a significant new water pollution control program for pollutant sources that have largely gone unregulated previously. This program addresses pollutants entering our waters from storm drainage systems owned or operated by all 566 municipalities, State, interstate or Federal government agencies.
- **Stormwater Management Rules:** In 2004, new stormwater management regulations were adopted that establish updated stormwater runoff requirements for all new major developments and incentives to encourage redevelopment. The new requirements include special buffer-area protections for Category One waters that will prevent degradation of public drinking water supplies and other exceptional water resources. The DEP and local stormwater requirements now include low impact development techniques, maintain annual groundwater recharge and reduce polluted runoff.

New Jersey's drinking water meets Federal and State standards 99% of the time when sampled as a result of local and State programs. Despite this success, the DEP recognizes the ongoing

importance of using new information such as that from the source water assessment reports to evaluate the need for additional protection measures for public drinking water sources. The Department is currently reviewing the source water assessment information to identify any necessary additional source water protections measures.

List and Web site of Many DEP Water Resource Protection Programs:

Clean and Plentiful Water
http://www.nj.gov/dep/cleanwater/

Water Supply and Safe Drinking Water
http://www.nj.gov/dep/watersupply/

Water, Coastal and Watershed Information
http://www.nj.gov/dep/infofinder/topics/water.htm

Water Monitoring and Standards
http://www.state.nj.us/dep/wmm/

Watershed Management
http://www.state.nj.us/dep/dwq/

Water Quality
http://www.state.nj.us/dep/dwq/

Compliance and Enforcement
http://www.nj.gov/dep/enforcement/

Green Acres
http://www.nj.gov/dep/greenacres/

New Jersey Geological Survey
http://www.nj.gov/dep/njgs/

Site Remediation and Waste Management
http://www.nj.gov/dep/srp/

Solid and Hazardous Waste
http://www.nj.gov/dep/dshw/

Underground Storage Tanks
http://www.nj.gov/dep/srp/bust/bust.htm

Land Use Regulation
http://www.nj.gov/dep/landuse/

Pesticide Control program
http://www.nj.gov/dep/enforcement/pcp/index.htm

Radiation Protection and Release Prevention
http://www.state.nj.us/dep/rpp/

Private Well Testing
http://www.nj.gov/dep/pwta/

Stormwater and Nonpoint Source Pollution
http://www.njstormwater.org/